

REPUBLIC OF UGANDA | HEALTH SECTOR

Uganda Health Sector Report 2026

Needs, supply, gaps, cost, allocation and outcomes across 122 districts: a needs-based analysis with the Health Planning and Resource Allocation System (HPRAS)

Population 2026: 47.4 million | Requirement 2026: UGX 1,966 bn | 41 mapped indicators

Run uga-unconstrained-2026 · norm version UGA-2026-v1 · price vintage UGA-2026Q1 · horizon 2026–2030

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About this report

This report answers six planning questions for Uganda's health sector: what the population needs, what the system has, where the gaps are, what closing them costs, where additional resources could go and what they would achieve. Every figure is computed by the Health Planning and Resource Allocation System (HPRAS) from the evidence in its database and can be traced to its source, year and quality tier.

Item	Value
Plan run	uga-unconstrained-2026 (unconstrained requirement, with scenario allocations)
Horizon	2026–2030; year Y is the financial year ending in Y (2026 = FY2025/26)
Geography	122 districts on the 2018 district set, 15 DHS sub-regions
Norm version / prices	UGA-2026-v1 / UGA-2026Q1
Coverage targets	UGA-NDP-ILLUSTRATIVE (illustrative, for review)
Currency	Uganda shillings (UGX); USD at 3,700 UGX per USD where shown
Scope	28 modelled services; the budget covers the whole sector, so the two are compared as a ratio, not closed as a gap
Quality tiers	measured < normed < imputed < assumed; a result carries the worst tier of its inputs
Rules	no composite index; capital always with its induced recurrent cost; deaths averted always with a range; no scenario marked recommended
Reproduction	python scripts/rebuild_all.py; julia --project=. scripts/run_plan.jl; python report/build/collect.py; python report/build/figures.py; python report/build/render_equations.py; node report/build/build_docx.js

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Executive summary

This report is a needs-based analysis of Uganda's health sector for 2026–2030. It starts from the health needs of the population, not from last year's budget. It asks six questions in order:

1. What does the population need?
2. What does the health system have?
3. Where are the gaps?
4. What would closing them cost?
5. Where could additional resources go?
6. What would they achieve?

Every figure comes from the Health Planning and Resource Allocation System (HPRAS) for the plan run uga-unconstrained-2026. The run covers 122 districts, 28 modelled services and a five-year horizon. Every figure carries its source, its year and a quality tier. Year 2026 means the financial year 2025/26.

The population and its needs

Uganda's population is projected at **47.4 million in 2026**, rising to **53.2 million in 2030**, a growth rate of 2.9% a year. The population is young:

- **8.4 million children under five;**
- **1.9 million births a year;**
- **10.3 million women of reproductive age.**

The largest districts, on the 2018 district set used throughout this report, are Wakiso (3.0 million), Kampala (2.0 million) and Arua (1.1 million). The smallest is Kalangala (76,000).

Need is sharply uneven across the country, and much of the unevenness is regional rather than district by district. Malaria need is the most strongly clustered indicator in the whole atlas (Moran's $I = 0.87$). Its hot spots run through Lango, Acholi, Teso and Karamoja; its cold spots are in the south-west. HIV need follows the UPHIA regional pattern: 0.37 times the national rate in Karamoja, 1.42 times in South Buganda. Severe acute malnutrition and hypertension also cluster by region.

Sub-regional survey estimates rest on a few hundred children or women each. For that reason, six of them are smoothed with a Fay–Herriot small-area model before use.

What it takes to meet the needs

Delivering the 28 modelled services at the illustrative national coverage targets would require **UGX 1,966 bn in 2026** (USD 531 million). That is **UGX 41,447 per person** (USD 11.20). The requirement rises to UGX 3,084 bn in 2030, 57% more, as the population grows and the targets rise.

The largest lines in 2026 are:

Service	Requirement, 2026	Share
Antiretroviral therapy	UGX 472 bn	24%
Outpatient consultations	UGX 228 bn	12%
Normal deliveries	UGX 202 bn	10%
Inpatient bed-days	UGX 190 bn	10%
Malaria diagnosis and treatment	UGX 162 bn	8%

By WISN workload, the modelled services alone need 32,775 full-time health workers in 2026 and 53,410 in 2030.

What the system has, and where the gaps are

The National Health Facility Registry lists **6,800 facilities**: 3,535 government, 1,012 private not-for-profit and 2,253 private. About 119,000 health workers are in post in public and PNFP facilities, 74% of the establishment. Nationally, 87% of people live within an hour's walk of a facility and 99% within an hour's drive. That still leaves **5.3 million people beyond an hour's walk**, most of them in the northern sub-regions. Karamoja has the lowest walking access (69%).

Capacity falls short of requirement most severely for:

- severe mental disorders (capacity is 0.18 of the requirement);
- hypertension management (0.20);
- outpatient consultations (0.46);
- the routine immunisations (about 0.68).

Hospital services (inpatient days, caesarean sections, major surgery) show capacity above requirement at national level. Physical space is the most common binding constraint: it limits 59% of district × service × level cells. Staff time limits 22%.

Gaps are reported in **four dimensions that are never added together**:

1. **Service units.** 23.8 million service units a year cannot be delivered with existing capacity, across 2,105 district-service combinations.
2. **Workforce.** A shortfall of 5,054 FTE in the cadres the modelled services use.
3. **Commodities.** UGX 858 bn. With no stock data yet, this is the whole commodity requirement, not a measured shortfall against stock.
4. **Facilities.** 260 facility-equivalents.

Closing the gaps in 2026 costs UGX 158 bn of capital and UGX 1,105 bn of recurrent cost. Without an asset register, the capital figure equals the capital requirement, so it tracks service volume rather than the facility gap alone. The capital also commits a further 15% of its value every year, once built, in **induced recurrent cost**: staff, maintenance and running costs.

The money

The approved health budget grew from UGX 1,317 bn in FY2015/16 to **UGX 4,614 bn in FY2025/26**, and to **UGX 5,271 bn in FY2026/27**. Execution is a binding constraint in its own right: 88% of the approved budget was spent in FY2021/22, and 67% of FY2025/26 is recorded so far.

The modelled requirement is 43% of the whole health envelope in 2026, falling to 40% by 2030 as the envelope grows faster than the requirement. This is a ratio to read, not a gap to close. The budget pays for far more than the 28 modelled services: administration, specialised institutes, training and more. At the primary-care level, however, the requirement already exceeds the local-government and KCCA health budget (ratio 1.10).

External financing is UGX 1,241 bn in FY2026/27:

- Global Fund, UGX 835 bn;
- GAVI, UGX 165 bn;
- unattributed projects, UGX 241 bn.

External money is equivalent to 63% of the modelled requirement. This engine's own parse of the MoFPED budget files agrees with an independent extract to within 0.5% on the total.

Where additional resources could go, and what they would achieve

The incremental envelope is **UGX 413 bn**: the approved increase from FY2025/26 to FY2026/27 in the institutions that deliver the modelled services. It is allocated under six rule-based scenarios (A–F) and by an optimiser that maximises lives saved. Each allocation buys something different:

- **Scenario E (geographic equity)** raises coverage the most, by 23.4 percentage points.
- **Scenarios B, C and D** each lift 45 districts above the coverage floor.
- **Scenario D (hospital expansion)** leaves the least unspent among the rules.
- **The optimiser averts 20,053 deaths (range 13,381–26,299)**, against 15,010 (10,321–19,293) for scenario E, the highest of the six rules on that measure.
- **Scenario F** allocates by disease burden. It averts the fewest deaths, 5,558 (3,758–7,222). It also leaves UGX 280 bn unspent, because the services it favours reach their need ceiling and have no remaining gap to fund.

No scenario is recommended. The choice between aggregate gain, geographic equity and particular services is a political one. The report's task is to make its consequences legible.

Equity

Coverage rises with household wealth for almost every service:

- facility delivery: 67% in the poorest quintile, 93% in the richest;
- modern contraception: 22% and 42%.

Malnutrition falls with wealth:

- stunting: 33% among the poorest, 17% among the richest;
- severe wasting: 2.3% and 0.8%.

DPT3 is the exception: coverage is flat across quintiles, which is consistent with delivery through outreach.

Geographically, both health workers and facilities are slightly concentrated where need is **lower**. The concentration index against need is –0.042 for health workers and –0.049 for facilities.

What the evidence is, and is not

The analysis uses:

- the DHS 2016 and malaria surveys up to 2024–25, read transiently from licensed microdata;
- UPHIA 2020–21;
- DHIS2 league tables;
- the national facility registry;
- MoFPED item-level budget files for FY2015/16 to FY2026/27;
- OpenStreetMap boundaries;
- travel-time access modelled by the national spatial data infrastructure (SDI).

It has been validated against published benchmarks, and 776 automated tests pass.

Three limitations matter most:

- **Illustrative coverage targets.** The targets must be replaced by the approved targets of the national development plan.
- **Derived staff in post.** The workforce in post is derived from staffing norms and fill rates, not from an HRIS extract.

- **Missing inventories.** There is no equipment inventory and no commodity stock data.

The medical officer cost used by the engine is 25% below the gross salary recorded by UCSN. Baseline DPT3 coverage from the district league tables (79.6%) is below the WHO/UNICEF estimate (91.3%). Both are flagged to the owners of the norms rather than corrected silently.

Chapter 19 sets out what these findings imply and what the next planning round should improve.

CHAPTER 1

1 Introduction

1.1 Purpose of the report

This report sets out, for the whole of Uganda and for each of its 122 plan districts, what the population's health needs imply for services, workforce, commodities, facilities and money over the planning horizon 2026–2030. It is produced from the Health Planning and Resource Allocation System (HPRAS), a needs-based planning engine built for the Economic Development Integrated Planning (EDIP) system. The report is written for the officials who have to turn a health sector strategy into a budget: planners in the Ministry of Health, budget and fiscal analysts in the Ministry of Finance, Planning and Economic Development, analysts at the National Planning Authority, and the development partners who co-finance the sector.

The report answers a normative question rather than a descriptive one. Most health sector analysis asks what the burden of disease is and how it is changing. This report asks what the population *requires*: how many services, delivered by whom, with what inputs, where, and at what cost. It then compares that requirement with what exists today, locates the gaps district by district, prices them, and shows what different allocations of the money actually available would buy. The engine documentation states the governing rule plainly: never start from money. The requirement is built up from the population and the services it needs. Money is an output of that chain. It becomes a binding constraint only at the allocation stage, when a fixed envelope has to be shared out.

Three features make the analysis useful for budget decisions rather than for advocacy alone.

- **Every figure is traceable.** Any number in the report can be decomposed into population × need rate × coverage target × units per case × norm × price, each with its source, year and quality tier.
- **The gaps are kept apart.** They are shown separately for service volume, workforce, commodities and facilities, with physical access shown beside them. They are never averaged into a single score.
- **Choices are not made for the reader.** Where the report compares allocation scenarios, it states what each one buys and leaves the trade-off between geographic equity and aggregate health gain to the political process.

The headline is that delivering the 28 modelled services at the illustrative coverage targets across 122 districts and 47.4 million people costs 1,966 bn UGX in 2026 (531 m USD), or 41,447 UGX (11.20 USD) per person. The same requirement rises to 3,084 bn UGX by 2030, an increase of 56.9% driven by population growth and by the rising coverage targets. The rest of the report explains where these figures come from, how far they can be trusted, and what they imply for the allocation of Uganda's health budget.

1.2 Uganda in 2026: the planning context

1.2.1 Population

The engine projects Uganda's population at 47.4 million in 2026, rising to 53.2 million in 2030 at a national growth rate of 2.9% a year (Figure 1.1). About 1.94 million births are expected in 2026, and 8.42 million children are under five. These are the denominators of almost every service in the plan: births drive antenatal care, deliveries, postnatal care and the prevention of mother-to-child transmission of HIV; the under-five population drives immunisation, child illness and the management of acute malnutrition.

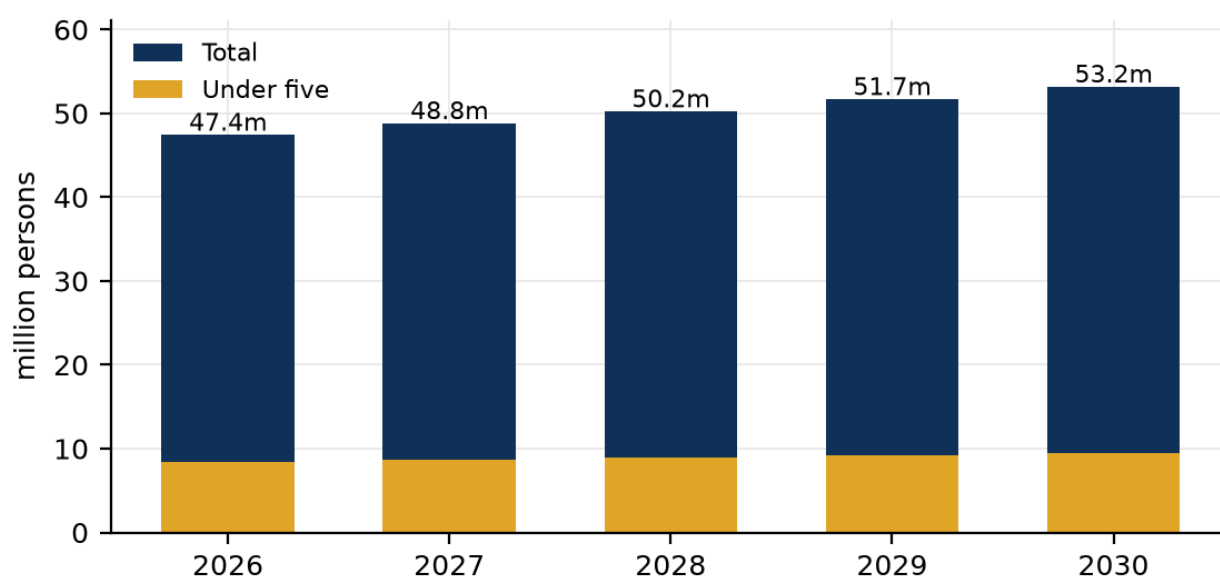


Figure 1.1: Projected population of Uganda, 2026-2030 (HM-01)

Source: HPRAS database, run uga-unconstrained-2026

Population is very unevenly spread across districts. Wakiso, with 3.01 million people, and Kampala, with 1.99 million, are by far the largest districts, followed by Arua (1.06 million), Mubende (959,000) and Kasese (930,000). At the other end, Kalangala (76,000), Ntoroko (89,000), Kween (127,000), Lyantonde (127,000) and Bukwo (129,000) are each smaller than a single urban division of the capital. This spread matters for planning. Fixed facility and staffing norms weigh more heavily per person in small districts. Volume-driven requirements, and therefore the absolute size of gaps, concentrate in the large ones. Chapter 4 sets out the projection and its age structure in detail.

1.2.2 Geography of the plan

The plan is built on the **2018 district set**: the 122 districts of the Ministry of Health's 2018 league tables. Uganda has created further districts and cities since 2018, and the current national registry lists 136 districts. Every source used here is folded onto the 2018 geography by one canonical district identifier (`scripts/uga_districts.py`). New districts are rolled up into the parent they were carved from, and cities into the district that contained them. Rolling up loses nothing for planning at the 2018 geography. Moving the plan to the current geography would need populations for the new districts, which the league tables do not provide.

Above the district sits the survey geography. The Uganda Demographic and Health Surveys and Malaria Indicator Surveys report at the level of **15 sub-regions**: Acholi, Ankole, Bugisu, Bukedi, Bunyoro, Busoga, Kampala, Karamoja, Kigezi, Lango, North Buganda, South Buganda, Teso, Tooro and West Nile. A constructed district-to-sub-region crosswalk is what lets a survey estimate reach a district. The engine therefore works at two resolutions. Population, facilities, workforce, budgets and results are held by district. Age structure, fertility, child illness, care-seeking and coverage baselines vary by sub-region. Figure 1.2 shows both layers. Uganda's land area in the district boundary set is 241,413 km².



Figure 1.2: The 15 DHS sub-regions and the 122 plan districts (2018 district set)

Source: Boundaries (c) OpenStreetMap contributors (ODbL)

1.2.3 Access

Physical access is broadly good by road and weaker on foot. On the travel-time surfaces taken from the spatial data infrastructure, 87.5% of the population lives within 60 minutes' walk of a functional facility and 98.9% within 60 minutes' drive. That still leaves about 5.28 million people beyond an hour's walk. The islands and the north-east are the weakest: Buvuma and Amudat have 36% of their population within an hour's walk, and Kalangala 42%. Chapter 7 treats access in full. It is always shown beside the gaps, never folded into them.

1.3 How the health system is organised

1.3.1 Levels of care

Uganda's health system is organised as a referral pyramid, and the engine's facility levels follow the Ministry of Health's taxonomy.

- **Community level.** Village health teams (VHTs) provide health promotion, community case management and referral. In the engine the VHT member is a workforce cadre with its own pay and available working time. The 2026 requirement includes 1,417 full-time-equivalent (FTE) VHT members for the modelled services.
- **Health Centre II (HC II).** The first facility level, serving a parish with outpatient care, antenatal care, immunisation and basic treatment. It is the most numerous level. The registry's outpatient-only clinics are counted as HC II equivalents.
- **Health Centre III (HC III).** The sub-county facility, adding maternity services, a basic laboratory and a small number of beds.
- **Health Centre IV (HC IV).** The county or health sub-district facility, which in principle adds a theatre for caesarean sections, blood transfusion and a medical officer.
- **General hospital.** The district hospital, providing inpatient care, surgery and referral support to the health centres.
- **Regional and national referral hospitals.** Specialist care for a region or for the country. The registry's national referral hospitals are folded into the engine's referral tier, because no service in the catalogue is delivered only at national level.

The MoH National Health Facility Registry lists 6,800 facilities in all: 4,101 HC IIs, 2,164 HC IIIs, 295 HC IVs, 215 general hospitals and 25 referral hospitals. The pyramid is steep. Health centres make up the overwhelming majority of service points, and the hospital tier, where most of the secondary services in the plan are delivered, is a few hundred facilities. Figure 1.3 maps the facilities that carry coordinates.

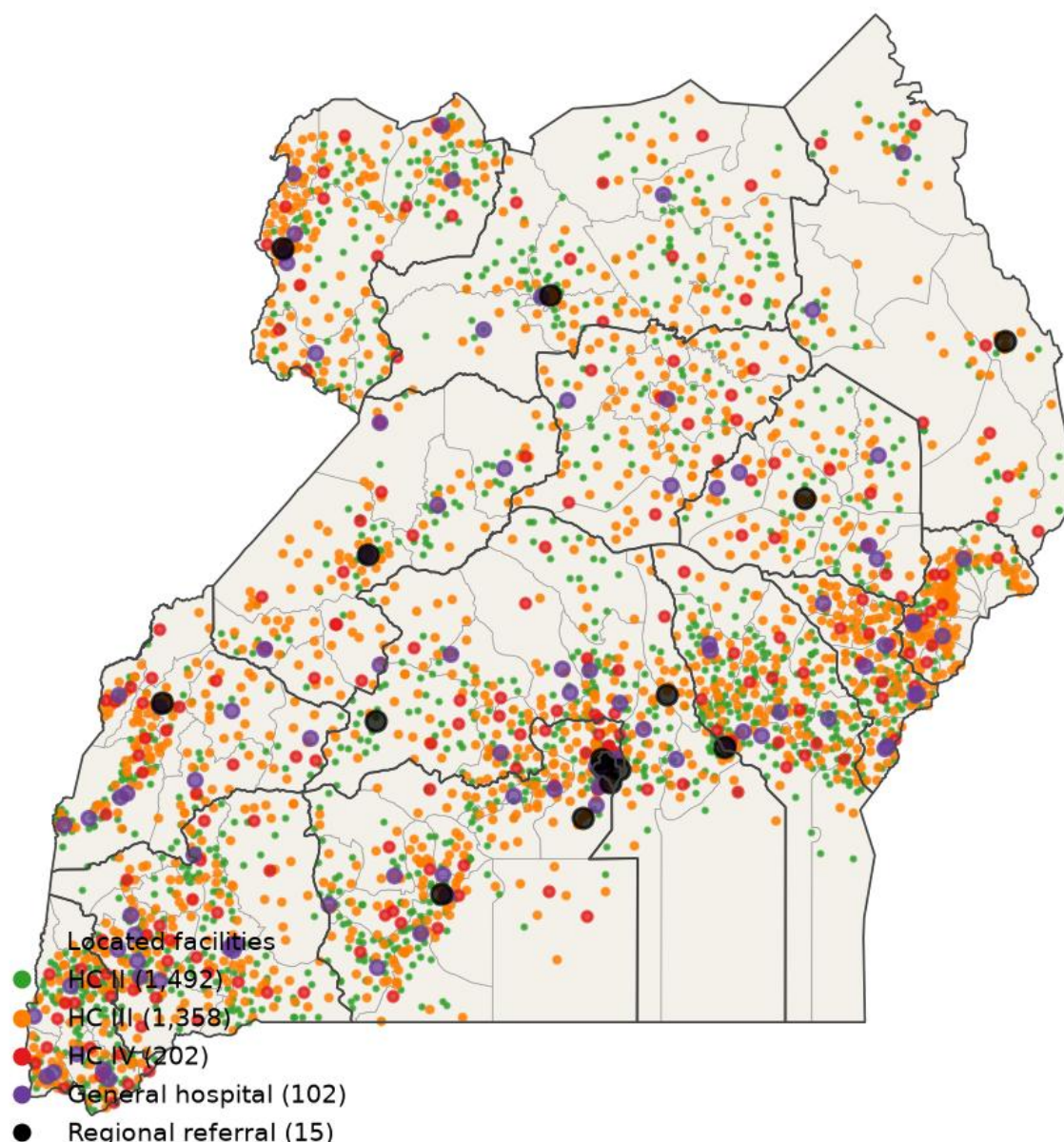


Figure 1.3: Located health facilities by level (all ownerships, operational)

Source: MoH National Health Facility Registry, geocoded by `facility_geo.py`. Boundaries (c) OpenStreetMap contributors (ODbL).

1.3.2 Ownership

Ownership is split three ways. The government owns 3,535 facilities, private-for-profit providers 2,253 and private not-for-profit (PNFP) providers, mainly faith-based, 1,012. The government is the majority owner at HC III, HC IV and referral level. Private-for-profit providers are the largest group at HC II level (1,866 of 4,101), and the PNFP sector owns the largest single share of general hospitals (83 of 215).

The engine counts the **public and PNFP network** as the capacity the plan can direct. Private-for-profit facilities are loaded into the database so that they are visible, but they are not counted as plan capacity (`scripts/load_supply.py`). This is a deliberate planning convention, not a statement that private care is unimportant. In the Malaria Indicator Survey 2024–25, public providers account for only 49.0% of the care sought for sick children nationally. For some services and places, notably Kampala, the private sector carries a large share of actual delivery. The engine picks this up through *revealed* capacity: a district cannot have less capacity than the volume it demonstrably delivers (Chapter 7).

1.3.3 Coordinates

The registry publishes no coordinates. Of the 6,800 facilities, 3,169 have been located by matching facility names within districts against the 2010 MoH facility register and OpenStreetMap (Chapter 3). Maps of facilities therefore show fewer than half the facilities in the country. District totals, and all capacity calculations, use the full registry count.

1.4 The six planning questions

The report, like the engine and its interface, is organised around six questions. They are the questions a ministry must be able to answer, with numbers to hand, to defend a sector plan and budget submission.

1. **What are the health needs?** How many people there are, by district and planning group; how much illness they experience; and how many services they therefore require (Chapters 4, 5 and 6).
2. **What do we currently have?** Facilities, staff in post, throughput capacity and physical access, and which constraint binds in each district: space, staff or observed delivery (Chapter 7).
3. **Where are the gaps?** The shortfall of service volume, workforce, commodities and facilities, district by district, each as its own dimension (Chapter 8).
4. **What will it cost?** Unit costs, the recurrent and capital requirement, and the multi-year cost to close the gap, always with capital and its induced recurrent cost shown together (Chapters 9 and 10).
5. **Where should resources go?** How a fixed incremental envelope would be distributed under six rule-based scenarios and under an optimiser, and what each distribution buys (Chapter 11).
6. **What will we achieve?** Coverage gained, deaths and disability-adjusted life years averted with their uncertainty ranges, the equity of the result, and its fiscal consequences in the medium-term expenditure framework (Chapters 12, 13 and 14).

The order of the questions is the order of the reasoning. Need comes before supply, supply before gaps, gaps before cost, and cost before allocation. A reader who wants to know "how much does health need?" is directed first to the population and the services it requires.

1.5 Scope: what is modelled and what is not

1.5.1 The 28 modelled services

The requirement covers **28 modelled services**, listed in Table 1.1. They were chosen to cover the bulk of primary-care volume and the main tracer services of the national health programmes:

- seven reproductive, maternal, newborn and child health services, from antenatal care and family planning to caesarean section and sick newborn care;
- seven childhood and adolescent immunisations, from BCG to HPV;
- five communicable disease services: malaria diagnosis and treatment, tuberculosis treatment, HIV testing, antiretroviral therapy and PMTCT;
- three non-communicable disease services: screening, hypertension management, and care for severe mental disorders and epilepsy;
- two nutrition services: community treatment of severe acute malnutrition and inpatient stabilisation of complicated cases;
- three hospital services: admissions for severe childhood illness, major non-obstetric surgery and general inpatient bed-days;
- the outpatient consultation, the largest single service by volume.

Twenty-one of the services are primary-tier and seven secondary-tier. Each service has a need basis that determines how its need is computed: universal for immunisation, births for maternal services, incidence or

prevalence for disease-specific services, a population rate for screening and family planning, episodes for outpatient care, and referral for services whose need arises from another service's volume (caesarean section, complicated SAM and inpatient bed-days).

Table 1.1: The 28 modelled services

Service	Category	Tier	Unit	Need basis	Referral
Outpatient consultation	Primary care	Primary	visit	episodes	
Antenatal care visit	RMNCAH	Primary	visit	births	
Normal delivery	RMNCAH	Primary	delivery	births	
Caesarean section	RMNCAH	Secondary	procedure	referral	yes
Pentavalent immunisation (DTP-HepB-Hib)	Immunisation	Primary	dose	universal	
Tuberculosis treatment course	Communicable	Primary	patient	incidence	
Malaria diagnosis and treatment	Communicable	Primary	case	incidence	
BCG immunisation	Immunisation	Primary	dose	universal	
Polio immunisation	Immunisation	Primary	dose	universal	
Measles-rubella immunisation	Immunisation	Primary	dose	universal	
Pneumococcal immunisation	Immunisation	Primary	dose	universal	
Rotavirus immunisation	Immunisation	Primary	dose	universal	
HPV immunisation	Immunisation	Primary	dose	universal	
Family planning	RMNCAH	Primary	user-year	population rate	
Postnatal care contact	RMNCAH	Primary	visit	births	
Severe acute malnutrition treatment	Nutrition	Primary	case	incidence	
NCD screening (blood pressure, glucose)	NCD	Primary	screen	population rate	
Hypertension management	NCD	Primary	patient-year	prevalence	
Severe childhood illness, admission	Hospital	Secondary	bed-day	incidence	
Sick newborn care	RMNCAH	Secondary	bed-day	births	
Obstetric complications (non-surgical)	RMNCAH	Secondary	bed-day	births	
Complicated SAM, inpatient stabilisation	Nutrition	Secondary	bed-day	referral	yes
Major surgery (non-obstetric)	Hospital	Secondary	procedure	population rate	
Severe mental disorders and epilepsy care	NCD	Primary	patient-year	prevalence	
HIV testing and counselling	Communicable	Primary	test	population rate	
Antiretroviral therapy	Communicable	Primary	patient-year	prevalence	
Prevention of mother-to-child transmission	Communicable	Primary	patient	births	
Inpatient bed-day	Hospital	Secondary	bed-day	referral	yes

Service catalogue of norm version UGA-2026-v1. Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_services.csv).

1.5.2 What lies outside the requirement

Several things are outside the scope of the requirement, and the reader should keep them in mind whenever the requirement is set against a budget.

- **Services not in the catalogue.** Stand-alone diagnostics (laboratory, imaging, histopathology), most specialist and tertiary care, emergency and trauma care beyond the modelled surgery, eye, dental and rehabilitative services, and much of non-communicable disease care beyond hypertension are not modelled.
- **System and support functions.** Supportive supervision, health information systems, supply chain management, district and national administration, maintenance and in-service training are not modelled as services. The engine's reference catalogue notes that their omission is why bottom-up costings routinely come in 15–25% below actual expenditure (docs/16_REFERENCE_CATALOGUES.md).

- **Functions that belong to other models.** Epidemiological transmission modelling, survey estimation, unit-price estimation, macro-fiscal envelope determination and general-equilibrium effects sit in sibling EDIP models (HealthModelling, UnitCostModelling, FINEX and CDCGE). HPRAS consumes their outputs or feeds them; it does not replicate them.

The budget, by contrast, covers everything: all services, all institutions, administration, capital projects, arrears and externally financed programmes. The requirement for the modelled services is therefore 43% of the approved FY2025/26 health budget of 4,614 bn UGX. That ratio is **read, not closed**. It does not mean the health budget is more than twice what is needed; it measures how much of the budget the modelled services account for at the target coverage. Chapter 13 sets out the reconciliation line by line.

1.6 Principles

The analysis follows ten design principles fixed in the engine's scope document (docs/00_SCOPE_AND_PRINCIPLES.md). Five of them shape what the reader will see in every chapter.

- **Needs first, money last.** The chain runs from population to cost; a budget is introduced only when resources have to be allocated.
- **Norms are data, not code.** Every coefficient, from staff minutes per consultation to wastage on a vaccine vial, lives in a versioned norms table with a source and a year. None is hard-coded in the engine's equations.
- **No composite index.** Gaps are reported as four separate dimensions — service, workforce, commodity and facility — and access is shown beside them. A district short of nurses is in a different situation from one short of theatres, and a planner cannot act on an average of the two.
- **Capital always has its induced recurrent cost beside it.** Every capital figure is accompanied by the recurrent obligation it creates: staff, maintenance, utilities and consumables. A plan that builds with capital it cannot later staff or run is a false economy, and the medium-term framework must carry that cost.
- **Scenarios are compared, not scored.** No allocation is described as recommended, best, preferred or optimal. The optimiser is described for what it is: the allocation that maximises lives saved on its stated objective. Deaths averted are always reported with their range, never as a point estimate.

The other principles are just as binding. Capacity is computed as throughput rather than from population ratios. Geography is a first-class dimension, so national totals are sums of district results. Feasibility constraints on recruitment and construction are real constraints. The health plan is a government plan that must become a programme budget and a medium-term expenditure framework (MTEF) submission.

1.7 How to read the report

1.7.1 The planning identity

Almost every figure in the chain from need to cost is one application of a single identity, evaluated service by service, district by district and year by year:

$$X_{s,d,t} = \sum_r P_{g(s),d,t} \times \iota_{s,d,t} \times C_{s,t}^* \times \nu_s \times \eta_{r,s} \times \sigma_{r,s} \times (1 + \omega_{r,s}) \times p_r \quad (1.1)$$

where

- X is the cost of service s in district d and year t ;
- P is the population of the eligible group $g(s)$;
- ι is the need rate (incidence, prevalence, a population rate, or 1 for universal services);

- C^* is the target coverage;
- v is the number of units of service per person needing it (doses, visits, bed-days);
- η , σ and ω are the quantity of resource r per unit of service, the share of cases that use it and its wastage;
- p is the unit price of resource r .

Chapter 2 sets out each step. Whenever a figure looks surprising, this identity is the first place to look for the explanation.

1.7.2 Quality tiers

Every input carries a quality tier, and every result inherits the **worst** tier among its inputs. In ascending order of doubt:

Tier	Meaning
measured	an administrative or survey observation for this district and year
normed	a published standard or guideline value applied
imputed	derived from a related observation by a stated method (another year, a sub-region, a similar district)
assumed	planning judgement with no direct empirical basis, awaiting review

Tables and maps carry these tiers wherever they are material. The tiers are a reading instruction: a figure marked **assumed** is a placeholder for a value that still has to be established. The norm version used here, UGA-2026-v1, is a **draft** that has not yet been through clinical review. No norm-dependent figure in this report should be treated as an approved standard.

1.7.3 Conventions

- **Plan year.** "2026" means FY2025/26, the financial year that ends in 2026. The horizon 2026–2030 therefore runs from FY2025/26 to FY2029/30 and aligns with the NDP IV planning period.
- **Currency.** Amounts are in Uganda shillings (UGX), usually in billions (bn UGX). Where a reader expects dollars, amounts are converted at the plan rate of 3,700 UGX per USD. All money is in constant 2026 prices unless a table says otherwise.
- **Rounding.** Money is rounded to the nearest bn UGX, or to 0.1 bn below 10 bn; people to the nearest thousand, or to one decimal place in millions; percentages to one decimal place. Totals may therefore differ slightly from the sum of rounded parts.
- **Units of service.** Each service has its own unit (visit, dose, delivery, case, patient-year, bed-day, test, screen, procedure), shown in Table 1.1. Service volumes are never added across services with different units. Workforce is in FTE, computed from staff minutes and the available working time of each cadre.
- **Run identifiers.** All results come from plan run `uga-unconstrained-2026`, which pins the norm version UGA-2026-v1, the price vintage UGA-2026Q1 and the target set UGA-NDP-ILLUSTRATIVE. As its name says, the target set is an illustrative NDP-style coverage trajectory, not an adopted national target. Changing the targets changes the requirement proportionally, service by service.
- **Envelope.** No live envelope has been received from the FINEX fiscal model. Allocation figures are computed against the approved increase in the health budget between FY2025/26 and FY2026/27 for the institutions that deliver the modelled services. No figure in this report is a FINEX result (Chapter 18).

1.8 Structure of the report

The report follows the chain of the engine, module by module, and then turns to cross-cutting analysis and institutional use.

- **Chapter 2, Approach and architecture**, sets out the planning chain HM-01 to HM-10, the data model, the planning identity, quality tiers, gates and reproducibility.
- **Chapter 3, Data sources, governance and quality**, describes every source, its licence and its known gaps.
- **Chapter 4, Population and demography (HM-01)**, projects the district population and its planning groups.
- **Chapter 5, Disease burden and health needs (HM-02)**, converts population into persons needing each service, including small-area estimation of survey indicators.
- **Chapter 6, Service demand and resource requirement (HM-03)**, converts need into required volumes, resources and workforce by the WISN method.
- **Chapter 7, Supply, capacity and physical access (HM-04)**, measures what exists and what binds.
- **Chapter 8, Health gaps (HM-05)**, sets out the four gap dimensions by district.
- **Chapter 9, Costing (HM-06)**, prices the requirement and the gap.
- **Chapter 10, Investment and workforce plan (HM-07)**, turns gaps into sites, recruitment and phasing, with induced recurrent costs.
- **Chapter 11, Resource allocation scenarios (HM-08)**, compares six rule-based scenarios and the optimiser under the incremental envelope.
- **Chapter 12, Health outcomes (HM-09)**, estimates deaths and DALYs averted, with ranges.
- **Chapter 13, Budget, MTEF and fiscal space (HM-10)**, sets the requirement against the approved budget, execution and the medium-term framework.
- **Chapter 14, Equity**, examines wealth, residence and geography.
- **Chapter 15, Spatial analysis and the GIS atlas**, tests for clustering in every mapped layer.
- **Chapter 16, Survey trends, small-area evidence and external cross-checks**, compares the engine with HealthModelling and UnitCostModelling aggregates.
- **Chapter 17, Calibration and validation**, reports the tests, gates and cross-checks.
- **Chapter 18, Integration with national systems**, describes the exchange interfaces, the interface and institutional use.
- **Chapter 19, Conclusions, limitations and next steps**, draws the analysis together.

Four annexes complete the report: **Annex A** is a compendium of every formula; **Annex B** holds the reference catalogues of services, cadres, prices, unit costs and time norms; **Annex C** gives district statistical tables for every module; and **Annex D** is a glossary of terms and abbreviations.

1.9 Implications for planning

The requirement in this report is a planning instrument, not a bid. It says what 28 services cost at stated targets with stated norms. Its value lies in the fact that each of those statements can be changed and the consequence traced. Ministries and development partners should use it to test targets and norms against each other, not to argue for a budget total.

The scope of the requirement should frame every comparison with the budget. A requirement that covers 43% of the approved health budget reflects what is modelled, not a surplus in the sector. As the catalogue is extended to diagnostics and to system and support functions, the ratio will rise. The most useful comparisons are therefore line by line — salaries, medicines, capital, primary care, hospitals — which Chapter 13 provides.

The district, not the nation, is the unit of the plan. Uganda's population ranges from 76,000 in Kalangala to more than 3 million in Wakiso, and its survey evidence varies strongly across the 15 sub-regions. National averages hide exactly the variation that allocation decisions must address. Every chapter therefore reports district results and maps.

Finally, the quality tiers should be read as a work plan. The weakest inputs, marked *imputed* or *assumed*, are identified throughout: the draft norms, the missing equipment and stock data, the absence of a human resource information system extract, and the illustrative targets. Each is a specific data request or review task. Chapter 19 lists them in order of their effect on the results.

CHAPTER 2

2 Approach and architecture

This chapter explains how the numbers in the report are produced. It matters because a planning figure is only as defensible as the chain of reasoning behind it. A Ministry of Finance analyst who is told that Uganda needs 1,966 bn UGX in 2026 for 28 services should be able to ask *why that much* and get an answer that goes down to a population, a need rate, a coverage target, a norm and a price. The engine behind this report, the Health Planning and Resource Allocation System (HPRAS), was designed around that requirement. This chapter describes its architecture, the planning identity at its core, the way data are organised and governed, the gates that stop a run rather than let it produce a misleading number, and the interface through which ministries use it.

2.1 A needs-based planning chain

2.1.1 From research questions to a planning question

Health modelling in Uganda has mostly answered descriptive and predictive questions: what child mortality is, what drives it, what it will be in 2030. HPRAS answers a normative question instead. How many services does the population require, what does delivering them take, what already exists, what is missing, what does the difference cost, and, given the money actually available, where should it go? The design consequence is summarised in the engine's first principle: **needs first, money last**. The chain starts from people, not from last year's budget grown by inflation or from a share of GDP. Money appears as an output of the chain, and becomes a binding constraint only when a fixed envelope has to be allocated.

2.1.2 The ten modules

The engine is organised as ten computational modules, HM-01 to HM-10, executed in dependency order (Table 2.1). Each writes its own result tables and reads only the results of modules earlier in the chain, together with the reference and norm tables. The single exception is a bounded loop between allocation (HM-08), the budget (HM-10) and the external fiscal model FINEX, described below.

Table 2.1: The ten modules of the planning chain

Module	Name	Question it answers	Implemented in
HM-01	Population and demography	Who is there, by district, planning group and year	src/NeedsChain.jl
HM-02	Disease burden and health needs	How many people need each service	src/NeedsChain.jl, scripts/derive_dhs_rates.py
HM-03	Service demand	How many services are required, and what resources and staff they imply	src/NeedsChain.jl, src/HealthPlanning.jl
HM-04	Supply	What facilities, staff and throughput capacity exist, and what binds	src/SupplyGaps.jl
HM-05	Gaps	Where need exceeds supply, in each dimension separately	src/SupplyGaps.jl
HM-06	Costing	What the requirement and the gap cost, recurrent and capital	src/SupplyGaps.jl, src/HealthPlanning.jl
HM-07	Investment and workforce	What must be built and recruited, and its induced recurrent cost	src/Allocation.jl

Module	Name	Question it answers	Implemented in
HM-08	Resource allocation	Where a fixed envelope should go under each rule, and under the optimiser	src/Allocation.jl, src/Optimise.jl
HM-09	Outcomes	What coverage, deaths and DALYs the allocation buys	src/Outcomes.jl
HM-10	Budget and MTEF	The plan as a programme budget and medium-term framework	src/Budget.jl

HM-01 to HM-07 produce the **unconstrained requirement**: what is needed. HM-08 produces the **constrained plan**: what can be done with the money available. Both are kept and reported side by side, because the difference between them is the financing gap, one of the most important results of the system. Around the ten modules sit cross-cutting services: provenance (`explain()`), reporting and narrative (`src/Report.jl`), ministry workbooks (`src/Exports.jl`), GIS and spatial statistics (`src/GIS.jl`), small-area estimation and trends (`src/SmallArea.jl`, `src/Trends.jl`), external cross-checks (`src/CrossChecks.jl`) and the exchange interfaces (`src/Integration.jl`).

2.1.3 The fiscal loop

The chain is not strictly one-way at its end. HM-10 emits a health expenditure requirement to FINEX, FINEX returns an envelope, and HM-08 re-allocates under it. Because a larger health wage bill can change the macroeconomic picture and hence the envelope, the engine documentation bounds the loop: at most five iterations, convergence when the envelope moves by less than 0.5% between iterations, and an explicit report of oscillation rather than a silent last iterate. No FINEX envelope is available for this report, so the loop runs a single pass against an envelope taken from the approved budget. The engine flags this in every output (Chapter 18).

2.2 The planning identity

HM-01 to HM-06 are a single identity, applied service by service, district by district and year by year. It is written here in its component steps, each of which the engine computes and stores separately.

2.2.1 Need

$$N_{s,d,t} = P_{g(s),d,t} \times \iota_{s,d,t} \quad (2.1)$$

where

- N is the number of persons (or episodes) needing service s in district d and year t ;
- P is the projected population of the service's eligible group $g(s)$ (for example children under one, women aged 15–49, pregnancies, adults 40 and over);
- ι is the need rate: incidence, prevalence or a population rate, or 1 for universal services such as immunisation.

The need rate is resolved district-first. An observed district rate beats a sub-regional one, which beats the national value, and the quality tier records which was used. Need for referral services (caesarean section, complicated severe acute malnutrition, inpatient bed-days) is deferred to HM-03, because it depends on the volume of the parent service.

2.2.2 Required volume

$$Q_{s,d,t} = N_{s,d,t} \times C_{s,t}^* \times \nu_s \quad (2.2)$$

where

- Q is the required volume in the service's own unit (visits, doses, deliveries, bed-days);
- C^* is the target coverage from the pinned target set;
- v is the number of units per person needing the service: four for a four-visit antenatal schedule, three for a three-dose vaccine, and the average length of stay for an admission counted in bed-days.

Coverage means complete receipt of the service. Partial coverage is modelled as a lower C^* , never a lower v ; mixing the two would double-count in the resource arithmetic. The volume is then split across facility levels by a normative level mix μ :

$$Q_{s,d,l,t} = Q_{s,d,t} \times \mu_{s,l} \quad \text{with} \quad \sum_l \mu_{s,l} = 1 \quad (2.3)$$

where l indexes the facility level (HC II, HC III, HC IV, general hospital, referral hospital). The mix states where a service *should* be delivered; HM-05 tests it against what exists. For a referral service c with parent service $p(c)$ and referral rate ρ , need is derived from the parent's volume:

$$N_{c,d,t} = Q_{p(c),d,t} \times \rho_c \quad (2.4)$$

2.2.3 Resource requirement: the bill of materials

Each service at each level has a **bill of materials**: a list of every resource it consumes, with a quantity per unit of service. The required quantity of resource r is

$$R_{r,s,d,l,t} = Q_{s,d,l,t} \times \eta_{r,s,l} \times \sigma_{r,s,l} \times (1 + \omega_{r,s,l}) \quad (2.5)$$

where

- η is the quantity of resource r per unit of service (minutes of a cadre's time, doses, tablets, tests, bed-days of space);
- σ is the share of cases that use the resource (for example, the fraction of deliveries that need oxytocin for postpartum haemorrhage);
- ω is the wastage or loss factor for the resource.

Wastage sits on the resource line, not on the service volume. A spoiled vaccine vial costs a dose of vaccine but does not cost nurse-minutes, and the engine's test suite checks this against the worked immunisation example in the manual.

2.2.4 Cost

$$X_{s,d,t} = \sum_l \sum_r R_{r,s,d,l,t} \times p_r \quad (2.6)$$

where p is the unit price of resource r in the pinned price vintage, in constant 2026 UGX. Staff are priced per minute, derived from monthly basic pay, an allowance multiplier and the cadre's available working time. Because norm lines for staff are in minutes, minutes $\times$ UGX per minute needs no conversion anywhere in the engine. Each resource carries a cost class, recurrent or capital, so every cost is split before it is ever totalled.

2.2.5 Workforce: from minutes to FTE

Staff requirements follow the WHO Workload Indicators of Staffing Need (WISN). The available working time of an FTE in cadre c is

$$AWT_c = (D_c - L_c) \times h_c \times 60 \times (1 - a_c) \quad (2.7)$$

where

- D is contracted working days per year;
- L is days lost to leave, public holidays, training and absence;
- h is hours per working day;
- a is the category allowance, the share of working time spent on non-service work such as meetings, records and supervision.

For a clinical cadre in the norm version, 261 working days less 49 days lost, at 8 hours a day with a 25% allowance, gives 76,320 minutes per FTE-year (Annex B, t_{cadres}). The FTE requirement is then the total minutes the bills of materials demand of that cadre, divided by its available working time:

$$\text{FTE}_{c,d,t} = \frac{\sum_s \sum_l R_{c,s,d,l,t}}{\text{AWT}_c} \quad (2.8)$$

Omitting the category allowance is, in the words of the engine's code, the commonest workforce-planning error in the sector. It understates staffing by the size of the allowance.

2.2.6 Capacity and gaps

Supply is treated as throughput capacity, not as a population ratio. For each service, district and level the engine computes a space-limited and a staff-limited capacity and takes the smaller:

$$K_{s,d,l} = \min \left(K_{s,d,l}^{\text{space}}, K_{s,d,l}^{\text{staff}} \right) \times \phi_d \quad (2.9)$$

where

- K^{space} is facilities $\times$ service points $\times$ throughput per day $\times$ operating days, with rooms, beds and theatres treated as separate pools and shared across the services that use them;
- K^{staff} is staff in post $\times$ available working time $\times$ the share allocated to the service $\div$ the time norm;
- ϕ is a district readiness factor.

The identity of the binding constraint (space or staff) is stored, because it tells a planner whether a district needs buildings or people. A district cannot have less capacity than it demonstrably delivers. Where observed coverage implies a larger volume than the normed throughput, capacity is raised to this **revealed** level and the binding constraint is recorded as **revealed**. The service gap is the difference between requirement and capacity:

$$G_{s,d,t} = Q_{s,d,t} - K_{s,d,t} \quad (2.10)$$

A positive G is a shortfall and a negative G a surplus. Surpluses are kept rather than clamped at zero, because spare capacity in one district matters for reallocation. The same logic produces the workforce gap in FTE, the commodity gap in money and the facility gap in facility-equivalents. The four dimensions are stored in separate columns of the district gap matrix and are never combined.

2.2.7 Beyond the identity: allocation, outcomes and the budget

The later modules apply further, explicit rules, each of which is stated in the chapter that reports it.

Allocation (HM-08). Each rule-based scenario spreads the incremental envelope by a weight. For scenario E, geographic equity, the weight of a district-service is its population times its coverage deficit raised to an equity exponent γ , which defaults to 1.5; a γ above one concentrates money on the largest deficits. The optimiser solves a linear programme. It maximises a stated objective (unmet need closed, lives saved, or an equity-weighted version) subject to the envelope, to the requirement as a ceiling on each district-service, and to district absorptive capacity. Coverage floors are soft with a large penalty, so an infeasible plan appears as a finding rather than a solver failure.

Outcomes (HM-09). Deaths averted follow the Lives Saved Tool form, in which services acting on the same outcome j combine multiplicatively:

$$\Delta_j = 1 - \prod_s (1 - AF_{s,j} \times E_{s,j} \times \Delta c_s) \quad (2.11)$$

where

- Δ is the proportional reduction in outcome j ;
- AF is the fraction of the outcome that service s can address;
- E is the efficacy of the service at full coverage;
- Δc is the coverage change the allocation buys.

The optimiser needs a linear objective and uses the sum of the terms instead of the product; the engine computes and reports the difference between the two forms on every run. Every effectiveness parameter carries a published confidence interval, and deaths averted are reported only with the resulting range.

Budget and MTEF (HM-10). The requirement is expressed in three views, programme, economic and administrative, and the engine asserts that they reconcile. The medium-term framework for year t is built as

$$M_t = X_t^{rec} + \theta \times \Sigma_{t-1}^{new} + W_t \times ((1 + \delta)^{t-t_0} - 1) + X_t^{cap} \quad (2.12)$$

where

- X^{rec} and X^{cap} are the recurrent and capital requirement in year t ;
- Σ^{new} is the cumulative new capital commissioned before year t ;
- θ is the induced recurrent share;
- W is the wage bill and δ the annual salary drift from staff moving up increments;
- t_0 is the base year.

2.3 Three tiers of data: norms, observations and results

The data model separates three kinds of information, and the separation is what lets the engine be both generic and reproducible.

2.3.1 The norms tier

The norms tier holds every technical coefficient the chain uses: the service catalogue, the bills of materials, level mixes, capacity standards, WISN parameters for each cadre, coverage targets, effectiveness parameters and fiscal parameters. The engine's second principle is that **norms are data, not code**. No equation in the source code contains a country coefficient. Adding a drug to a treatment protocol is a new row in a table, not a change to the engine.

The central structure is a header-and-lines design. A `service_norm` header row exists for each service, facility level and norm version. It carries the unit, the total contact time, the throughput per service point per day and the referral rate. Beneath it, the `service_norm_line` table holds the bill of materials: one row per resource, with quantity η , share of cases σ , wastage ω , cost class, source, source year and quality tier. This is the same shape as a manufacturing bill of materials. It is needed because a normal delivery uses a midwife *and* a nurse, oxytocin *and* chlorhexidine *and* gloves *and* a delivery kit, each with its own quantity, wastage and price, and because the package differs between an HC III and a hospital.

Norms are resolved by a **most-specific-match** rule: a district-specific norm beats an urban or rural one, which beats the national norm. If nothing matches, the engine raises an error rather than returning zero. Coverage

targets are held apart from the norms, because targets are political and norms technical, and they are revised on different cycles.

The fiscal parameters of the norm version are shown in Table 2.2. Only two enter the computation. The **induced recurrent share** of 0.15 is the recurrent obligation each unit of new capital creates every year. The **salary drift** of 0.025 is the annual growth in the wage bill from staff moving up salary increments, which a wage bill grown only by inflation would miss. The remaining parameters are benchmarks used only for reconciliation and cross-checks, and the requirement never reads them:

- the FY2025/26 health budget of 4,591 bn UGX and on-budget external financing of 1,371 bn UGX, both from the UNICEF Uganda Health Sector Budget Brief FY2025/26;
- that brief's shares of the budget: 29% salaries, 16% medical commodities, 27% primary health care, 20% hospitals and 38% policy, regulation and ministry-managed programmes;
- per capita health spending of 27 USD;
- total government expenditure of 72,900 bn UGX and GDP of 220,000 bn UGX, used as denominators.

Table 2.2: Fiscal parameters of the norm version

Parameter	Value
induced_recurrent_share	0.1500
salary_drift	0.0250
govt_expenditure_lcu	72,900,000,000,000
bench_health_budget_lcu	4,591,000,000,000
bench_external_lcu	1,370,800,000,000
bench_share_salaries	0.2900
bench_share_commodities	0.1600
bench_share_phc	0.2700
bench_share_hospitals	0.2000
bench_share_policy	0.3800
bench_per_capita_usd	27
gdp_lcu	220,000,000,000,000

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_fiscal_params.csv).

2.3.2 The observations tier

The observations tier holds what has been measured: district populations, need rates and coverage baselines derived from surveys, the facility registry, the derived workforce in post, HMIS inpatient deaths, approved budgets and expenditure, and the aggregates vendored from HealthModelling and UnitCostModelling. Every observed row carries its source, its source year and its quality tier. Loaders in `scripts/` do all harmonisation of codes, units, district identifiers and fiscal years. The compute modules never harmonise, because harmonisation hidden inside a calculation cannot be seen or tested. Chapter 3 describes each source.

2.3.3 The results tier

Every computed table is keyed by a `run_id` as its leading column: population projection, service need, service demand, resource requirement, workforce requirement, capacity, gaps, cost, allocation, outcome and GIS layers. The plan run behind this report computed 7,320 population rows, 17,080 need rows, 61,000 demand rows, 247,050 resource rows and 9,150 workforce rows in 28.6 seconds. The supply, gap and cost stage then wrote 61,000 capacity rows, 17,080 service-gap rows, 62,830 resource-gap rows and 304,062 cost rows in 33.7 seconds. Results are never overwritten across runs; a new run is a new `run_id`.

2.3.4 Storage

The canonical schema is written as forward-only PostgreSQL migrations (`database/migrations/`); the engine runs here on a SQLite working copy, the offline mode the manual specifies for single-user and field use. `scripts/rebuild_all.py` rebuilds it from source in a fixed order, so that the norms tier and the loaders always move together.

2.4 Reproducibility

Every result belongs to a **plan run**, and every run pins the things that could change its numbers:

Pin	Value in this report
Run identifier	uga-unconstrained-2026
Country and base year	UGA, 2026
Horizon	2026–2030
Geography version	UGA-HMIS-2018 (the 122 districts of the 2018 league tables)
Norm version	UGA-2026-v1
Price vintage	UGA-2026Q1
Target set	UGA-NDP-ILLUSTRATIVE

The pins are written to a `run_manifest` table together with a hash of the pinned configuration and the creator of the run. The reproducibility contract is that **two runs with identical pins produce identical numbers**, and the test suite checks it. Pinning also lets a ministry defend a published plan later. When the norms are revised, the revision is a new norm version, and a run pinned to UGA-2026-v1 still reproduces the figures in this report.

The norm version carries a status: draft, proposed, approved, superseded or rejected. Approved versions are immutable, and edits fork a new draft. UGA-2026-v1 is a **draft**. Its norms come from published standards and first-pass encoding and have not been through the service-by-service clinical review the manual requires before approval.

2.5 Gates: failures that are fatal

A planning model loses credibility fastest when it produces a plausible-looking number that is wrong. The commonest way to do that is to cost a missing norm or price at zero. HPRAS is built to fail loudly instead. The engine manual defines seven pre-run gates (Table 2.3).

Table 2.3: Pre-run data quality gates

Gate	Condition that aborts the run
G1	A service with a non-zero required volume lacks a resolvable norm (bill of materials)
G2	A required resource lacks a price in the run's price vintage
G3	The facility census covers less than a configured share of known facilities
G4	The population projection is missing for a district-year in the horizon
G5	Two input datasets are on different geography versions
G6	The coverage target set is incomplete for a service in the basic package
G7	The norm version is not approved and the run is not flagged as exploratory

Gates G1 and G2 matter most, and they are coded as pre-run gates in `validate_norms`, together with a check that every service's level mix sums to one. If any fails, `scripts/run_plan.jl` prints the failures and exits without computing. The run behind this report passed all three. Two error types enforce the same rule inside the computation: `NormNotFound` and `PriceNotFound` are raised whenever a norm or price cannot be resolved, and they are never caught as a zero. The other conditions are handled structurally. A run with no base population raises an

error. Every source is folded onto the single 2018 district identifier before it is loaded. Because the norm version is still a draft, this run is exploratory in the sense of G7, and the reports generated from it say so.

Several further checks run after the computation and are treated as gates on the model's internal consistency:

- **The optimiser gate.** The optimiser must match or beat the best rule-based scenario on its own objective, or the model is mis-specified. In this run it averts 20,053 deaths against 15,010 for the best rule, and the gate passes.
- **The linearisation check.** The linear objective used by the optimiser and the multiplicative form used for reporting differ by 5.9%, within the 10% tolerance set in the manual.
- **The budget reconciliation.** The programme, economic and administrative views of the budget all total 1,966 bn UGX for 2026, with a maximum difference of 0.0017 UGX.

Cross-checks are a separate category and are never used as a method. The engine compares its results with external benchmarks after the computation: the wage bill share of recurrent cost, the primary-care share, per capita cost in USD, and the UnitCostModelling and HealthModelling aggregates. A cross-check outside its expected range is reported with a reason. It prompts a review of the norms and never an automatic rescaling. In this run the primary-care share of 79.4% lies above the expected 35–60% range. The report flags this as a property of a catalogue in which 21 of the 28 services are primary-tier, not as a finding about Uganda.

2.6 Quality tiers and their propagation

Every input datum carries one of four quality tiers, ordered from most to least reliable:

Tier	Meaning
measured	an administrative or survey observation for this district and year
normed	a published standard or guideline value applied
imputed	derived from a related observation: another year, a sub-region, a similar district, a modelled surface
assumed	planner judgement with no empirical basis, awaiting review

A result inherits the **worst** tier among its inputs:

$$q(y) = \max_i q(x_i) \quad \text{with} \quad \text{measured} < \text{normed} < \text{imputed} < \text{assumed} \quad (2.13)$$

where $q(y)$ is the tier of a result y computed from inputs $x_1 \dots x_n$, and the maximum is taken in the order of severity shown. Three examples from HM-01 to HM-03 show how this works in practice:

- A district's population group is *measured* where the district's DHS sub-region supplies the age share, and *imputed* where the national share is used instead.
- The need for a service takes the worse of its population's tier and its need rate's tier.
- Referral needs, which depend on a referral rate, are *assumed* until the rates are reviewed.

The reduction is done in the declared order of severity, never alphabetically, so a district is never presented as better evidenced than its inputs allow. The manual adds a display rule: any national aggregate with more than 30% of its inputs *assumed* must carry a warning.

The tiers are not a ranking of the analysts' confidence. They are a property of the data, computed by the engine, and they show on every figure in the report's tables, in the web application and in the ministry workbooks, where each workbook carries a quality-tier legend.

2.7 Provenance: the explain() decomposition

The seventh principle requires that any figure on any screen be explainable as *this population × this need rate × this coverage target × this norm × this price*, with the source and year of each factor. HPRAS implements this as a function, `explain`, not as documentation. Given a run, a district, a service and a year, it returns two things.

1. **The volume factors:** the population of the eligible group and its tier; the need rate and its basis; the persons needing the service; the target coverage; the units per case; and the resulting required units. The planning identity of Equation (2.1) and Equation (2.2) is visible in the output, not merely asserted elsewhere, and a test checks this.
2. **The bill of materials:** for each facility level, every resource line with its quantity, share of cases, wastage, effective quantity, unit price, line cost, cost class, norm source, norm quality, price source and price quality.

The unit cost of a service at a level is therefore the sum of its lines,

$$u_{s,l} = \sum_r \eta_{r,s,l} \times \sigma_{r,s,l} \times (1 + \omega_{r,s,l}) \times p_r \quad (2.14)$$

and the district cost is $u \times Q$ summed over levels. The manual sets a performance target of 200 milliseconds for one decomposition. The command line (`hpras explain --run <id> --cell <district>:<service>:<year>`) and the web application both report the time taken. A companion function, `run_diff`, compares two runs service by service and ranks the changes. It is the tool for answering "what changed, and why" after a norm revision or a change of targets.

2.8 The six-question interface

The engine's outputs are organised around the six planning questions of Chapter 1, and so are its application, its reports and this report. Table 2.4 maps each question to the modules that answer it and the outputs that carry the answer.

Table 2.4: The six planning questions and where they are answered

Question	Modules	Main outputs	Chapters
1 What are the health needs?	HM-01, HM-02, HM-03	population by group; persons needing; required volumes, resources and FTE	4, 5, 6
2 What do we currently have?	HM-04	facilities, staff in post, capacity with its binding constraint, access	7
3 Where are the gaps?	HM-05	district gap matrix in four separate dimensions, with access beside it	8
4 What will it cost?	HM-06, HM-07	unit costs; recurrent and capital requirement; cost to close; induced recurrent	9, 10
5 Where should resources go?	HM-08	six rule-based scenarios and the optimiser, shown together, none ranked	11
6 What will we achieve?	HM-09, HM-10	coverage, deaths and DALYs averted with ranges, equity, MTEF and fiscal space	12, 13, 14

The manual's acceptance test for the whole system is that a user who has not seen it before can get a defensible answer to all six questions for one country in under ten minutes, and can trace any number on any screen to its sources. Chapter 18 describes the application, the command line and the ministry workbooks that deliver this.

2.9 Testing

The engine carries 776 tests, organised in the five layers the manual specifies: unit tests of pure functions against worked examples; identity tests that the planning identity holds for every service, including the manual's immunisation example; property tests such as "raising a coverage target never reduces volume or cost"; gate tests that a missing norm or price raises an error, and that no composite score column exists anywhere in the database; and plausibility tests, which are reported but not fatal. Further test sets cover each module, the DHS evidence, the optimiser gate, the budget reconciliation and the vendored references. Chapter 17 reports the results.

2.10 Limitations of the approach

The architecture guarantees traceability and internal consistency; it cannot guarantee that the inputs are right. Four limitations follow from the design and should be kept in view throughout the report.

- **Arithmetic is exact; norms are not.** The requirement is exactly as good as the bills of materials, time norms, level mixes and prices in the draft norm version. Staff time norms are the largest single driver of cost, and they have not yet been clinically reviewed.
- **The catalogue is partial.** The chain costs 28 services. System and support functions and stand-alone diagnostics are outside it, so the requirement is not a sector total.
- **Capacity is only as good as the supply data.** There is no equipment inventory, no stock data and no human resource information system extract, so capacity rests on registry counts, derived establishment and revealed delivery (Chapters 3 and 7).
- **The fiscal loop is open.** Without a live FINEX envelope, allocations are computed against the approved budget increase and cannot be presented as the result of a macro-fiscal model.

2.11 Implications for planning

The value of a needs-based chain lies in its traceability. A ministry that adopts its figures also adopts a way to challenge them: any requirement can be decomposed into its factors, and any factor can be changed, versioned and re-run with its consequence visible. Budget discussions can then move from contested totals to specific norms, targets and prices, which are the things policy can actually change.

The draft status of the norm version is the most important caveat on every figure in the report. The next step is institutional rather than technical: the Ministry of Health's clinical programmes should review the bills of materials and time norms service by service, record every change with its justification, and approve a norm version. Until then, the figures are a transparent first estimate, not a standard.

The separation of targets from norms should be used deliberately. The target set in this run is illustrative. Substituting the NDP IV targets, or alternative trajectories, is a data change that the engine propagates through every module. This is the most direct way for planners to see what a political commitment on coverage costs, in money, staff and facilities, district by district.

CHAPTER 3

3 Data sources, governance and quality

The arithmetic of the planning chain is simple and can be checked by hand. Its inputs cannot. This chapter describes every data source the plan rests on: what it supplies, which module it feeds, how it was obtained and processed, under what licence, and with what quality tier. It also sets out the governance rules the engine applies to licensed and personal data, and the gaps that no source currently fills. These gaps are not footnotes. The absence of an equipment inventory, of commodity stock data and of a human resource information system extract shapes several of the results in later chapters, and planners need to know where those results stand on evidence and where on assumption.

The chapter follows the chain: population first, then the survey evidence on need and coverage, routine health information, the facility registry and its geography, the national budget, prices and norms, and the external aggregates taken from sibling models. It closes with governance, quality tiers and known gaps.

3.1 An overview of the evidence base

Table 3.1 summarises the sources by module. Most are real observations of Uganda: the district population series, three rounds of household survey microdata, the Ministry of Health's registry of 6,800 facilities, and twelve years of item-level budget files. The weakest inputs are the ones that should come from ministry operational systems — HMIS service output, the human resource information system, the logistics management information system and a facility readiness survey. These were not available to this analysis, and the engine substitutes a documented proxy for each, flagged by its quality tier.

Table 3.1: Sources of the plan, by module

Source	Supplies	Feeds	Typical tier
MoH District League Tables 2014–2018	district population; coverage for tracer services; OPD contacts per capita; approved posts filled; HMIS reporting completeness	HM-01, HM-02, HM-04	measured
UBOS population projections and UN WPP	national growth rate and national age shares	HM-01	measured / normed
Uganda DHS 2016, MIS 2018–19, MIS 2024–25 microdata	sub-regional age structure, fertility, child illness, care-seeking, parasitaemia, coverage, severe wasting, equity breakdowns	HM-01, HM-02, HM-04, equity	measured at sub-region, imputed at district
Uganda DHS 2022 (published report)	maternal, neonatal and under-five mortality rates	HM-09	imputed
UPHIA 2020–21 (published summary)	regional HIV prevalence, to apportion the national ART need	HM-02	imputed
UNAIDS / Uganda AIDS Commission	national number of people living with HIV	HM-02	imputed
HMIS form 108, DHIS2 exports 2012–2018	facility inpatient deaths by condition, age, sex and district	HM-08 scenario F, condition catalogue	measured
MoH National Health Facility Registry	6,800 facilities by level, ownership and district	HM-04	measured

Source	Supplies	Feeds	Typical tier
2010 MoH facility register and OpenStreetMap	facility coordinates; district boundaries	HM-04, GIS	measured / imputed
SDI travel-time access (via HealthModelling)	share of population within 30, 60 and 120 minutes' drive and 60 minutes' walk	HM-04, HM-05, HM-07	imputed
MoFPED approved budgets FY2015/16–FY2026/27 and expenditure	health lines by vote, institution, programme, item and fund	HM-08, HM-10	measured
NDP IV Human Capital Development PIAP (NPA)	costed actions FY2025/26–FY2029/30	HM-10, indicative only	imputed
Salary structures, reference prices, WISN method, first-pass norms	prices, available working time, bills of materials	HM-03, HM-06	normed / assumed
UCSN coefficients and HealthModelling aggregates (vendored)	unit-cost coefficients, fiscal extract, small-area and equity references, survey trends	cross-checks	reference only

The engine records every source it cites in a `data_source` table with its custodian and licence. Table 3.2 lists the sources registered there for the prices, norms and population series. Survey, registry and budget files carry their provenance on each loaded row instead: source, source year and quality tier.

Table 3.2: Registered data sources (`data_source` table)

Id	Source	Custodian	Licence
MoPS-CSI-2022	Uganda Ministry of Public Service, Circular Standing Instruction No. 1 of 2022, Salary Structure FY2022/23	Ministry of Public Service	Government of Uganda
MoPS-CSI-2025	Uganda Ministry of Public Service, Salary Structure FY2025/26	Ministry of Public Service	Government of Uganda
UNICEF-SD	UNICEF Supply Division vaccine price data	UNICEF	Public
GF-PPM	Global Fund Pooled Procurement Mechanism reference pricing	The Global Fund	Public
SMGL-2019	Costs and cost-effectiveness of a district strengthening strategy, Uganda and Zambia (Saving Mothers Giving Life)	Global Health: Science and Practice	Public
STOPTB-GDF	Stop TB Partnership Global Drug Facility medicines catalogue	Stop TB Partnership	Public
HMIS-108	Uganda HMIS form 108 inpatient morbidity and mortality returns, DHIS2 export 2012-2018	Uganda Ministry of Health	Government open data, aggregate only
MoH-MFL	Uganda Ministry of Health health facility register (GIS)	Uganda Ministry of Health	Government open data
AICTEM-NORM	AICTEM first-pass service norm, pending clinical review	AICTEM Health Analytics	CC-BY-4.0
UNAIDS-UGA	UNAIDS and Uganda AIDS Commission HIV estimates	UNAIDS / Uganda AIDS Commission	Public
GF-ARV	Global Fund antiretroviral pooled procurement pricing	The Global Fund	Public
UBOS-WPP	Uganda Bureau of Statistics population projections and UN World Population Prospects	UBOS / UN DESA	Public
WHO-WISN	WHO Workload Indicators of Staffing Need methodology	World Health Organization	Public

Source: HPRAS database, run `uga-unconstrained-2026 (report/build/data/t_sources_registered.csv)`.

3.2 Population and demography

3.2.1 The district base

The plan's population denominators start from the district populations published in the Ministry of Health's **District League Tables** for 2014 to 2018. For each district the loader takes the most recent year observed. HM-01 grows it forward to each plan year at the national growth rate of 2.9% a year, taken from the Uganda Bureau of Statistics projections and the UN World Population Prospects (source UBOS-WPP in Table 3.2). The result is 47.4 million people in 2026 across the 122 plan districts. The base is *measured*: it is an observed district figure, not a national total disaggregated top-down. National totals are always sums of district results.

The league tables use the 2018 district geography, and it is the plan's geography. Every other source is folded onto it by a single canonical district identifier (`scripts/uga_districts.py`), which handles three kinds of difference: suffixes ("Abim District", "Gulu City"), misspellings, and districts and cities created after 2018. One misspelling mattered. The 2018 league table writes "KYAKWANZI" for Kyankwanzi. Left alone, the district appeared twice, and about 290,000 people were projected and planned for twice. The current registry lists 136 districts. The districts created since 2018 are rolled up into their parents.

3.2.2 Demographic factors

Population is split into planning groups (under one, under five, children 5–14, women of reproductive age, adults 15 and over and 40 and over, older people, girls 9–14 and girls aged 10), and births and pregnancies are derived. The national factors are listed in Table 3.3. Three points about the table matter for interpretation.

First, the national age shares from UBOS and WPP are a fallback. Where a district's DHS sub-region has a survey-weighted estimate, HM-01 uses the sub-regional share and flags the group *measured*. The national figure applies only where no sub-regional value exists. The two sources differ materially. The UBOS-WPP under-five share is 16.5%, against 17.7% in the DHS 2016 household roster and 16.3% in the MIS 2024–25 roster. The share of women aged 15–49 is 23.5% against 21.7% and 21.3%. These differences move the denominators of every maternal and child service.

Second, the crude birth rate of 0.0409 births per person per year comes from births in the last year in the DHS 2016. The number of pregnancies exceeds live births by a pregnancy-loss factor of 0.12, a first-pass norm. Using live births alone would understate antenatal need.

Third, the annualised child illness rates in the table (9.7 fever, 5.8 diarrhoea and 13.9 cough episodes per child per year) are stored as reference upper bounds only. They convert two-week prevalence into annual episodes on the assumption that episodes are instantaneous and independent, whereas real episodes last several days. No need rate uses them. The care-seeking fraction of 0.7227 for children under five, from the MIS 2024–25, is used to adjust routine utilisation data for the share of illness that never reaches a facility. The outpatient contact rate of 0.6409 per person per year is the national 75th percentile of the league tables' observed district rates. Every district is lifted at least to this floor, so that low utilisation in under-served districts is not planned in as low need.

Table 3.3: National demographic factors

Factor	Value	Unit	Source	Year
pregnancy loss factor	0.1200	proportion	AICTEM-NORM	2026
opd contacts per capita year	0.6409	contacts	Uganda MoH District League Table	2026
sex ratio at birth	1.0300	ratio	AICTEM-NORM	2026
population growth rate	0.0290	proportion/yr	UBOS-WPP	2024

Factor	Value	Unit	Source	Year
crude birth rate	0.0409	births/person/yr	Uganda DHS 2016	2016
share u1	0.0360	proportion	UBOS-WPP	2024
share u5	0.1650	proportion	UBOS-WPP	2024
share wra	0.2350	proportion	UBOS-WPP	2024
share adult 15p	0.4900	proportion	UBOS-WPP	2024
share adult 40p	0.1520	proportion	UBOS-WPP	2024
share girls 9 14	0.0720	proportion	UBOS-WPP	2024
share girls 10	0.0120	proportion	UBOS-WPP	2024
share child 5 14	0.2900	proportion	UBOS-WPP	2024
share elderly 60p	0.0390	proportion	UBOS-WPP	2024
alos days general	4.2000	days	AICTEM-NORM	2026
careseeking fraction u5	0.7227	proportion	Uganda MIS 2024-25	2025
u5 fever episodes yr	9.7454	episodes/child/yr	Uganda MIS 2024-25	2025
u5 diarrhoea episodes yr	5.8202	episodes/child/yr	Uganda DHS 2016	2016
u5 cough episodes yr	13.9	episodes/child/yr	Uganda DHS 2016	2016

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_demog_national.csv).

3.3 Household surveys: the evidence on need and coverage

3.3.1 Microdata read under licence

The strongest evidence on need comes from three Uganda household surveys held in the AICTEM DHS mirror: the **Demographic and Health Survey 2016**, the **Malaria Indicator Survey 2018–19** and the **Malaria Indicator Survey 2024–25**. The microdata are licensed individually to a registered user and may not be redistributed. The loader (`scripts/load_dhs.py`) reads one recode at a time from the archive into memory, computes survey-weighted aggregates, and deletes the extracted file in a `finally` block, so that it is removed even if the computation fails. No individual-level record reaches the repository or the database. The smallest unit stored is the sub-region, and equity cells with fewer than 25 cases are not stored.

The survey region variable for Uganda is the 15 sub-regions. A constructed district-to-sub-region crosswalk (`scripts/uga_subregions.py`) carries each estimate to the districts in that sub-region. It is assembled from the UBOS sub-region definitions and must be verified against the official classification before a norm version built on it is approved. A district it cannot place falls back to the national value and is flagged.

3.3.2 What the surveys show

Table 3.4 summarises the DHS 2016 indicators the engine uses, by sub-region.

- **Child illness varies more than coverage.** The two-week prevalence of fever among children under five ranges from 11.5% in Bunyoro to 67.0% in Busoga, around a national 34.0%.

- **Care-seeking is uneven.** It ranges from 48.9% in Bukedi to 83.7% in Karamoja.
- **Coverage gaps are sharpest for maternal care.** Four or more antenatal visits range from 44.5% in Bunyoro to 68.1% in Ankole. Facility delivery ranges from 58.4% in Bunyoro to 94.7% in Kampala. Postnatal care after discharge is low everywhere (15.0% nationally) and lowest in Ankole (6.2%).
- **Severe wasting is concentrated.** It stands at 6.0% of children in West Nile against 1.4% nationally, a pattern that drives the geography of acute malnutrition need in Chapter 5.

Table 3.4: Uganda DHS 2016: child illness, care-seeking, coverage and severe wasting by sub-region (survey-weighted)

Sub-region	Fever (2 wk)	Diarrhoea (2 wk)	Cough (2 wk)	Care sought	DPT 3	Measles 1	ANC 4+	Facility delivery	PNC after discharge	Severe wasting
National	34.0%	20.0%	41.4%	67.4%	79.7%	80.2%	60.2%	76.3%	15.0%	1.4%
Acholi	49.5%	24.7%	30.2%	80.8%	86.8%	84.6%	60.9%	86.3%	10.2%	1.4%
Ankole	16.0%	16.9%	37.4%	80.5%	83.4%	82.5%	68.1%	73.9%	6.2%	0.8%
Bugisu	19.5%	14.7%	29.9%	68.7%	73.1%	79.8%	47.0%	63.5%	26.8%	3.2%
Bukedi	34.7%	18.3%	39.8%	48.9%	76.9%	77.3%	54.7%	68.8%	17.2%	0.9%
Bunyoro	11.5%	10.2%	20.5%	56.6%	81.3%	84.5%	44.5%	58.4%	8.7%	0.2%
Busoga	67.0%	28.0%	31.5%	56.2%	71.2%	70.2%	66.1%	78.2%	10.4%	0.8%
Kampala	14.5%	16.2%	42.2%	67.2%	81.6%	82.8%	66.9%	94.7%	18.1%	1.5%
Karamoja	43.2%	24.0%	51.4%	83.7%	86.8%	91.3%	66.0%	81.5%	38.2%	3.3%
Kigezi	14.8%	16.0%	36.0%	69.4%	88.9%	95.6%	59.4%	72.4%	10.3%	1.0%
Lango	44.8%	20.8%	44.1%	66.2%	83.0%	74.5%	55.9%	69.2%	17.8%	2.1%
North Buganda	28.1%	17.2%	54.2%	73.4%	76.0%	73.3%	57.6%	75.4%	17.9%	1.0%
South Buganda	26.2%	20.6%	57.7%	79.5%	76.1%	76.3%	64.8%	83.6%	18.6%	0.0%
Teso	60.9%	30.0%	51.0%	59.8%	91.1%	87.2%	53.4%	75.0%	17.1%	0.3%
Tooro	24.3%	22.4%	40.0%	61.2%	76.2%	86.9%	64.0%	76.6%	12.9%	1.6%
West Nile	42.6%	16.0%	36.8%	74.3%	83.1%	82.2%	65.2%	83.2%	9.5%	6.0%

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_dhs_7B.csv).

Table 3.5 gives the same picture from the MIS 2024–25, the freshest survey in the estate.

- **Fever has fallen nationally but remains concentrated.** Child fever stands at 31.2%, down from 34.0% in 2016. It is highest in Lango (62.9%) and Teso (56.4%) and lowest in Kigezi (8.9%) and Ankole (10.0%).
- **Parasitaemia is even more concentrated.** Rapid diagnostic test positivity ranges from 0.9% in Kampala and Kigezi to 59.6% in Lango, against 21.1% nationally.
- **Care-seeking for sick children has risen.** It stands at 72.3% nationally, up from 67.4% in 2016, and ranges from 60.0% in Kampala to 87.7% in Karamoja.

Table 3.5: Uganda MIS 2024–25: child fever, care-seeking and parasitaemia by sub-region

Sub-region	Fever (2 wk)	Care sought	Malaria RDT+	Malaria microscopy+
National	31.2%	72.3%	21.1%	12.5%
Acholi	47.3%	72.2%	46.5%	23.3%
Ankole	10.0%	73.3%	2.0%	1.5%
Bugisu	29.3%	77.2%	12.7%	6.1%
Bukedi	43.7%	68.8%	16.1%	11.8%
Bunyoro	30.4%	68.4%	26.3%	17.7%

Sub-region	Fever (2 wk)	Care sought	Malaria RDT+	Malaria microscopy+
Busoga	40.4%	69.5%	29.4%	20.9%
Kampala	16.8%	60.0%	0.9%	0.4%
Karamoja	38.3%	87.7%	39.9%	26.5%
Kigezi	8.9%	70.9%	0.9%	0.6%
Lango	62.9%	73.2%	59.6%	31.7%
North Buganda	30.2%	70.8%	20.0%	11.4%
South Buganda	19.0%	78.1%	4.1%	2.3%
Teso	56.4%	73.7%	44.2%	22.8%
Tooro	14.4%	77.9%	13.9%	9.1%
West Nile	30.8%	60.9%	16.6%	8.0%

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_dhs_91.csv).

Figure 3.1 places the three survey rounds side by side. The north and east — Lango, Teso, Acholi and Busoga — carry most of the fever burden, and the south-western highlands carry little of it.

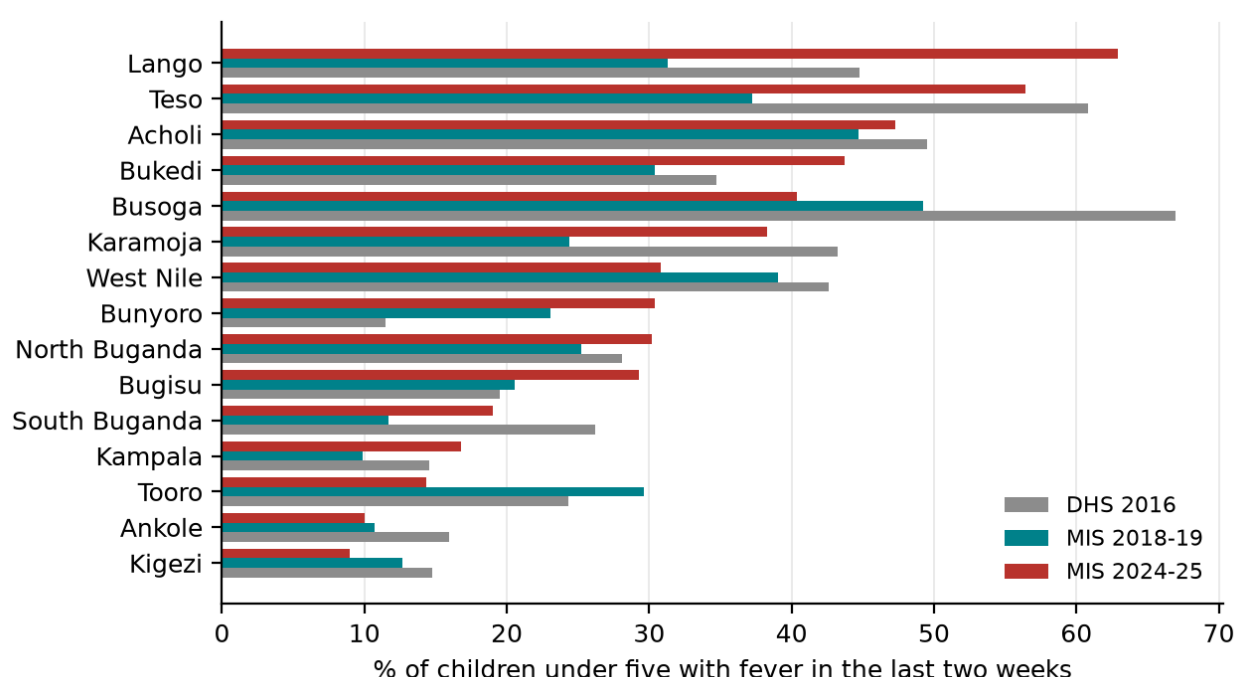


Figure 3.1: Child fever prevalence by sub-region and survey: the geographic shape of malaria need

Source: Uganda DHS 2016, MIS 2018-19 and MIS 2024-25 microdata (survey-weighted)

3.3.3 From survey estimates to need rates

The engine uses these estimates in three ways (scripts/derive_dhs_rates.py).

1. **Demography.** Sub-regional age structure and fertility enter HM-01.
2. **Malaria need.** Malaria need is set by a national anchor, the WHO incidence of 0.30 suspected cases per person per year, distributed across districts by the sub-regional child fever index. The index tracks fever rather than fever × parasite positivity. The service unit is a *suspected* case: someone with fever who must be tested. Positivity determines how many tested cases receive an antimalarial, which belongs on the drug lines of the norm, not on the need rate. The index is population-weighted, so the national anchor is preserved. It is bounded to between 0.35 and 2.50 times the national value, because a ratio of small survey estimates is unstable at the tails, and each bound that binds is logged. The resulting district rates are imputed.
3. **Coverage baselines.** Coverage baselines and the care-seeking adjustment enter HM-04 and fill gaps in the league tables.

Sub-regional survey estimates rest on a few hundred children or women each, so the direct values are noisy. Six indicators are passed through a **Fay–Herriot small-area estimator** before use: child fever, severe wasting, DPT3, four antenatal visits, facility delivery and postnatal care. Each estimate is shrunk toward a national model in proportion to its sampling variance. The variance is binomial, taken at the pooled proportion and multiplied by a design effect of 2.0. This is an approximation, because the loader keeps the sample size rather than a design-based standard error, and it is stated in every source string. Direct and smoothed values are kept side by side, so the shrinkage can be audited. For four antenatal visits, the engine's estimates differ from HealthModelling's design-based estimates by at most 1.7 percentage points (Chapter 5).

3.3.4 Published survey results

Three further survey sources enter as published aggregates rather than microdata.

- **Uganda DHS 2022.** The 2022 microdata are not in the local mirror, so the published report supplies the baseline mortality rates for HM-09: a maternal mortality ratio of 189 per 100,000 births, neonatal mortality of 22 per 1,000 and under-five mortality of 52 per 1,000. These replaced the DHS 2016 rates (336, 27 and 64), which would have overstated baseline deaths, and therefore deaths averted.
- **UPHIA 2020–21.** The Uganda Population-based HIV Impact Assessment summary sheet reports HIV prevalence among adults for 11 regions. Each region is a union of DHS sub-regions, so the crosswalk is exact. The engine uses the regional figures, from 2.1% in Karamoja to 8.1% in South Buganda, to apportion the national need for antiretroviral therapy while keeping the national total. The DHS HIV biomarker recode is licensed separately and is not used.
- **UNAIDS and the Uganda AIDS Commission.** The national number of people living with HIV, 1,527,238 in 2024, anchors the ART need rate. The rate is derived so that the total reconciles to this figure, rather than read off the headline prevalence, which is measured on a narrower age band.

3.4 Routine health information

3.4.1 League tables

The District League Tables 2014–2018 are the main routine source available to the analysis. Besides population, they supply:

- observed coverage for the tracer services;
- outpatient contacts per capita;
- the share of approved posts filled, the strongest workforce signal in the estate;
- HMIS reporting completeness.

The workbooks change layout from year to year, and the loader (`scripts/load_estate.py`) maps each layout separately. Where the league tables and the DHS disagree on immunisation, the plan uses the survey estimate for children aged 12–23 months as its baseline. The league tables put DPT3 at a population-weighted 89.6%, against 79.7% in the survey, and 33 districts reported coverage above 100% — a sign of target populations that are too small.

3.4.2 HMIS form 108

The HMIS form 108 exports from DHIS2 for 2012–2018 record facility-based inpatient deaths by condition, age band, sex and district. They supply the condition catalogue and the burden weights of allocation scenario F. Recorded facility deaths are shaped by reporting and by who reaches a hospital, so they measure *recorded* burden, not total burden. Chapter 11 returns to this.

3.4.3 What is missing

The AICTEM DHIS2 acquisition pipeline has been built and verified end to end against the public DHIS2 demonstration server, but it has no access to Uganda's national instance. So the engine has no current HMIS service output. Current delivery is inferred from coverage and need rather than observed facility by facility. Obtaining read-only access to the national DHIS2 is the single most valuable data action identified in the engine documentation (`docs/19_EXISTING_DATA_ASSETS.md`).

3.5 Facilities and geography

3.5.1 The National Health Facility Registry

The authority on what facilities exist is the Ministry of Health's **National Health Facility Registry (NHFR)**. The engine downloads the master facility list from the registry's public endpoint, the same one its own download button uses, in pages of 500 records (`scripts/fetch_nhfr.py`). The list holds 6,800 facilities:

- by ownership: 3,535 government, 2,253 private for profit and 1,012 private not for profit;
- by level: 4,101 HC IIs, 2,164 HC IIIs, 295 HC IVs, 215 general hospitals and 25 referral hospitals.

Three processing decisions shape its use.

- **Personal data are dropped.** The registry records names, mobile numbers and e-mail addresses of facility contact persons. These are personal data with no planning use, and they are never written to disk.
- **Levels are mapped to the engine's taxonomy.** Outpatient clinics are treated as HC II equivalents, and the national referral hospitals are folded into the referral tier.
- **Private-for-profit facilities are loaded but not counted as plan capacity.** Capacity the plan can direct is the public and PNFP network. The private sector enters the analysis through revealed delivery (Chapter 7).

3.5.2 Geocoding

The registry publishes no coordinates. `scripts/facility_geo.py` attaches them from two sources, tried in order:

1. the official GPS points of the 2010 MoH facility register, each re-assigned to the district polygon it falls in;
2. OpenStreetMap health features (hospitals, clinics and doctors, as points and building centroids) from a Geofabrik extract of August 2026.

Matching is by name, within the same district. Names are reduced to their distinctive core, with level tokens held separately. A pair whose levels conflict is rejected: "Kitgum HC IV" is not "Kitgum Hospital". A match needs a score of at least 90 and a lead of 5 points over the next candidate. An ambiguous best match is left unlocated, never guessed. On these rules **3,169 of the 6,800 facilities** are located. The located share is lowest for HC IIs, where 1,492 of 4,101 facilities carry coordinates. Maps of facilities show only these points; counts, capacity and every district figure use the full registry.

The 2010 register itself is a superseded vintage, a public-and-PNFP list of 111 districts with no Kampala. Since the NHFR became available, it contributes coordinates only, never counts.

3.5.3 Boundaries

District boundaries are OpenStreetMap administrative boundaries at admin level 4, dissolved onto the 2018 plan districts by the same rules the loaders use (`scripts/build_geo.py`). They give the 122 plan districts, a total area of 241,413 km², the 15 sub-regions, and the queen-contiguity adjacency used by the spatial statistics of Chapter 15. OpenStreetMap data are licensed under the Open Database Licence (ODbL). Every map in this report credits "© OpenStreetMap contributors", and any published derivative database must be shared alike.

3.5.4 Travel-time access

Physical access comes from the travel-time surfaces of AICTEM's spatial data infrastructure (SDI), vendored through HealthModelling. For each of 135 districts in 2020 they give the share of the population within 30, 60 and 120 minutes' drive and within 60 minutes' walk of a functional facility. The engine folds them onto the 122 plan districts. They are a modelled raster product and carry the tier `imputed`. The engine does no routing or raster computation of its own; that work stays in the SDI.

3.6 The national budget

3.6.1 Item-level budget files

The Ministry of Finance, Planning and Economic Development publishes item-level approved budgets. The engine loads every health line from the files for **FY2015/16 to FY2026/27**, together with expenditure files (`scripts/load_budget.py`). The files come in six different layouts, each read by its own adapter and normalised to one long table. Each line is classified by:

- vote and institution (Ministry of Health, National Medical Stores, national, regional and specialised referral hospitals, agencies, local-government primary health care and KCCA health);
- programme, sub-programme and output;
- item;
- fund (wage, non-wage, GoU development, external financing, appropriation-in-aid and arrears);
- a cost class aligned with the requirement's own resource classes.

What counts as health. The health votes are taken in full, together with the health lines of the consolidated local-government vote and of KCCA. In files that still carry the old sector classification, the health sector code is used as well, and no line is counted twice.

Vote renumbering. When programme budgeting was introduced in FY2022/23, vote numbers were reassigned. Numbers that belonged to hospitals before FY2022/23 now belong to unrelated bodies, and numbers that belonged to local governments now belong to embassies. The loader therefore takes only the stable vote codes by number and recognises hospitals, local governments and health agencies by name.

Plan-year convention. Each financial year is assigned to the plan year in which it ends, so FY2025/26 is plan year 2026. This aligns FY2025/26–FY2029/30 with the plan horizon and with the NDP IV.

What the files cannot show. The national files hold local governments as a single vote. Local-government primary health care is therefore available only as a national total, not by district.

On this reading the approved health budget rose from 1,317 bn UGX in FY2015/16 to 4,614 bn UGX in FY2025/26 and 5,271 bn UGX in FY2026/27. The engine's parse of the FY2026/27 files is checked against HealthModelling's independent fiscal extract of the same budget. The two agree to within +0.5% on the total, –0.7% on the wage bill, +1.1% on external financing and +0.4% on domestic financing. Chapter 13 analyses the budget, its execution and the medium-term framework.

3.6.2 The NDP IV programme implementation action plan

The National Planning Authority publishes the NDP IV Human Capital Development Programme Implementation Action Plan (PIAP) as a PDF in which 164 of 171 pages are images of tables. The engine reads it by optical character recognition, cell by cell against a fitted table grid, and checks every sub-total against the sum of the actions above it; nothing is silently corrected (`scripts/ocr_piap.py`, `scripts/parse_piap.py`). Figures recovered by OCR from images are nonetheless **indicative only**, and the report uses them for orientation, never as an input to the requirement or the envelope.

3.7 Prices and norms

Prices and norms populate the parameter tier, and their sources are listed in Table 3.2.

- **Staff prices** derive from the Ministry of Public Service salary structures (Circular Standing Instruction No. 1 of 2022 and the FY2025/26 structure). Basic pay is converted to UGX per minute of available working time with an allowance multiplier.
- **Vaccines and nutrition commodities** are priced from UNICEF Supply Division data.
- **Antiretrovirals and other programme medicines** are priced from the Global Fund's pooled procurement reference prices.
- **Tuberculosis medicines** are priced from the Stop TB Partnership's Global Drug Facility catalogue.
- **Available working time** follows the WHO WISN method.
- **Bills of materials** are an AICTEM first-pass norm set, released under CC-BY-4.0 and explicitly pending clinical review.
- **The published cost study** of the Saving Mothers, Giving Life programme is registered as a cross-check on unit costs, not as an input.

When UnitCostModelling (UCSN) supplies a resolved price snapshot, it replaces the price table wholesale under a new price vintage. Until then, prices and norms are *normed* where they come from a published standard and *assumed* where they are first-pass values. Annex B lists them in full.

3.8 Aggregates from sibling models

Two sibling EDIP models contribute aggregates. The files are **copied into this repository** (`data/vendor/healthmodelling/`), so the engine and its tests run without the originals present. `PROVENANCE.md` lists every copied file.

- **HealthModelling**, the AICTEM DHS Health Modelling System, contributes:
 - the SDI travel-time access table;
 - Fay–Herriot small-area estimates for 12 indicators across the 15 sub-regions from the DHS 2016;
 - equity breakdowns by wealth, residence, education and sex;
 - national estimates for each DHS round from 1995 to 2016, with their trend forecasts;
 - mortality rates from the DHS 2016;
 - the FY2026/27 fiscal extract with external financing by funder. HealthModelling applied its disclosure control of at least 25 cases per cell before export. Its code for small-area estimation and trend forecasting is copied under its MIT licence with the logic unchanged.
- **UnitCostModelling** contributes unit-cost coefficients: medical officer employment cost, nurse, midwife and physician density, hospital beds per 1,000 and baseline DPT3 coverage.

These aggregates are used as **cross-checks and validation references, never as rescaling factors**. A disagreement between the engine and UCSN is a question for the owner of the norm, answered with a new norm version. Two exceptions enter the computation, each with its tier: the travel-time access table and HealthModelling's under-five mortality index, which moves the geography of child deaths without changing their national total. Chapter 16 reports the comparisons.

3.9 Governance and licences

3.9.1 Classification

The engine follows a four-way data classification (`docs/18_DATABASE_SPECIFICATION.md`):

Class	Examples	Handling in this analysis
Restricted	DHS and MIS microdata, GPS cluster coordinates, individual payroll and HR records, patient data	never in the repository or the database; aggregated transiently, aggregates only stored
Sensitive	facility-level staffing and stock data, unpublished ceilings, draft allocations	none held beyond the published registry
Internal	draft norms, draft plan runs	this report's norm version is a draft
Public	approved plans, published catalogues, aggregate gap analyses	publishable with attribution

HPRAS holds no individual-level data of any kind. The smallest unit is the facility for the registry and the sub-region for surveys. Contact persons' names, telephone numbers and e-mail addresses in the registry are discarded at download.

3.9.2 Licences

Source	Licence and obligation
DHS and MIS microdata	licensed to a registered user; no redistribution; aggregates only, following HealthModelling's data governance
OpenStreetMap boundaries and facility points	ODbL: credit "© OpenStreetMap contributors"; derived databases shared alike
MoH facility registry, HMIS 108 exports	government open data, aggregate use only
MoFPED budget files, NPA PIAP	public government documents
UNICEF, Global Fund, Stop TB price data; UNAIDS; UBOS and UN WPP	public; cite
HealthModelling code and aggregates	MIT licence kept beside the files; survey aggregates not to be republished as microdata
AICTEM first-pass norms	CC-BY-4.0

Every ministry workbook the engine writes ends with a Sources sheet listing each source cited by the run's prices, norm lines, need rates, coverage baselines and mortality rates, with its year, the tables that cite it and its quality tiers.

3.10 Quality tiers across the evidence base

Every loaded row carries a quality tier, and results inherit the worst tier of their inputs (Chapter 2). Registry counts, league-table observations, budget lines and survey estimates at the sub-region are *measured*; published standards such as EPI schedules, WISN parameters and reference prices are *normed*; survey estimates carried to districts, the malaria and HIV apportionment, the access surfaces, the readiness proxy and the mortality baseline are *imputed*; first-pass norm lines, referral rates and the commodity gap are *assumed*. Supply data for all 122 districts are *measured*, because every district's facility count now comes from the current registry.

3.11 Known gaps

Five gaps in the evidence base have a direct effect on the results, and each is handled by a documented fallback rather than by silence.

1. **No equipment inventory, and no facility readiness survey.** Uganda has no Service Provision Assessment in the DHS mirror, and no SARA or HHFA microdata were available. Capacity therefore cannot be discounted for non-functioning theatres, missing equipment or absent power. The engine uses HMIS reporting completeness from the league tables as a readiness proxy, flagged *imputed*, and the median where a district has no value, flagged *assumed*. Surgical capacity at HC IV level is the result most likely to be overstated.

2. **No commodity stock data.** Without an extract from the logistics management information system, commodity availability is unknown. The engine sets the commodity gap equal to the full commodity requirement and flags it *assumed*, rather than assuming that supplies are available. The commodity gap of 858 bn UGX in 2026 should be read as the commodity requirement at target, not as a measured shortage.
3. **No human resource information system extract.** Staff in post are derived, not observed: establishment is the minimum staffing schedule applied to each registry facility, and staff in post are establishment × the league tables' observed fill rate. This gives 119,127 FTE in post and a fill rate of 73.5%. The derivation cannot distinguish approved, filled and present posts, which the manual requires to be reported separately.
4. **No live counterparts for the fiscal interfaces.** The FINEX envelope, the MTEF ceilings and MEL actuals are stubs. Allocations use the approved budget increase instead, and no figure in this report is a FINEX result (Chapter 18).
5. **Ageing survey evidence outside malaria.** The latest full DHS microdata in the estate are from 2016. For antenatal care, delivery, immunisation, family planning and nutrition, the freshest sub-regional baselines are ten years old. The MIS 2024–25 refreshes only the malaria and care-seeking indicators.

3.12 Implications for planning

The evidence base is strongest where Uganda has invested in public data: the population series, the household surveys, the facility registry and the budget files. It is weakest where the data sit in ministry operational systems. The most valuable improvements are therefore institutional rather than analytical: read-only access to the national DHIS2, an extract from the human resource information system reconciled to payroll, a logistics management information system extract, and the microdata of any facility readiness assessment. Each would replace an *assumed* or *imputed* input with a *measured* one, and the engine is built to absorb them without changing its code.

Planners should read the commodity and workforce gaps in the light of these gaps. The commodity gap is the full commodity requirement by construction. The workforce gap rests on a derived, not observed, staff count. Both are right in direction and approximate in size. Neither should be quoted as a measured shortage.

The survey evidence is a genuine asset and should be kept current. The sub-regional variation it reveals — sixfold in child fever, severalfold in severe wasting, wide gaps in maternal care — is what gives the plan its geography. When the DHS 2022 microdata become available in the mirror, they should replace the 2016 baselines for every non-malaria indicator.

Finally, the governance rules should be kept as the data estate grows. The engine holds no individual-level data, discards personal contact details at the point of download, and keeps licensed microdata out of the repository. These are the conditions under which ministries and survey programmes can continue to share data with it.

CHAPTER 4

4 Population and demography (HM-01)

This chapter answers the first question in the planning chain: how many people will need health services in each district of Uganda, in each year from 2026 to 2030, and in which age and life-stage groups? Every later number in the report is a multiple of the population. That includes the malaria episodes, antenatal visits, doses of vaccine, health worker posts and billions of shillings. An error in HM-01 passes undamped through need, demand, cost, allocation and outcomes. So the population module has to be conservative, transparent and consistent with official statistics.

For Uganda the stakes are higher than usual. The population is young and growing fast, and fertility and age structure differ sharply between sub-regions. A district in Teso and a district in Kigezi of the same total size do not need the same number of deliveries, vaccinations or child admissions. A national age structure applied to every district would hide those differences. The engine therefore combines two sources:

- an observed district population base;
- the sub-regional age structure and fertility measured by the Uganda Demographic and Health Survey (DHS).

The rest of this chapter sets out how the two are combined, what the projection shows, and where it is weakest.

4.1 What the module produces

HM-01 writes one table, `population_projection`. It holds the number of people in each planning group g , in each district d and in each year t of the horizon. The planning groups are not age-sex cells. They are the denominators that health services are actually defined on:

- the total population (ALL);
- infants under one (U1), who are the denominator for the whole immunisation schedule;
- children under five (U5), for severe acute malnutrition and severe childhood illness;
- children aged 5–14;
- girls aged 9–14, and girls aged exactly 10, who form the single-year cohort for HPV vaccination;
- women of reproductive age, 15–49 (WRA), for family planning;
- live births, for delivery, postnatal and newborn care;
- pregnancies, for antenatal care and prevention of mother-to-child transmission;
- adults aged 15 and over, for HIV, hypertension and severe mental disorders;
- adults aged 40 and over, for NCD screening;
- persons aged 60 and over.

The run projects 122 districts, which is the district geography of the 2018 league tables (geography version UGA-HMIS-2018), over five years. That gives the 7,320 population rows recorded in the plan log.

4.2 Method

4.2.1 Design and implementation

The engine manual (`docs/03_HM01_POPULATION.md`) specifies a full cohort-component projection. It ages single-year cohorts forward with life-table survivorship, generates births from age-specific fertility, adds net migration,

and rakes district totals to the national projection. The manual also states the governing principle: where the national statistics office publishes sub-national projections, the model should use them and not compete with them, "a planning model that disagrees with the official population is dismissed on sight".

The implementation in `src/NeedsChain.jl` (`compute_population!`) is deliberately simpler. It projects the observed district base forward at a national growth rate. It then splits each district total into planning groups using the age structure measured by the DHS for that district's sub-region. This keeps the total close to the official trajectory and adds the demographic geography that matters most for service planning. It does not model district-specific fertility decline, mortality or migration. Those are listed as limitations at the end of the chapter.

4.2.2 Base population and growth

The base is the district population recorded in the Uganda Ministry of Health District League Tables. `scripts/load_estate.py` reads the population column of each league-table workbook for 2014 to 2018 and flags it measured. HM-01 takes the most recent year observed for each district. For all 122 districts that year is 2018, when the league tables give a total of 37,741,300 people.

Each district total is grown forward at a single national rate:

$$P_{d,t} = P_{d,b} \times (1 + g)^{t-b} \quad (4.1)$$

where:

- $P_{d,t}$ is the total population of district d in year t ;
- $P_{d,b}$ is the league-table population of district d in its base year b (2018 for every district);
- g is the national population growth rate, 0.029 per year, held in `demographic_factor` with source UBOS-WPP 2024.

Eight years of growth at 2.9% carry the 2018 base to 47,439,473 people in 2026. The same rate then carries it to 53,186,493 in 2030.

4.2.3 Sub-regional age structure

The DHS Person Recode (PR), the household roster, records the age and sex of every household member. `scripts/load_dhs.py` reads the recodes one at a time into memory, computes survey-weighted shares by sub-region, and deletes the extracted file. No microdata is stored. For each band it computes the weighted share of household members whose age falls in the band. Two bands are single-sex: women 15–49, and girls aged 9–14 and exactly 10. Where a band is available from more than one survey, the structure prefers the full DHS 2016 (survey code 7B) over the malaria indicator surveys.

The share is applied to the district total:

$$P_{g,d,t} = P_{d,t} \times s_{g,r(d)} \quad (4.2)$$

where:

- $P_{g,d,t}$ is the population of planning group g in district d and year t ;
- $s_{g,r}$ is the DHS share of group g in sub-region r ;
- $r(d)$ is the DHS sub-region to which district d belongs, from the crosswalk in `district_subregion` (122 of 122 districts mapped).

The function first resolves a factor at the sub-region. Only if the sub-region has no estimate does it fall back to the national value, and in that case it flags the row `imputed` rather than `measured`. In this run every district resolved to its sub-region.

Table 4.1 lists the factors. The spread is substantial. The under-five share runs from 15.4% in Kampala to 19.5% in Karamoja. Women of reproductive age are 30.6% of Kampala's population but 18.3% of Karamoja's. The share of persons aged 60 and over ranges from 2.5% in Kampala to 7.6% in Kigezi. The sub-regional estimates rest on large samples. The DHS 2016 roster behind the under-five share holds between 4,485 persons (Karamoja) and 8,137 persons (Busoga) per sub-region, and 91,108 nationally.

Table 4.1: Sub-regional demographic factors from the DHS PR and BR recodes

Sub-region	u1	u5	child 5 14	wra	adult 15p	elderly 60p
Acholi	3.5%	17.2%	34.5%	21.0%	48.3%	4.5%
Ankole	3.6%	17.5%	32.2%	21.5%	50.3%	5.3%
Bugisu	3.6%	17.0%	32.6%	20.1%	50.3%	6.1%
Bukedi	3.5%	18.5%	33.2%	20.3%	48.3%	4.8%
Bunyoro	4.0%	18.9%	30.9%	21.7%	50.2%	4.1%
Busoga	3.5%	18.4%	34.8%	20.2%	46.9%	4.2%
Kampala	2.8%	15.4%	20.4%	30.6%	64.3%	2.5%
Karamoja	4.0%	19.5%	33.5%	18.3%	47.0%	7.3%
Kigezi	2.9%	15.6%	30.4%	22.0%	54.0%	7.6%
Lango	2.8%	16.4%	33.4%	20.7%	50.2%	5.0%
North Buganda	3.4%	17.5%	30.9%	21.0%	51.6%	5.0%
South Buganda	3.5%	18.2%	26.6%	24.5%	55.2%	4.6%
Teso	4.3%	18.3%	31.5%	21.8%	50.2%	5.5%
Tooro	3.4%	18.7%	31.1%	21.2%	50.2%	4.8%
West Nile	3.5%	17.8%	33.6%	21.4%	48.6%	5.0%

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_demog_factors.csv).

4.2.4 Births and pregnancies

Births are driven by a crude birth rate built from two survey quantities. The DHS Individual Recode (IR) records, for every woman aged 15–49, the number of births in the last twelve months. The survey-weighted mean of that count is the general fertility rate (GFR). Multiplying it by the share of women of reproductive age converts births per woman into births per head of population:

$$\text{CBR}_r = \text{GFR}_r \times s_{\text{WRA},r} \quad (4.3)$$

$$B_{d,t} = P_{d,t} \times \text{CBR}_{r(d)} \quad (4.4)$$

where:

- $\text{CBR}[r]$ is the crude birth rate of sub-region r (births per person per year);
- $\text{GFR}[r]$ is the general fertility rate of sub-region r ;
- $s[\text{WRA},r]$ is the share of women aged 15–49 in sub-region r ;
- $B[d,t]$ is live births in district d and year t .

The national crude birth rate from the DHS 2016 is 0.0409 births per person per year. It replaces an assumed value of 0.0369 that the engine carried before the survey was read. The GFR itself runs from 0.113 in Kampala to 0.263 in Karamoja.

Antenatal care is needed for every pregnancy, not only every live birth. Pregnancies exceed births by miscarriage and stillbirth, so they are derived with a pregnancy-loss factor:

$$\text{PREG}_{d,t} = B_{d,t} \times (1 + \lambda) \quad (4.5)$$

where λ is the pregnancy-loss factor, 0.12 in `demographic_factor` (an AICTEM norm). The manual notes that planning antenatal care from live births would understate need by 10–15%. The factor lives in the norms table rather than in code so that the Ministry can revise it.

4.2.5 The derived groups together

The implementation derives eleven planning groups from each district total: nine age-structure shares (Equation (4.2)), births (Equation (4.4)) and pregnancies (Equation (4.5)). The engine's validation checks that pregnancies are never fewer than births and that the nested groups are consistent: under-fives are never fewer than infants, and adults 15+ never fewer than adults 40+. The HPV cohort illustrates why a single-year group matters. Only girls turning ten are vaccinated each year, and they number 828,277 in 2026. Planning HPV vaccination to all girls aged 9–14 would multiply the requirement roughly five-fold.

4.3 Results

4.3.1 The national projection

Uganda's projected population is 47.4 million in 2026, rising to 53.2 million in 2030 (Figure 4.1, Table 4.2). Growth is 2.9% in every year, by construction, and adds about 1.4 million people in the first year of the horizon. That rises to almost 1.5 million by the last year, because a constant rate applies to a growing base. Over the whole horizon the population grows by 12.1%.

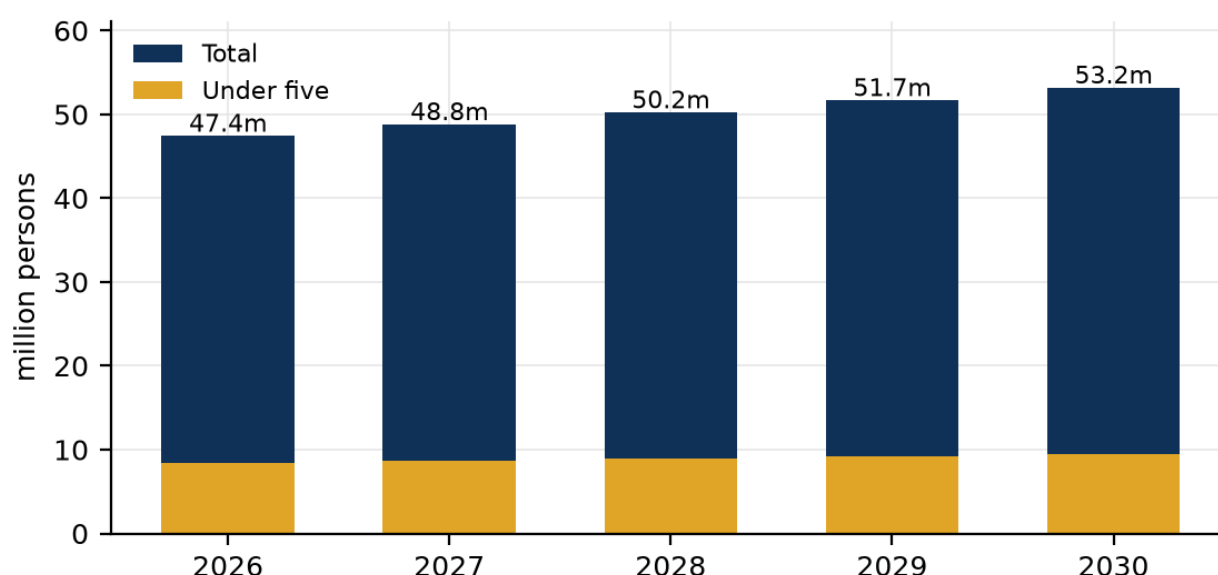


Figure 4.1: Projected population of Uganda, 2026–2030 (HM-01)

Source: HPRAS database, run uga-unconstrained-2026

Table 4.2: National population projection

Year	Population	Annual growth
2026	47,439,473	-
2027	48,815,217	2.90%
2028	50,230,859	2.90%
2029	51,687,554	2.90%
2030	53,186,493	2.90%

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_pop_years.csv).

4.3.2 Planning groups

Table Table 4.3 sets out the planning groups for 2026 and 2030. Children under five number 8.4 million in 2026, 17.8% of the population. Children aged 5–14 are a further 14.8 million (31.2%), so almost half of all Ugandans are under fifteen. There are 1.94 million live births and 2.18 million pregnancies in 2026. Infants under one number 1.65 million, fewer than births because the infant count is a survey share of the resident population, which already

reflects infant deaths. Women of reproductive age are 10.3 million (21.8%). Adults aged 15 and over number 24.2 million, just over half the population. Adults aged 40 and over are 7.5 million and persons aged 60 and over 2.3 million (4.9%).

Table 4.3: Projected population by planning group, 2026 and 2030

Group	2026	2030	Share of total 2026	Growth 2026-30
Total population	47,439,473	53,186,493	100.0%	12.1%
Infants under one year	1,654,037	1,854,415	3.5%	12.1%
Children under five	8,424,248	9,444,797	17.8%	12.1%
Children 5-14	14,821,483	16,617,021	31.2%	12.1%
Girls 9-14	4,104,939	4,602,229	8.7%	12.1%
Girls aged 10	828,277	928,618	1.7%	12.1%
Women of reproductive age 15-49	10,339,879	11,592,496	21.8%	12.1%
Pregnancies in the year	2,175,143	2,438,649	4.6%	12.1%
Live births in the year	1,942,092	2,177,365	4.1%	12.1%
Adults 15 and over	24,193,742	27,124,675	51.0%	12.1%
Adults 40 and over	7,497,835	8,406,155	15.8%	12.1%
Persons 60 and over	2,339,986	2,623,462	4.9%	12.1%

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_pop_groups.csv).

Every group grows at the same 12.1% between 2026 and 2030. That is a direct consequence of the method. The age shares are held fixed at their survey values, so the structure does not age over the horizon. In reality Uganda's fertility is declining slowly and its population is ageing. Over five years the effect is small, but it runs in a known direction. The fixed structure slightly overstates the growth of child groups and understates the growth of older adults. That matters most for the NCD services, whose need grows faster than the projection shows.

4.3.3 Sub-regional structure

Figure Figure 4.2 and Table Table 4.4 show population and structure by DHS sub-region. South Buganda is the largest sub-region, with 6.1 million people in 2026, followed by North Buganda (5.0 million) and Busoga (4.9 million). Karamoja is the smallest, at 1.3 million.

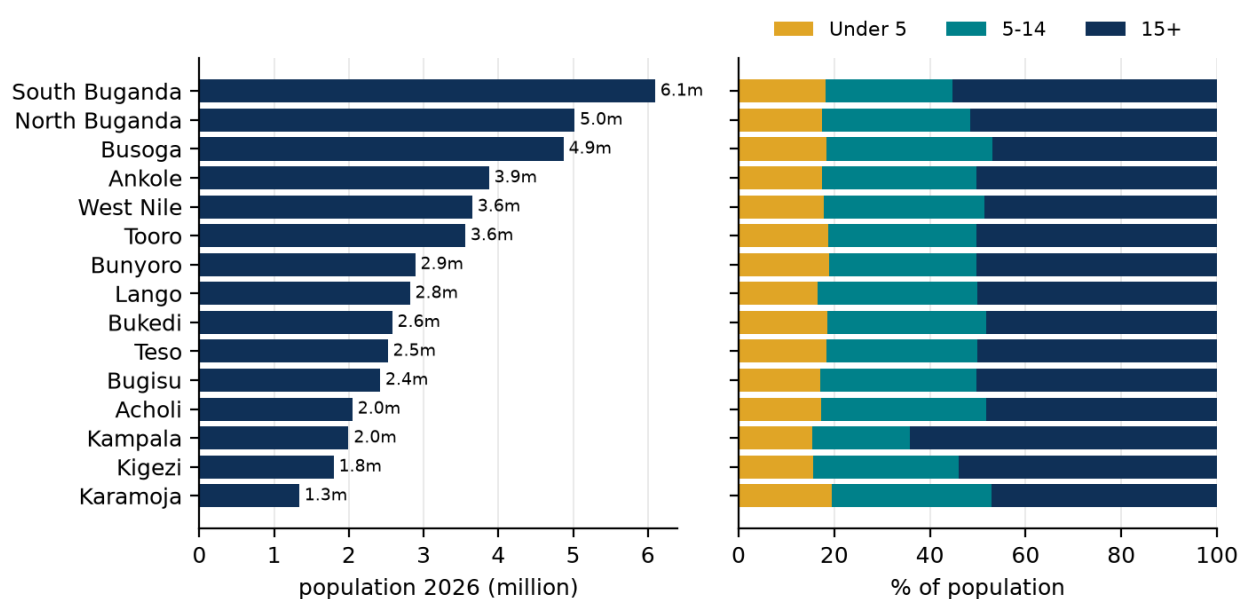


Figure 4.2: Population and age structure by sub-region, 2026 (sub-regional DHS age shares applied to district totals)

Source: HPRAS database, run uga-unconstrained-2026

Table 4.4: Population and structure by DHS sub-region, 2026

Sub-region	Population 2026	Under five	Women 15-49	Adults 15+	Births per 1,000	Density /km2
South Buganda	6,095,021	18.2%	24.5%	55.2%	42.6	233
North Buganda	5,018,556	17.5%	21.0%	51.6%	40.6	138
Busoga	4,869,103	18.4%	20.2%	46.9%	41.1	292
Ankole	3,871,953	17.5%	21.5%	50.3%	41.9	237
West Nile	3,649,471	17.8%	21.4%	48.6%	41.0	232
Tooro	3,555,198	18.7%	21.2%	50.2%	39.1	255
Bunyoro	2,886,242	18.9%	21.7%	50.2%	46.2	147
Lango	2,814,972	16.4%	20.7%	50.2%	34.8	205
Bukedi	2,577,531	18.5%	20.3%	48.3%	39.5	558
Teso	2,518,203	18.3%	21.8%	50.2%	51.1	196
Bugisu	2,416,388	17.0%	20.1%	50.3%	39.5	575
Acholi	2,045,961	17.2%	21.0%	48.3%	38.5	72
Kampala	1,993,294	15.4%	30.6%	64.3%	34.5	10,201
Kigezi	1,793,814	15.6%	22.0%	54.0%	32.4	339
Karamoja	1,333,765	19.5%	18.3%	47.0%	48.2	48

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_pop_subregion.csv).

Three contrasts stand out.

- **Kampala is demographically unlike the rest of the country.** Adults aged 15 and over are 64.3% of its population against 51.0% nationally. Women aged 15–49 are 30.6% against 21.8%, and children aged 5–14 only 20.4%. This is the signature of working-age migration into the capital. Kampala's need for antenatal care, family planning, HIV services and NCD care per head is therefore high. Its need for child services per head is the lowest in the country.
- **Karamoja and Teso carry the highest fertility.** Karamoja has the highest under-five share (19.5%) and the second-highest birth rate, 48.2 per 1,000. Teso has the highest birth rate of all, 51.1 per 1,000. At the other end, Kigezi's birth rate is 32.4 per 1,000, well below the national 40.9. Across sub-regions the birth rate, and with it the per-capita need for maternal and newborn services, differs by more than half.
- **Kigezi is the oldest sub-region.** Persons aged 60 and over are 7.6% of its population and under-fives 15.6%. Kigezi also has the lowest birth rate. This pattern will matter increasingly for hypertension and NCD care.

Population density ranges from 48 persons per km² in Karamoja and 72 in Acholi to 575 in Bugisu and 558 in Bukedi. Kampala, at 10,201 per km², is a city rather than a region. Density matters less for need than for supply and access (Chapter 7): a sparse sub-region needs more facilities per head to keep people within reach of care.

4.3.4 Districts

The distribution of district sizes is wide (Figure 4.3). Wakiso is by far the most populous district, at 3.0 million in 2026, followed by Kampala (2.0 million), Arua (1.06 million), Mubende (0.96 million) and Kasese (0.93 million). The smallest districts are Kalangala (75,544), Ntoroko (89,370), Kween (126,702), Lyantonde (127,456) and Bukwo (128,965). The largest district is therefore about forty times the size of the smallest. That spread is why per-capita and per-1,000 measures, not totals, are used on every map in this report.

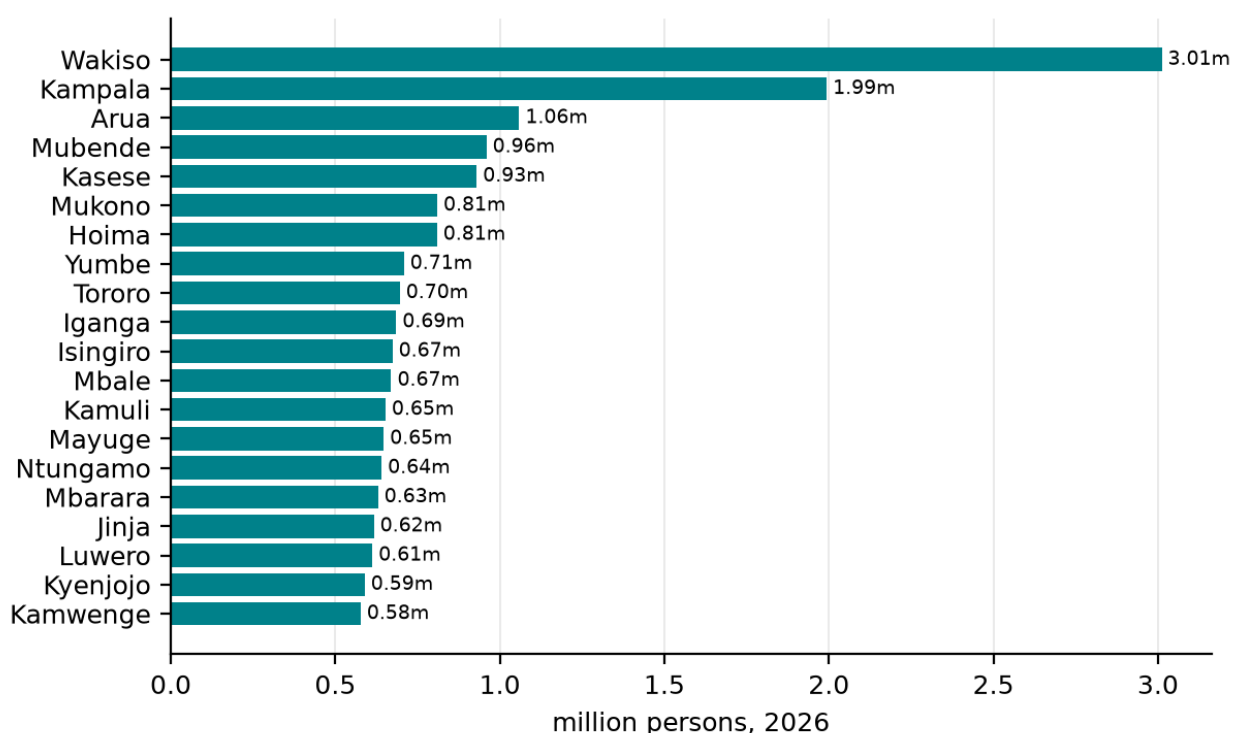


Figure 4.3: The 20 most populous districts, 2026

Source: HPRAS database, run uga-unconstrained-2026

Annex C (a_pop) gives the full district table.

4.4 The geography of population: maps and clusters

Each map in this report has two panels. The left panel shows the value by district. The right panel shows the local Moran (LISA) clusters, computed with 999 permutations on the district adjacency graph:

- a **high-high** (HH) cluster, or hot spot, is a district with a high value surrounded by high values;
- a **low-low** (LL) cluster, or cold spot, is a low district surrounded by low values;
- the outliers (HL, LH) are districts that differ significantly from their neighbours.

The global Moran's I summarises how strongly the whole layer is spatially clustered. Values near 0 mean no pattern and values near 1 mean strong clustering.

One caution applies to every HM-01 map except density. The age shares and birth rates are measured at sub-region level and applied uniformly to every district within the sub-region. Neighbouring districts in the same sub-region therefore carry identical values. That builds spatial autocorrelation into the layer by construction, and it raises Moran's I. The clusters show which sub-regions differ from their neighbours. They say nothing about variation within a sub-region, because the method cannot see any.

4.4.1 Population density

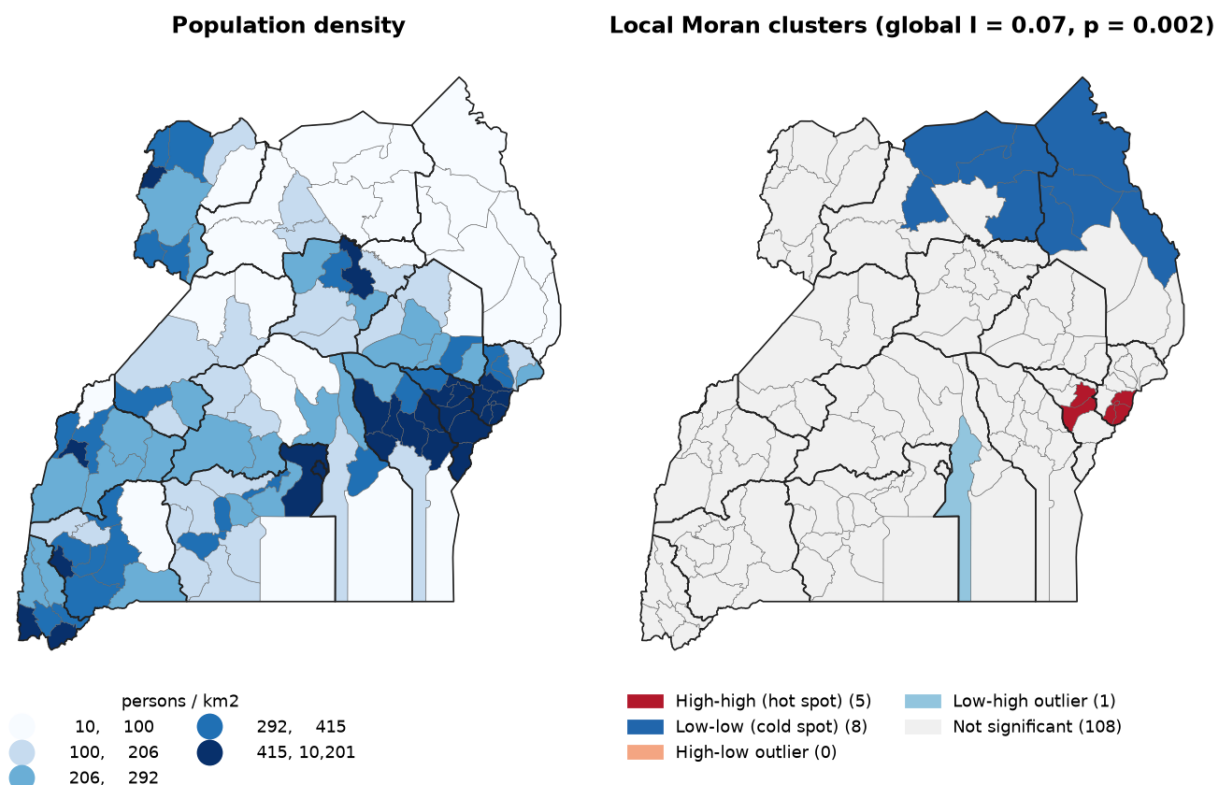


Figure 4.4: HM-01 - Population density (persons / km²), by district, 2026; right: local Moran (LISA) clusters, 999 permutations

Source: HPRAS database, run uga-unconstrained-2026; quality tier derived. Boundaries (c) OpenStreetMap contributors (ODbL).

Density (Figure 4.4) is the one HM-01 layer that varies freely by district, since it divides each district's own projected population by its own area. The district median is 252 persons per km². The range runs from 9.7 in Kalangala and 14.0 in Buvuma, both island districts, to 1,069 in Wakiso, 1,292 in Mbale and 10,201 in Kampala.

The global Moran's I is only 0.07 ($p = 0.002$). Density is significantly but weakly clustered, because a few very dense districts (Kampala, Wakiso, Mbale) sit next to much less dense neighbours. The local analysis finds five hot-spot districts on the slopes of Mount Elgon: Budaka and Butaleja in Bukedi, and Bududa, Manafwa and Namisindwa in Bugisu. This is the densest rural farming zone in the country. It finds eight cold-spot districts across Karamoja (Kaabong, Kotido, Moroto) and Acholi (Abim, Agago, Gulu, Kitgum, Lamwo). Mukono is a low-high outlier: less dense than the metropolitan districts around it. For planning, the northern and north-eastern cold spot is where fixed facilities serve the fewest people each, and where walking distance rather than facility capacity is likely to bind.

4.4.2 Children under five

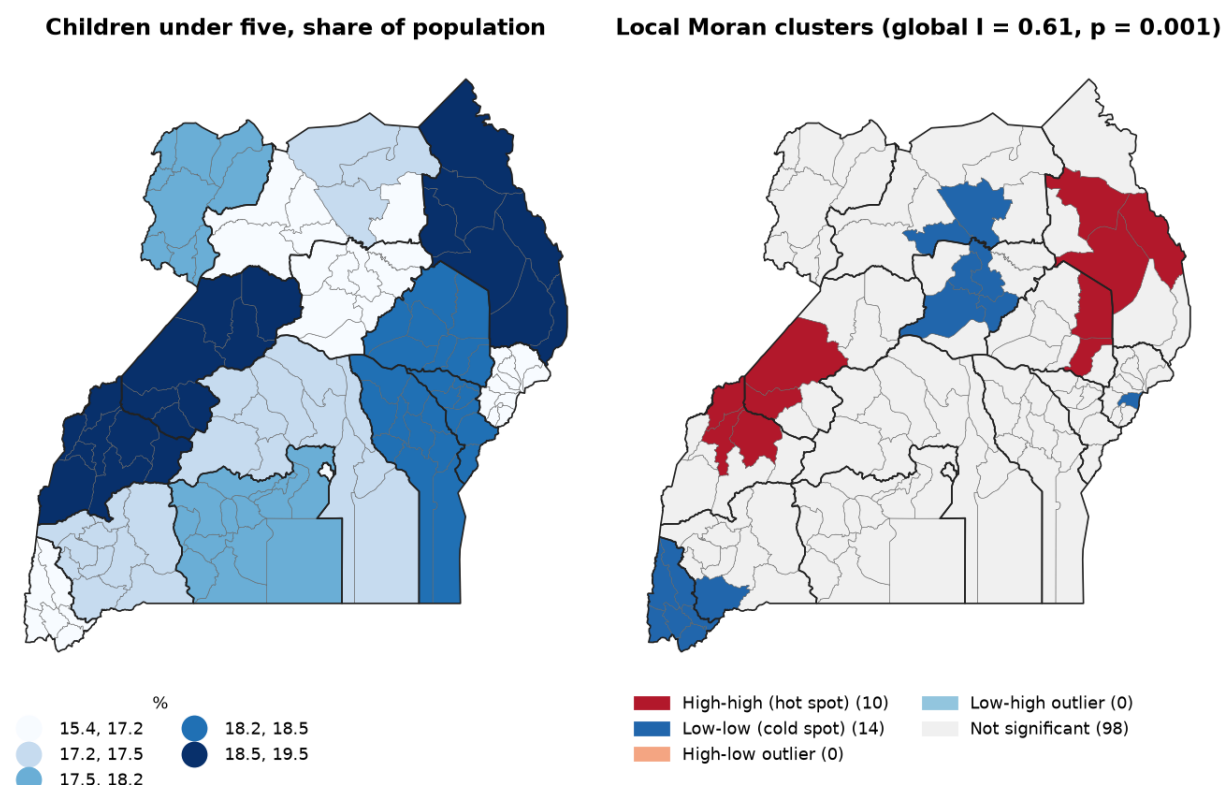


Figure 4.5: HM-01 - Children under five, share of population (%), by district, 2026; right: local Moran (LISA) clusters, 999 permutations

Source: HPRAS database, run uga-unconstrained-2026; quality tier measured. Boundaries (c) OpenStreetMap contributors (ODbL).

The under-five share (Figure 4.5) runs from 15.4% in Kampala to 19.5% in the Karamoja districts, with a district median of 17.8%. It is the most clustered HM-01 layer, with a global Moran's I of 0.61 ($p = 0.001$).

The ten hot-spot districts fall in two belts:

- the west: Hoima and Kagadi in Bunyoro, and Kabarole, Kyenjojo and Ntoroko in Tooro;
- the east and north-east: Katakwi and Kumi in Teso, and Kotido, Moroto and Napak in Karamoja.

The fourteen cold-spot districts are concentrated in Kigezi (six districts) and Lango (four), with two in Acholi and one each in Bugisu and Ankole.

The under-five share drives the child-health services: severe acute malnutrition, severe childhood illness admissions and part of the immunisation denominator. The hot spots are where child need per head is highest before any difference in disease risk is added. In Karamoja the young age structure coincides with the highest severe-wasting prevalence outside West Nile (Chapter 5), so the two effects compound.

4.4.3 Births

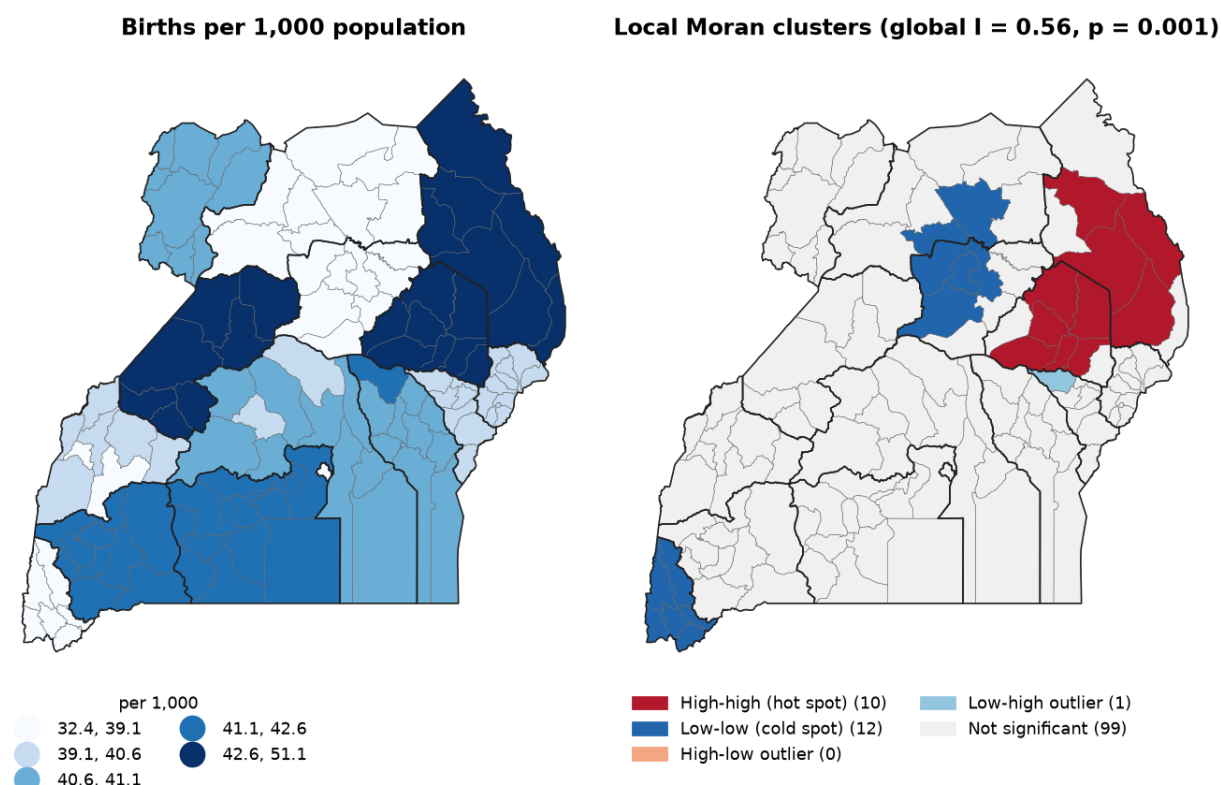


Figure 4.6: HM-01 - Births per 1,000 population (per 1,000), by district, 2026; right: local Moran (LISA) clusters, 999 permutations

Source: HPRAS database, run uga-unconstrained-2026; quality tier measured. Boundaries (c) OpenStreetMap contributors (ODbL).

Births per 1,000 population (Figure 4.6) range from 32.4 in the Kigezi districts to 51.1 in the Teso districts. The global Moran's I is 0.56 ($p = 0.001$). The ten hot-spot districts are all in Teso (Amuria, Katakwi, Kumi, Ngora, Serere, Soroti) and Karamoja (Kotido, Moroto, Nakapiripirit, Napak). The twelve cold-spot districts are in Kigezi (Kabale, Kanungu, Kisoro, Rubanda, Rukiga, Rukungiri), Lango (Apac, Kole, Lira, Oyam) and Acholi (Omoro, Pader). Pallisa, in Bukedi, is a low-high outlier next to the Teso hot spot.

This map is the template for maternal and newborn need. Deliveries, postnatal care and sick newborn care are proportional to births. Antenatal care and prevention of mother-to-child transmission are proportional to pregnancies, which are births multiplied by a constant. The facility-deliveries map in Chapter 6 reproduces this pattern exactly, with the same Moran's I. A Teso district needs more than half as many deliveries again per head as a Kigezi district, and midwifery staffing, delivery beds and maternal commodities must follow.

The Lango cold spot deserves comment, because Lango is also the hottest malaria sub-region (Chapter 5). Its low birth rate, 34.8 per 1,000, comes from a combination of a low general fertility rate and a modest share of women of reproductive age. Lango's service mix therefore leans towards adult and malaria care rather than maternal care.

4.5 Data quality and limitations

The quality tiers used throughout the report are, from strongest to weakest: measured, normed, imputed and assumed. The HM-01 outputs sit as follows.

- **Total population: `measured` base, projected.** The 2018 league-table populations are official figures, but they are eight years old in 2026. Every district has been grown at the same national rate. Districts growing faster than the nation, such as urbanising districts around Kampala or districts hosting refugee settlements, are understated. Slower-growing districts are overstated. The manual's cohort-component model, with raking to UBOS sub-national projections, is the intended replacement. The engine's validation

rules (district totals summing to the national total, and raking factors within $\pm 5\%$) are designed for that model.

- **Age structure and births: `measured`, at sub-region resolution.** The shares are direct survey-weighted estimates with large samples. They are, however, from the DHS 2016 and are held constant to 2030, so the population does not age over the horizon. They are also uniform within each sub-region, so within-sub-region differences are invisible, for example between an urban municipality and its rural hinterland.
- **Pregnancies: `measured` births times a `normed` factor.** The pregnancy-loss factor of 0.12 is a planning norm, not a Ugandan measurement.
- **Geography.** The district set is the 2018 league-table geography of 122 districts. Districts created since then are inside their parent districts. A move to the current boundaries needs the district crosswalk the manual specifies.

None of these limitations changes the national total by much, because the growth rate is the official one. Their effect is on distribution: which districts receive how much of the requirement. That is exactly what HM-05 and HM-08 act on.

4.6 Implications for planning

- **Plan to the demographic structure, not only the headcount.** Two districts of equal size can differ by more than half in births per head, and by several percentage points in their under-five and working-age shares. Allocation formulas based on total population alone will under-fund maternal and child services in Teso, Karamoja, Bunyoro and Tooro. They will under-fund adult services in Kampala, South Buganda and Kigezi.
- **Maternal and newborn services must scale with fertility.** The Teso–Karamoja birth-rate hot spot is where delivery capacity, midwives and newborn care should be expanded first if coverage targets are to be met without widening regional gaps.
- **Kampala and the metropolitan districts need an adult-heavy service mix.** A working-age population with 30.6% women of reproductive age implies high demand for family planning, antenatal care, HIV and NCD services per head, even though the child share is the lowest in the country.
- **Replace the growth-rate projection with UBOS district projections.** The single most valuable improvement to HM-01 is to load the official sub-national projections and let the cohort-component step supply only the age detail. Until then, district totals, and especially those of fast-growing peri-urban and refugee-hosting districts, should be read with caution.
- **Refresh the age structure when the DHS 2022 microdata become available.** The model's demographic geography is anchored to 2016. A newer survey would update both the shares and the birth rates that drive the maternal, newborn and child services.

CHAPTER 5

5 Disease burden and health needs (HM-02)

This chapter turns the population of Chapter 4 into need. For each of the 28 modelled services it asks how many people, in each district and year, would benefit clinically from the service, whether or not they currently seek or receive it. Need is distinct from demand (people who would seek care), from utilisation (people who received care) and from the required volume (need times a coverage target, Chapter 6). A plan built on utilisation entrenches inequity: utilisation in an under-served district is low *because* the district is under-served. The engine manual calls this "the single most common error in sector budgeting", and HM-02 is designed so that the engine cannot make it.

For Uganda, three burdens dominate the geography of need:

- **malaria**, whose intensity varies by a factor of several between the north-east and the south-western highlands;
- **HIV**, whose prevalence runs from 2.1% of adults in Karamoja to 8.1% in South Buganda;
- **child undernutrition**, concentrated in West Nile and Karamoja.

Getting these right matters for the whole requirement: antiretroviral therapy alone is 24.0% of the 2026 requirement (Chapter 6), and malaria is the second-largest volume of care after outpatient consultations. Most of the method below is therefore about how district need is built from national anchors and survey geography, including the small-area estimation that stabilises sub-regional survey estimates.

5.1 The need identity and the need bases

5.1.1 Need as population times rate

The core of HM-02 is a single identity, applied for every service s , district d and year t :

$$N_{s,d,t} = P_{g(s),d,t} \times \iota_{s,d,t} \quad (5.1)$$

where:

- $N[s,d,t]$ is the number of persons (or episodes) needing service s ;
- $P[g(s),d,t]$ is the population of the planning group $g(s)$ on which the service is defined, from HM-01;
- $\iota[s,d,t]$ is the need rate: an incidence, a prevalence, a population rate or 1 for universal services.

The rate is resolved district-first (`compute_needs!` in `src/NeedsChain.jl`). An observed district rate beats a national one. If a district rate exists only for an earlier year, it is reused with its own quality tier. Only when no district rate exists does the national rate apply. Each need row carries the worse of the quality tiers of its population and its rate.

5.1.2 Need bases

Each service declares a need basis, and the basis fixes both the population group and the meaning of the rate. Table 5.1 lists the national rates for 2026 with their source, year and quality tier.

Table 5.1: National need rates, 2026 (district rates vary around these where evidence exists)

Service	Rate	Basis	Source	Year	Quality
Malaria diagnosis and treatment	0.3000	incidence	WHO World Malaria Report, Uganda incidence per capita	2024	normed
Tuberculosis treatment course	0.0020	incidence	WHO Global TB Report, Uganda incidence 198/100,000	2024	normed
Pentavalent immunisation (DTP-HepB-Hib)	1.0000	universal	EPI schedule: every surviving infant	2026	normed
Antenatal care visit	1.0000	births	every pregnancy requires antenatal care	2026	normed
Normal delivery	1.0000	births	every birth requires skilled attendance	2026	normed
Caesarean section	0.1000	referral	WHO population need for caesarean, 10-15% of births	2015	normed
Inpatient bed-day	0.0385	referral	admissions per outpatient contact	2026	assumed
Severe childhood illness, admission	0.0600	incidence	severe illness admissions, children under five, East Africa 50-100 per 1,000 child-years	2020	assumed
Sick newborn care	0.1000	births	WHO: ~10% of newborns need special care (low birth weight, asphyxia, sepsis)	2022	assumed
Obstetric complications (non-surgical)	0.0800	births	WHO: ~15% of births develop complications; the caesarean-managed share is excluded	2015	assumed
Complicated SAM, inpatient stabilisation	0.1200	referral	WHO: 10-15% of SAM cases have medical complications	2013	normed
Major surgery (non-obstetric)	0.0050	population_rate	Lancet Commission on Global Surgery: 5,000 procedures per 100,000	2015	normed
Severe mental disorders and epilepsy care	0.0200	prevalence	WHO mhGAP: psychosis, bipolar disorder and epilepsy ~2% of adults	2016	imputed
BCG immunisation	1.0000	universal	EPI schedule	2026	normed
Polio immunisation	1.0000	universal	EPI schedule	2026	normed
Measles-rubella immunisation	1.0000	universal	EPI schedule	2026	normed
Pneumococcal immunisation	1.0000	universal	EPI schedule	2026	normed
Rotavirus immunisation	1.0000	universal	EPI schedule	2026	normed
HPV immunisation	1.0000	universal	EPI schedule, one cohort of girls aged 10	2026	normed
Postnatal care contact	1.0000	births	every birth needs postnatal care after discharge	2026	normed
NCD screening (blood pressure, glucose)	1.0000	population_rate	WHO PEN: annual BP screening for adults 40+	2020	normed
Hypertension management	0.2250	prevalence	Uganda STEPS survey 2023: raised blood pressure 23.5% of adults 18-69	2023	imputed
Family planning	0.4300	population_rate	Uganda DHS 2016: modern method use 27.3% plus unmet need among all women 15-49	2016	imputed
Antiretroviral therapy	0.0620	prevalence	UNAIDS Uganda 2024: 1,527,238 PLHIV reconciled to projected adults 15+	2024	imputed

Service	Rate	Basis	Source	Year	Quality
HIV testing and counselling	0.4500	population_rate	Uganda HIV testing services volume, tests per adult per year	2024	assumed
Prevention of mother-to-child transmission	0.0300	births	HIV prevalence among pregnant women, below adult prevalence reflecting a younger age profile	2024	imputed
Outpatient consultation	0.6409	episodes	Uganda league-table 75th percentile	2026	imputed
Severe acute malnutrition treatment	0.0260	incidence	Uganda DHS 2016 severe wasting, scaled to DHS 2022 wasting, $0.0100 \times K=2.6$	2016	imputed

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_need_rates.csv).

The bases are:

- **Universal.** Every member of the group needs the service, and the rate is 1. The six infant vaccines are defined on infants under one. HPV vaccination is defined on the single-year cohort of girls aged 10.
- **Births.** The service is needed per birth or per pregnancy. Normal delivery, postnatal care and sick newborn care use live births. Antenatal care and PMTCT use pregnancies. Sick newborn care (0.10) and non-surgical obstetric complications (0.08) apply a WHO share to births.
- **Incidence.** Episodes per person per year. Malaria is 0.30 nationally (WHO World Malaria Report) and tuberculosis 198 per 100,000 (WHO Global TB Report). Severe childhood illness admissions are 0.06 per child under five, an assumed East African benchmark. Severe acute malnutrition (SAM) is derived below.
- **Prevalence.** The share of a group living with a condition that needs continuous care. Antiretroviral therapy uses 0.062 of adults aged 15+, reconciled to UNAIDS. Hypertension uses 0.225 of adults aged 15+ (Uganda STEPS 2023). Severe mental disorders and epilepsy use 0.02 of adults (WHO mhGAP).
- **Population rate.** A normative rate of contact. Family planning uses 0.43 of women 15–49: total demand, meaning modern-method use plus unmet need, from the DHS 2016. HIV testing uses 0.45 tests per adult per year. NCD screening is one screen per adult aged 40+ per year. Major surgery uses 5,000 procedures per 100,000 (Lancet Commission on Global Surgery).
- **Episodes.** Outpatient contacts per person, discussed below.
- **Referral.** The need arises from the planned volume of a parent service, so it is resolved in HM-03 (Chapter 6). Caesarean need is 10% of planned deliveries. Inpatient admissions are 0.0385 per planned outpatient contact. Complicated SAM is 12% of SAM cases treated.

Two definitional choices deserve emphasis because they change volumes by large factors:

- Family planning is planned against total demand, not current use. Planning to current use would freeze coverage where it is and make unmet need invisible.
- Antenatal need is counted in pregnancies, 12% above births (Chapter 4).

5.2 How district geography enters the need rates

For most services the rate is national and the district variation comes only from the population structure. Four services have rates that genuinely vary by district (Table 5.2): malaria, severe acute malnutrition, antiretroviral therapy and PMTCT. Outpatient care also varies, through the utilisation floor. For each, the engine keeps a **national anchor**, a published total it does not overrule, and uses survey data only for the **geographic shape**. The manual (ch. 18 §18.7, option 2) calls this "apportioning a national rate by a relevant covariate". Everything produced this way is flagged *imputed*.

Table 5.2: Services whose need rate varies by district, 2026

Service	Distinct district rates	Lowest	Highest	Ratio
Antiretroviral therapy	10	0.0229	0.0883	3.9
Prevention of mother-to-child transmission	10	0.0111	0.0427	3.9
Malaria diagnosis and treatment	15	0.1050	0.6014	5.7
Severe acute malnutrition treatment	15	0.0111	0.0778	7.0

Source: HPRAS database, run `uga-unconstrained-2026 (report/build/data/t_need_district_var.csv)`.

5.2.1 Malaria: a national anchor apportioned by child fever

The service unit for malaria is a suspected case: a person presenting with fever, who must be tested and, if positive, treated. The need rate therefore tracks fever incidence. Parasite positivity determines how many suspected cases receive an artemisinin combination. That belongs on the drug lines of the norm, not on the need rate.

An earlier version multiplied fever by RDT positivity. It produced a 389-fold spread and would have planned almost no malaria services for Kampala, a city of two million. In the current norm for a health centre III, adult and paediatric artemether-lumefantrine are applied to 45% and 50% of suspected cases respectively. The rapid diagnostic test is applied to every case.

The sub-regional index is the smoothed child fever prevalence relative to its population-weighted national mean:

$$\bar{f} = \frac{\sum_d f_{r(d)} P_d}{\sum_d P_d} \quad (5.2)$$

$$l_{\text{mal}, d} = l_{\text{WHO}} \times \min \left(\max \left(\frac{f_{r(d)}}{\bar{f}}, 0.35 \right), 2.5 \right) \quad (5.3)$$

where:

- $f[r]$ is the Fay–Herriot smoothed prevalence of fever in the last two weeks among children under five in sub-region r , from the Uganda Malaria Indicator Survey 2024-25 (the newest survey is preferred for malaria);
- $P[d]$ is the base population of district d ;
- $\bar{f}$ is the population-weighted mean, so the index averages 1 and the national anchor is preserved;
- $l[\text{WHO}]$ is the national anchor, 0.30 suspected episodes per person per year;
- the bounds $[0.35, 2.5]$ clamp the index, because a ratio of small survey estimates is unstable at the tails. Any binding is logged.

Figure Figure 5.1 shows the fever prevalence behind the index in each of the three surveys the engine reads. Figure Figure 5.2 (below) and the malaria map show the result.

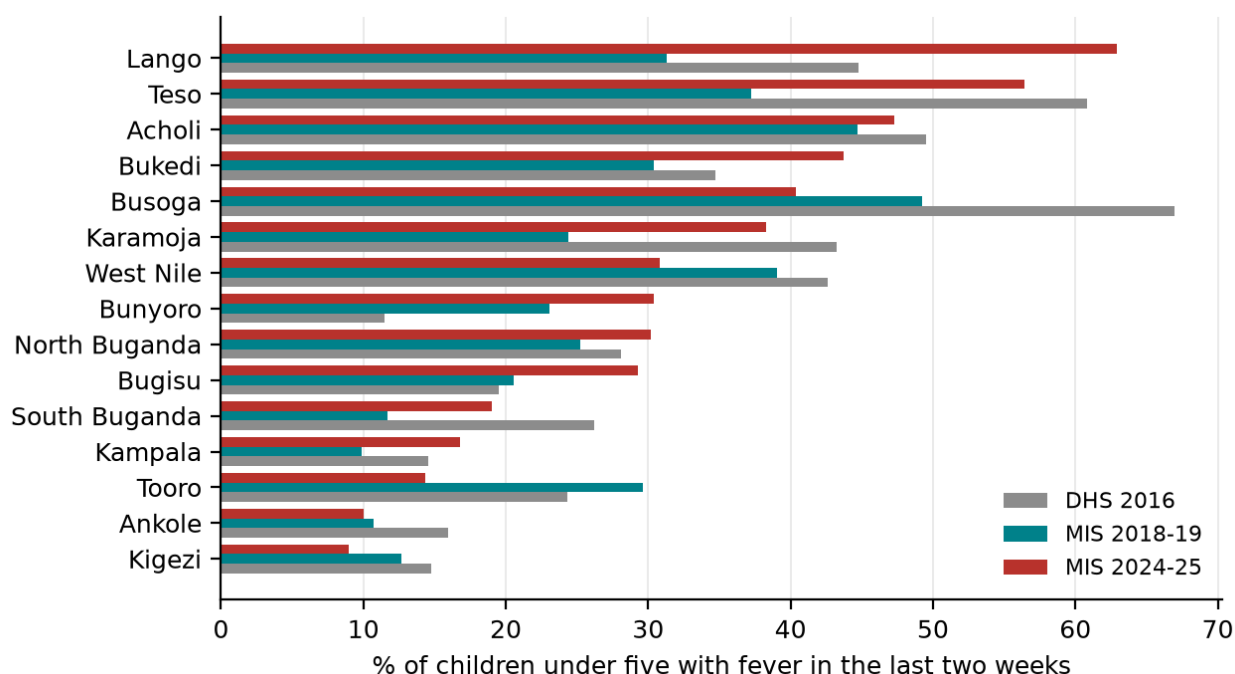


Figure 5.1: Child fever prevalence by sub-region and survey: the geographic shape of malaria need

Source: Uganda DHS 2016, MIS 2018-19 and MIS 2024-25 microdata (survey-weighted)

The smoothed fever prevalence in the MIS 2024-25 (Table 5.6) runs from 10.1% in Kigezi and 11.2% in Ankole to 55.5% in Teso and 61.6% in Lango. The index that results is:

- 2.00 in Lango, 1.81 in Teso, 1.52 in Acholi, 1.41 in Bukedi, 1.30 in Busoga and 1.24 in Karamoja;

- 0.37 in Ankole, 0.49 in Tooro, 0.57 in Kampala and 0.63 in South Buganda;
- 0.35 in Kigezi, where the floor binds. Kigezi's six districts are the only ones clamped.

District malaria need rates therefore range from 0.105 to 0.601 suspected episodes per person per year, a ratio of 5.7.

The figure also carries a warning. Sub-regional fever prevalence moves a great deal between surveys:

- Busoga fell from 67.0% in the DHS 2016 to 49.2% in the MIS 2018-19 and 40.4% in the MIS 2024-25;
- Lango fell from 44.8% to 31.3% and then rose to 62.9%;
- nationally the three surveys give 34.0%, 27.0% and 31.2%.

Some of this is real change in transmission, and some is fieldwork season and sampling noise. The index is a shape for the current planning period, to be refreshed with each survey.

5.2.2 From two-week prevalence to annual episodes

Surveys measure whether a child had fever in the last two weeks. Services are planned per year. If episodes arrive independently as a Poisson process at rate λ per year, the chance of at least one episode in a 14-day window is:

$$p = 1 - e^{-\lambda \times 14/365} \quad (5.4)$$

so that

$$\lambda = -\ln(1 - p) \times \frac{365}{14} \quad (5.5)$$

where:

- p is the two-week period prevalence;
- λ is the implied annual episode rate per child.

The national fever prevalence of 31.2% in the MIS 2024-25 converts to 9.7 episodes per child per year. The DHS 2016 diarrhoea prevalence of 20.0% converts to 5.8, and cough of 41.4% to 13.9. The engine stores these rates but deliberately does **not** use them as need rates. The conversion is an upper bound: real episodes last several days, so a 14-day window cannot hold as many as independence implies. The malaria level comes from the WHO anchor; the survey supplies only the shape.

5.2.3 Care-seeking

The MIS 2024-25 finds that medical treatment was sought for 72.3% of child fever and cough episodes. The engine stores this as `careseeking_fraction_u5`, the divisor that converts an HMIS case count into implied incidence (an undercount factor of 1.38). It is not applied to need; it exists so that an HMIS count is never mistaken for need.

5.2.4 HIV: UPHIA geography, UNAIDS anchor

Antiretroviral therapy is the largest single line of the requirement, so its geography matters more than any other. The national anchor is derived to reconcile with UNAIDS rather than read from a headline prevalence. About 95% of Uganda's 1,527,238 people living with HIV (UNAIDS 2024) are adults. Dividing them by the projected population aged 15 and over gives 0.062. The code notes why this is consistent with the published adult prevalence of 4.9%, which is measured on the narrower 15–49 age band.

The geographic shape comes from the published regional prevalence of the Uganda Population-based HIV Impact Assessment 2020-21 (UPHIA; Summary Sheet, August 2022). UPHIA reports eleven regions, each an exact union of DHS sub-regions, so the crosswalk loses nothing. Adult prevalence runs from 2.1% in Karamoja and 2.8% in West Nile to 7.6% in Mid North (Achoi and Lango) and 8.1% in Central 1 (South Buganda). The national figure is 5.8%. The rate is:

$$\bar{h} = \frac{\sum_d h_{r(d)} A_d}{\sum_d A_d} \quad (5.6)$$

$$\iota_{\text{ART},d} = \iota_{\text{nat}} \times \frac{h_{r(d)}}{\bar{h}} \quad (5.7)$$

where:

- $h[r]$ is the UPHIA adult prevalence of the region containing sub-region r ;
- $A[d]$ is the adult population (15+) of district d , the ART denominator;
- $\bar{h}$ is the adult-weighted mean prevalence;
- ι_{nat} is the national anchor, 0.062.

Because the index is weighted by adults, the national total of 1,500,012 persons needing ART in 2026 is unchanged. Only its distribution moves. The index runs from 0.37 in Karamoja to 1.42 in South Buganda. District ART need rates run from 0.0229 to 0.0883 per adult, a ratio of 3.9. PMTCT is apportioned the same way around its national rate of 0.030 per pregnancy, from 0.0111 to 0.0427.

Before this step the largest cost line in the plan was spread by population alone. The same UPHIA geography is used for HIV deaths in HM-09, so need and mortality share one map. The quality tier stays *imputed*: a modelled national total apportioned by a survey, at UPHIA-region resolution only.

5.2.5 Severe acute malnutrition: prevalence to incidence

The DHS measures severe wasting, a weight-for-height z-score below -3 , as a prevalence at the moment of the survey. The SAM treatment service treats cases over a year. An episode of SAM lasts about two months, so a year holds several, and annual incidence is prevalence multiplied by a correction factor. The survey level is also dated: the only anthropometry in the local cache is from the DHS 2016. The published DHS 2022 puts wasting at 2.9% against 4.0% in 2016, so the 2016 prevalence is scaled by that ratio. The 2016 sub-regional shape is kept.

$$\tilde{w}_r = \hat{w}_r \times \frac{2.9}{4.0} \quad (5.8)$$

$$\iota_{\text{SAM},d} = K \times \min(\max(\tilde{w}_{r(d)}, 0.3 \tilde{w}_0), 4 \tilde{w}_0) \quad (5.9)$$

where:

- $\hat{w}[r]$ is the Fay–Herriot smoothed severe-wasting prevalence of sub-region r , from the DHS 2016;
- $\tilde{w}[r]$ is that prevalence scaled to the DHS 2022 wasting level, and $\tilde{w}[0]$ is the same for the national value;
- $K = 2.6$ is the UNICEF planning default for converting prevalence to annual incidence;
- the bounds 0.3 and 4 times national protect against sampling extremes.

The national severe-wasting prevalence of 1.38% becomes 1.00% after scaling. Multiplied by 2.6 it gives 0.026 cases per child under five per year. The sub-regional rates run from 0.0111 in South Buganda to 0.0778 in West Nile, a ratio of 7.0, the widest of any need rate. Neither bound binds in this run. K is uncertain, so every SAM figure is *imputed*. Complicated SAM, which needs inpatient stabilisation, is 12% of the SAM cases treated and is resolved in HM-03.

5.2.6 Hypertension and tuberculosis: national rates

For hypertension and tuberculosis the engine has no sub-national evidence and does not invent a shape. Hypertension need is 0.225 of adults aged 15+: the Uganda STEPS survey 2023 measured raised blood pressure in 23.5% of adults aged 18–69 (26.4% in 2014), lowered slightly for the 15–17-year-olds and not raised for those over 70, two effects that roughly offset. Its district variation comes entirely from the adult share of the population. Tuberculosis need is the WHO incidence of 198 per 100,000, applied uniformly.

5.2.7 Outpatient care: the 75th-percentile floor

Outpatient consultations have no natural epidemiological denominator. The manual (ch. 04, "The OPD problem") ranks three options:

1. a condition build-up;
2. a benchmark contact rate;
3. observed utilisation, adjusted upward.

The engine currently uses option 3, the fallback, and flags it imputed:

$$l_{\text{OPD},d} = \max(u_d, u_{75}) \quad (5.10)$$

where:

- $u[d]$ is the observed OPD contacts per person in district d , from the 2016 league table;
- $u[75]$ is the national 75th percentile of the observed district rates.

The league table gives OPD rates for 112 districts, from 0.22 to 0.84 contacts per person per year. The 75th percentile is 0.64, and 84 of the 112 districts are lifted to it. The ten districts without an observation take the same national value. The result, 31.1 million contacts in 2026 (655.7 per 1,000), is conservative. The floor replaced a generic benchmark of 1.4 contacts per person per year that the engine carried before, and it remains anchored to what Ugandan facilities delivered in 2016, not to what a well-served population uses. Because outpatient care is the second-largest cost line, the option is recorded with every run.

5.3 Results: need by service

Figure 5.2 and Table 5.3 give the need for every service in 2026 and 2030, and per 1,000 population in 2026.

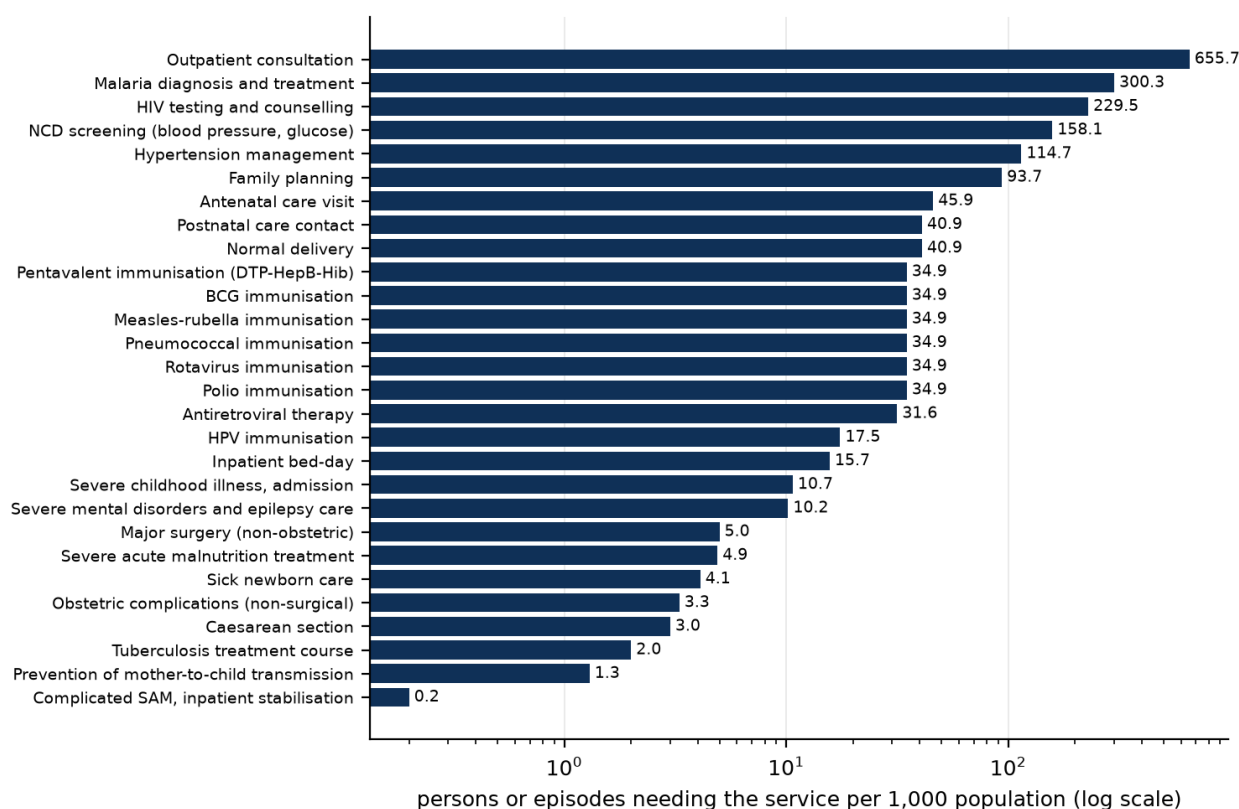


Figure 5.2: Need by service, 2026: persons or episodes per 1,000 population

Source: HPRAS database, run uga-unconstrained-2026

Table 5.3: Persons (or episodes) needing each service

Service	Persons needing 2026	2030	Per 1,000 (2026)
Outpatient consultation	31,108,279	34,876,869	655.7
Malaria diagnosis and treatment	14,244,339	15,969,959	300.3
HIV testing and counselling	10,887,184	12,206,104	229.5
NCD screening (blood pressure, glucose)	7,497,835	8,406,155	158.1
Hypertension management	5,443,592	6,103,052	114.7
Family planning	4,446,148	4,984,773	93.7
Antenatal care visit	2,175,143	2,438,649	45.9
Postnatal care contact	1,942,092	2,177,365	40.9
Normal delivery	1,942,092	2,177,365	40.9
Pentavalent immunisation (DTP-HepB-Hib)	1,654,037	1,854,415	34.9
BCG immunisation	1,654,037	1,854,415	34.9
Measles-rubella immunisation	1,654,037	1,854,415	34.9
Pneumococcal immunisation	1,654,037	1,854,415	34.9
Rotavirus immunisation	1,654,037	1,854,415	34.9
Polio immunisation	1,654,037	1,854,415	34.9
Antiretroviral therapy	1,500,012	1,681,730	31.6
HPV immunisation	828,277	928,618	17.5
Inpatient bed-day	742,555	1,074,208	15.7
Severe childhood illness, admission	505,455	566,688	10.7
Severe mental disorders and epilepsy care	483,875	542,494	10.2
Major surgery (non-obstetric)	237,197	265,932	5.0
Severe acute malnutrition treatment	230,533	258,461	4.9
Sick newborn care	194,209	217,736	4.1
Obstetric complications (non-surgical)	155,367	174,189	3.3
Caesarean section	143,715	195,963	3.0
Tuberculosis treatment course	93,930	105,309	2.0
Prevention of mother-to-child transmission	64,010	71,764	1.3
Complicated SAM, inpatient stabilisation	9,682	20,160	0.2

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_need_persons.csv).

The largest volumes are 31.1 million outpatient contacts (655.7 per 1,000), 14.2 million suspected malaria episodes (300.3 per 1,000, the anchor rate preserved by the population weighting), 10.9 million HIV tests, 7.5 million NCD screens and 5.4 million people with hypertension needing treatment. Hypertension is the largest chronic-care need in the model, more than three times the 1.5 million people needing antiretroviral therapy.

Maternal and child needs are smaller in volume but large in cost per case: 2.18 million pregnancies, 1.94 million births, 1.65 million infants to vaccinate and 828,277 girls aged 10 for HPV. The rarer services include 505,455 severe childhood illness admissions, 230,533 cases of SAM, 194,209 sick newborns and 93,930 tuberculosis cases.

The referral services depend on planned volumes and so move faster than population. Caesarean need is 143,715 in 2026 and 195,963 in 2030. Inpatient admissions are 742,555 and 1,074,208. Complicated SAM rises from 9,682 to 20,160. Their need rises by 36% to 108% over the horizon, against 12.1% for population, because the parent services' coverage targets rise. Chapter 6 explains the mechanism.

5.4 Small-area estimation

5.4.1 Why smoothing is needed

At the level of the fifteen sub-regions, some DHS indicators rest on a few hundred observations. DPT3 is measured on children aged 12–23 months, between 119 (Kigezi) and 249 (Busoga) per sub-region. Severe wasting affects about 1% of children and is measured on 164 to 399 per sub-region. Used unmodified, such estimates would turn chance fluctuations in the survey into differences in planned services. The engine therefore passes six sub-regional indicators through a Fay–Herriot small-area model before use: child fever (the malaria index), severe wasting (SAM), DPT3, ANC4+, facility delivery and postnatal care after discharge. The estimator was copied from the AICTEM DHS Health Modelling System (HealthModelling), `SmallAreaEstimation.jl`, into `src/SmallArea.jl` with its logic unchanged. The need loaders use a Python port, `scripts/small_area.py`, which a test checks against the Julia original to 1e-10 (`docs/21_HEALTHMODELLING_INTEGRATION.md`).

5.4.2 The Fay–Herriot model

The model has two levels. The **sampling model** says that the direct survey estimate for area i equals the true value plus sampling error:

$$y_i = \theta_i + e_i, \quad e_i \sim N(0, D_i) \quad (5.11)$$

The **linking model** says that the true values vary around a regression on area covariates:

$$\theta_i = x_i^T \beta + u_i, \quad u_i \sim N(0, \sigma_u^2) \quad (5.12)$$

where:

- $y[i]$ is the direct survey-weighted estimate for sub-region i ;
- $\theta[i]$ is the true sub-regional value;
- $e[i]$ is the sampling error, with known variance $D[i]$;
- $x[i]$ is the vector of area covariates, and β its coefficients. In this engine $x[i]$ is an intercept only, so the model mean is a precision-weighted national mean;
- $u[i]$ is the area effect, with between-area variance σ_u^2 .

The best predictor of $\theta[i]$ combines the direct estimate and the model prediction. The result is the empirical best linear unbiased predictor (EBLUP):

$$\hat{\theta}_i = x_i^T \hat{\beta} + \gamma_i (y_i - x_i^T \hat{\beta}) \quad (5.13)$$

$$\gamma_i = \frac{\sigma_u^2}{\sigma_u^2 + D_i} \quad (5.14)$$

where:

- $\hat{\theta}[i]$ is the EBLUP;
- $\gamma[i]$ is the shrinkage weight: the share of its own direct estimate that area i keeps.

A precise estimate (small $D[i]$) or a heterogeneous indicator (large σ_u^2) keeps γ near 1, and the EBLUP stays close to the direct value. A noisy estimate is pulled toward the model mean. The coefficients are estimated by generalised least squares:

$$\hat{\beta} = (X^T V^{-1} X)^{-1} X^T V^{-1} y, \quad V = \text{diag}(D_i + \sigma_u^2) \quad (5.15)$$

5.4.3 Sampling variance

The DHS loader stores each estimate with its unweighted sample size, not a design-based standard error. The sampling variance is therefore approximated as binomial, inflated by a design effect for the cluster sample, and evaluated at the **pooled** proportion:

$$\bar{p} = \frac{\sum_i y_i n_i}{\sum_i n_i} \quad (5.16)$$

$$D_i = \delta \times \frac{\bar{p}(1-\bar{p})}{n_i} \quad (5.17)$$

where:

- $n[i]$ is the unweighted sample size in sub-region i ;
- $\bar{p}$ is the sample-weighted pooled proportion across sub-regions;
- $\delta = 2.0$ is the design effect, within the 1.5–2.5 typical of DHS sub-regional proportions.

The approximation is stated in the source string of every smoothed value, and both the direct and the smoothed value are stored in `sae_estimate` so that the shrinkage can be audited.

5.4.4 Estimating the between-area variance

The between-area variance σ_u^2 is estimated by the Fay–Herriot moment method, iterated as a fixed point. It starts from the moment estimate:

$$\sigma_u^2 = \max(\text{var}(y) - \bar{D}, 10^{-6}) \quad (5.18)$$

and then repeats, fifty times, a GLS fit of β followed by the update:

$$S = \sum_i \frac{(y_i - x_i^T \hat{\beta})^2}{D_i + \sigma_u^2}, \quad T = \sum_i \frac{1}{D_i + \sigma_u^2} \quad (5.19)$$

$$\sigma_u^2 \leftarrow \max\left(\sigma_u^2 + \frac{S - (m-p)}{T}, 10^{-8}\right) \quad (5.20)$$

where:

- $\bar{D}$ is the mean sampling variance;
- m is the number of areas (15) and p the number of covariates (1).

The update drives the weighted sum of squared residuals toward its expected value, $m - p$. That is the Fay–Herriot moment condition, a close relative of the REML estimator. The mean squared error of each EBLUP is approximated by its leading term:

$$\text{mse}(\hat{\theta}_i) \approx \gamma_i D_i \quad (5.21)$$

and the standard errors and 95% intervals reported below come from it. With fewer than four areas the estimates are left direct.

5.4.5 Why the pooled variance matters: severe wasting

The choice of the pooled proportion in Equation (5.17) is not a detail. It is what makes the method work for rare outcomes. With each area's own proportion, an area whose sample happened to contain almost no severely wasted children would get a sampling variance of almost zero. The smoother would then trust it completely, exactly where it is least reliable.

South Buganda shows the problem. Its DHS 2016 sample of 345 children contained no child below -3 SD, so its direct estimate is 0.00% (Table 5.4). Its own-proportion variance would be zero, and with it $\gamma = 1$ and a planned SAM need of zero. With the pooled variance, its shrinkage weight is 0.62 and its EBLUP 0.59%. That is still the lowest in the country, but it is no longer an artefact.

At the other end, West Nile's direct 5.96% is pulled to 4.13% ($\gamma = 0.58$). Karamoja's 3.27% becomes 2.44%, and Bugisu's 3.20% becomes 2.36%. The smoothed range, 0.6% to 4.1%, is much narrower than the direct 0.0% to 6.0% (Table 5.5). West Nile, Karamoja and Bugisu remain clearly the highest.

Table 5.4: Fay-Herriot small-area estimates: Severe wasting

Sub-region	n	Direct	EBLUP	Shrinkage weight	EBLUP s.e.
Acholi	269	1.40%	1.47%	0.56	0.78%
Ankole	290	0.76%	1.09%	0.58	0.76%
Bugisu	204	3.20%	2.36%	0.49	0.84%
Bukedi	326	0.93%	1.17%	0.61	0.74%
Bunyoro	316	0.16%	0.72%	0.60	0.74%
Busoga	399	0.76%	1.04%	0.65	0.69%
Kampala	164	1.53%	1.54%	0.44	0.88%
Karamoja	227	3.27%	2.44%	0.52	0.82%
Kigezi	190	1.03%	1.30%	0.47	0.85%
Lango	300	2.12%	1.88%	0.59	0.76%
North Buganda	347	1.01%	1.22%	0.62	0.72%
South Buganda	345	0.00%	0.59%	0.62	0.73%
Teso	367	0.29%	0.75%	0.64	0.71%
Tooro	372	1.59%	1.57%	0.64	0.71%
West Nile	297	5.96%	4.13%	0.58	0.76%

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_sae_severe_wasting.csv).

5.4.6 Effect across the six indicators

Table Table 5.5 summarises the smoothing, and Figure Figure 5.3 shows each sub-region's direct estimate and EBLUP.

Table 5.5: Small-area smoothing: effect on each indicator

Indicator	Survey	Direct range	EBLUP range	Shrinkage weight
ANC4+	7B	44.5% - 68.1%	46.5% - 67.0%	0.82 - 0.89
DPT3	7B	71.2% - 91.1%	75.1% - 86.8%	0.42 - 0.60
Facility delivery	7B	58.4% - 94.7%	59.5% - 93.2%	0.91 - 0.95
PNC after discharge	7B	6.2% - 38.2%	6.7% - 36.5%	0.92 - 0.95
Fever (2 wk)	91	8.9% - 62.9%	10.0% - 61.6%	0.95 - 0.97
Severe wasting	7B	0.0% - 6.0%	0.6% - 4.1%	0.44 - 0.65

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_sae_summary.csv).

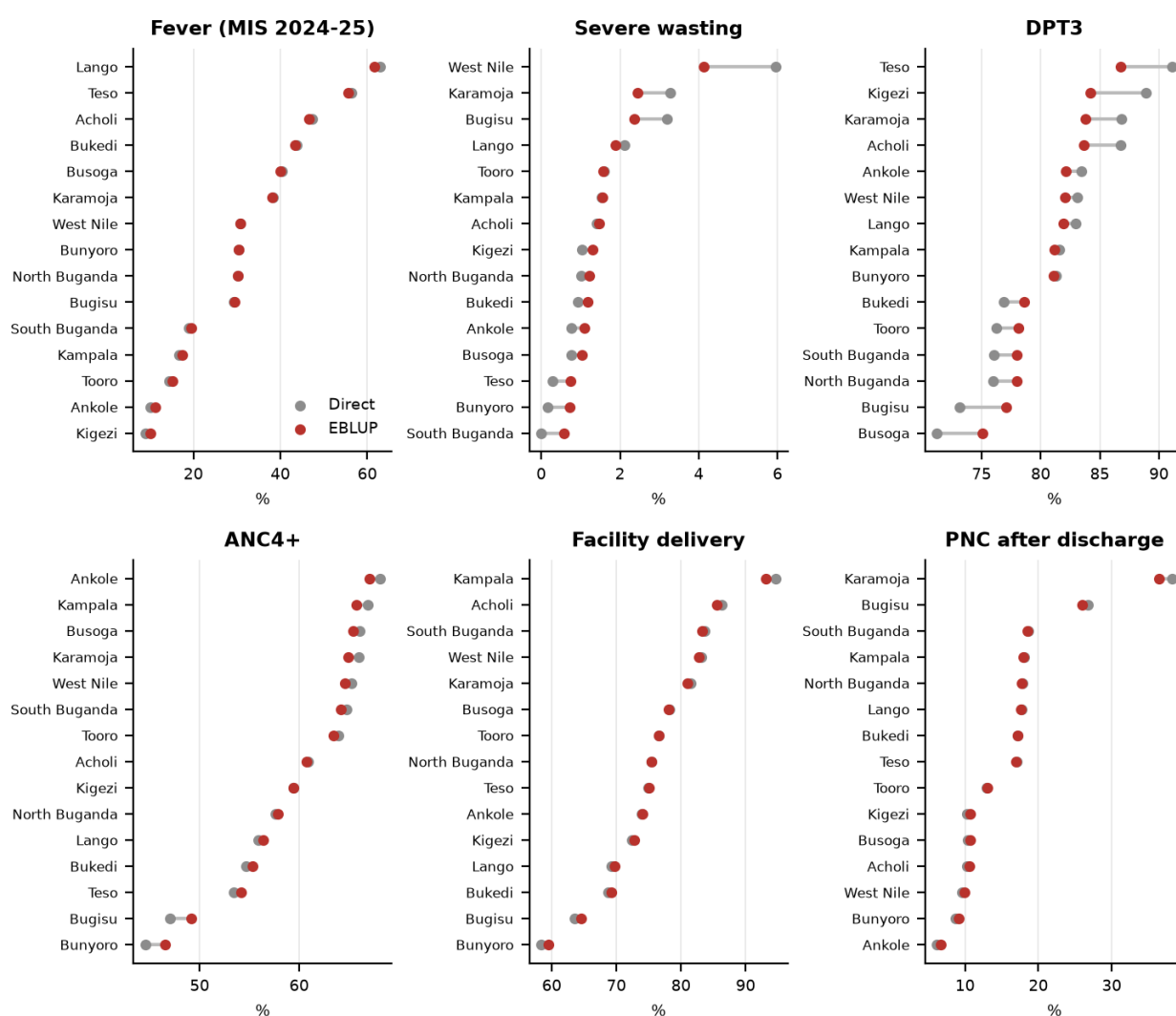


Figure 5.3: Direct survey estimates (grey) and Fay-Herriot EBLUPs (red) by sub-region: noisy estimates move toward the model

Source: HPRAS database, run uga-unconstrained-2026

The shrinkage weight is the key to reading the table.

- **Fever (γ 0.95–0.97).** Samples are large (300 to 534 children) and sub-regions differ enormously, so the direct estimates are kept almost unchanged (Table 5.6). The malaria geography is signal, not noise.
- **Facility delivery (γ 0.91–0.95), postnatal care (γ 0.92–0.95) and ANC4+ (γ 0.82–0.89)** rest on several hundred recent births per sub-region and move little.
- **DPT3 (γ 0.42–0.60)** is the most smoothed coverage indicator: small samples and modest true differences. The direct range of 71.2% to 91.1% narrows to 75.1% to 86.8%; Kigezi's 88.9%, from only 119 children, becomes 84.2%.
- **Severe wasting (γ 0.44–0.65),** discussed above.

Table 5.6: Fay-Herriot small-area estimates: Fever (2 wk)

Sub-region	n	Direct	EBLUP	Shrinkage weight	EBLUP s.e.
Acholi	380	47.25%	46.59%	0.96	3.34%
Ankole	300	10.04%	11.23%	0.95	3.74%
Bugisu	410	29.29%	29.39%	0.96	3.22%
Bukedi	482	43.70%	43.30%	0.97	2.98%
Bunyoro	532	30.40%	30.44%	0.97	2.84%
Busoga	452	40.35%	40.04%	0.96	3.07%
Kampala	328	16.77%	17.52%	0.95	3.58%

Sub-region	n	Direct	EBLUP	Shrinkage weight	EBLUP s.e.
Karamoja	534	38.25%	38.06%	0.97	2.83%
Kigezi	343	8.95%	10.05%	0.95	3.51%
Lango	393	62.92%	61.62%	0.96	3.29%
North Buganda	401	30.20%	30.27%	0.96	3.25%
South Buganda	431	19.01%	19.50%	0.96	3.14%
Teso	464	56.39%	55.52%	0.96	3.03%
Tooro	392	14.36%	15.10%	0.96	3.29%
West Nile	461	30.79%	30.84%	0.96	3.04%

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_sae_fever_2wk.csv).

Figure 5.4 maps the smoothed coverage of ANC4+, facility delivery and DPT3 by sub-region. Facility delivery is highest in Kampala (93.2%), Acholi (85.5%) and South Buganda (83.2%), and lowest in Bunyoro (59.5%) and Bugisu (64.5%). ANC4+ is lowest in Bunyoro (46.5%) and Bugisu (49.1%). Bunyoro and Bugisu therefore stand out on both maternal indicators. DPT3 is highest in the north-east, Teso (86.8%) and Karamoja (83.8%), and lowest in Busoga (75.1%). These smoothed values are the coverage baselines HM-03 and HM-04 fall back on where a district has no league-table observation.

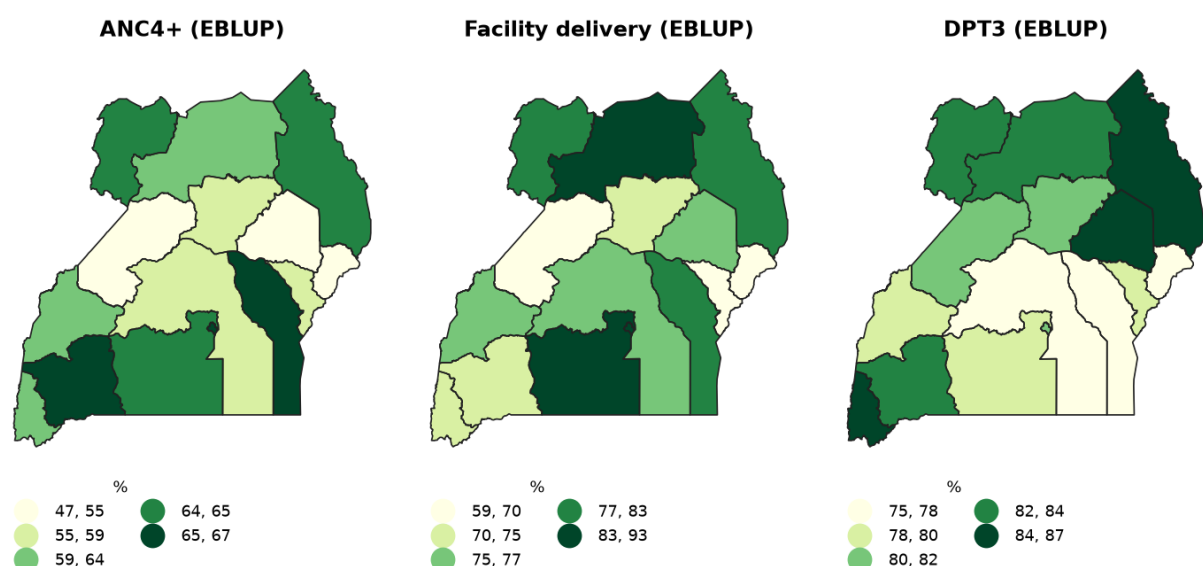


Figure 5.4: Coverage by sub-region after Fay-Herriot smoothing, DHS 2016

Source: HPRAS database, run uga-unconstrained-2026. Boundaries (c) OpenStreetMap contributors (ODbL).

5.4.7 Comparison with HealthModelling

HealthModelling produced its own Fay-Herriot estimates of ANC4+ from the same survey, using design-based standard errors. The comparison is a direct test of the binomial approximation (Table 5.7).

Table 5.7: ANC4+: this engine's small-area estimates against HealthModelling's

Sub-region	Direct	EBLUP (this engine)	EBLUP (HealthModelling)	Difference (pp)
Acholi	60.9%	60.7%	60.8%	-0.01
Ankole	68.1%	67.0%	66.9%	0.11
Bugisu	47.0%	49.1%	49.9%	-0.74
Bukedi	54.7%	55.3%	55.6%	-0.22
Bunyoro	44.5%	46.5%	48.2%	-1.72
Busoga	66.1%	65.4%	65.6%	-0.21
Kampala	66.9%	65.7%	65.9%	-0.21
Karamoja	66.0%	64.9%	64.9%	0.04
Kigezi	59.4%	59.4%	59.5%	-0.02

Sub-region	Direct	EBLUP (this engine)	EBLUP (HealthModelling)	Difference (pp)
Lango	55.9%	56.4%	56.5%	-0.08
North Buganda	57.6%	57.8%	57.9%	-0.03
South Buganda	64.8%	64.2%	64.3%	-0.11
Teso	53.4%	54.2%	54.2%	0.02
Tooro	64.0%	63.5%	63.7%	-0.25
West Nile	65.2%	64.6%	64.6%	-0.04

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_sae_anc4_vs_ref.csv).

Across the fifteen sub-regions:

- the two EBLUPs agree within 0.25 percentage points in thirteen;
- Bugisu differs by 0.74 points;
- Bunyoro differs by 1.72 points, with 46.5% here against 48.2% in HealthModelling. Bunyoro has the lowest direct estimate (44.5%), so it is the sub-region most sensitive to how much shrinkage is applied. HealthModelling's design-based variance for Bunyoro is evidently larger than the binomial approximation, and pulls the estimate further toward the mean.

All differences fall within the 0.03 (3 percentage points) recorded in the integration note. The approximation is adequate for planning; a design-based variance would replace it once the loader stores one.

5.5 The geography of need: maps and clusters

The five HM-02 maps show need per 1,000 population (per 100,000 for tuberculosis) by district in 2026, with local Moran clusters. The caution from Chapter 4 applies with more force here: most need rates vary at sub-region or UPHIA-region level, so districts within a region carry identical values, and the high Moran's I values partly reflect that construction. What the clusters identify reliably is which blocks of the country stand apart.

5.5.1 Malaria

Malaria: suspected cases needing care

Local Moran clusters (global I = 0.87, p = 0.001)

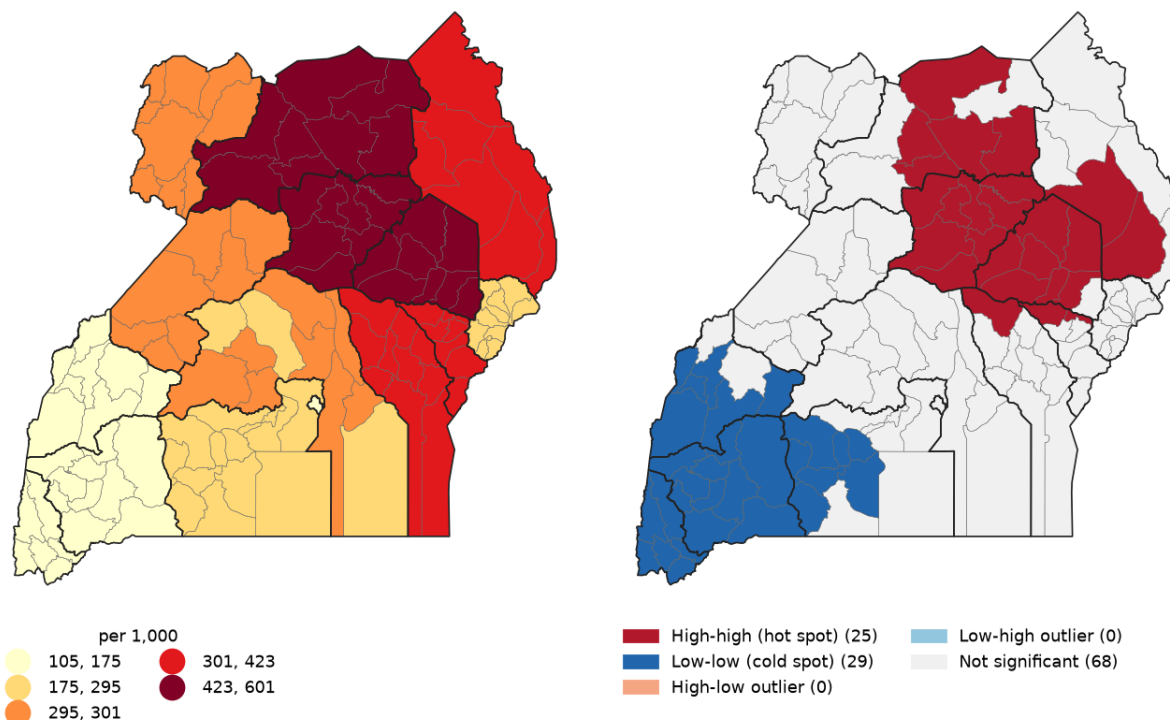


Figure 5.5: HM-02 - Malaria: suspected cases needing care (per 1,000), by district, 2026; right: local Moran (LISA) clusters, 999 permutations

Source: HPRAS database, run uga-unconstrained-2026; quality tier imputed. Boundaries (c) OpenStreetMap contributors (ODbL).

Malaria need (Figure 5.5) is the most strongly clustered layer in the whole atlas. Its global Moran's I is 0.87 ($p = 0.001$), the highest of the 41 layers across the ten modules. Need runs from 105 suspected episodes per 1,000 in the Kigezi districts, at the floor, to 601 per 1,000 in the Lango districts (Amolatar, Apac, Dokolo, Kole, Lira, Otuke and their neighbours).

The map divides the country in two:

- **A hot spot of 25 districts across the north and east:** Lango (eight districts), Teso (seven), Acholi (five), two each in Bukedi and Karamoja, and one in Busoga. This is the belt of highest child fever prevalence in the MIS 2024-25.
- **A cold spot of 29 districts across the south-west:** Ankole (ten districts), South Buganda (seven), Tooro (six) and Kigezi (six). This is where child fever prevalence is lowest.

For planning, districts in the hot spot need between two and almost six times as many malaria tests and treatments per head as districts in the cold spot. That need should shape the distribution of RDTs and artemisinin combinations, the clinical and laboratory time behind them (Chapter 6), and the allocation weights of HM-08. It also explains the highest per-capita requirements in the country: Dokolo, in Lango, has the highest in Chapter 6.

5.5.2 HIV: people needing antiretroviral therapy

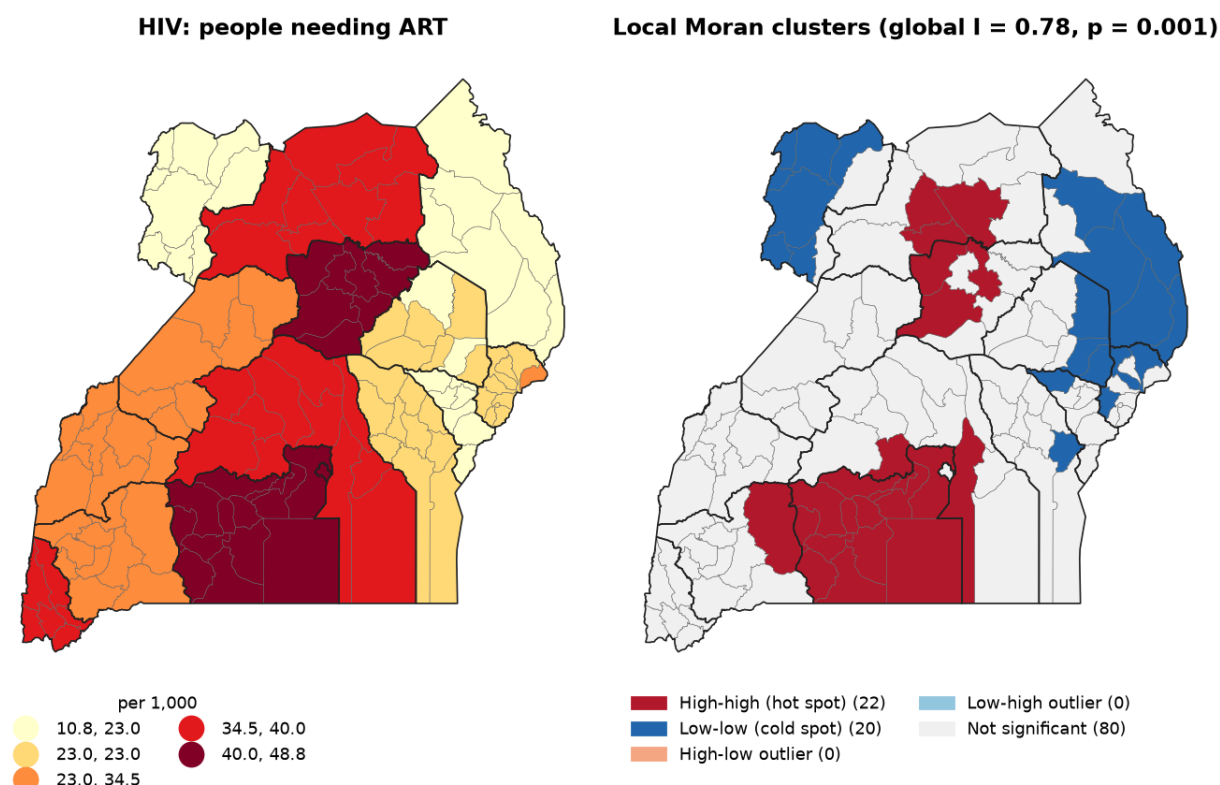


Figure 5.6: HM-02 - HIV: people needing ART (per 1,000), by district, 2026; right: local Moran (LISA) clusters, 999 permutations

Source: HPRAS database, run uga-unconstrained-2026; quality tier imputed. Boundaries (c) OpenStreetMap contributors (ODbL).

ART need per 1,000 population (Figure 5.6) runs from 10.8 in the Karamoja districts to 48.8 in South Buganda (Kalungu, Kyotera, Lyantonde, Masaka, Mpigi, Wakiso and the other districts of Central 1). The global Moran's I is 0.78 ($p = 0.001$).

- **The 22-district hot spot** is dominated by South Buganda (13 districts), with two North Buganda districts and one Ankole district adjoining it. A second group of three Acholi and three Lango districts reflects Mid North's UPHIA prevalence of 7.6%.
- **The 20-district cold spot** lies in West Nile (seven districts) and Karamoja (five), with Teso (three), Bugisu (three), Busoga and Bukedi. These are the UPHIA regions with prevalence of 2.1% to 4.5%.

The map is the main reason the per-capita requirement is lowest in the West Nile districts (Chapter 6). ART is the largest single cost line, and West Nile's HIV prevalence is the second-lowest in the country. A district such as Arua needs about a third as much ART per head as Masaka.

5.5.3 Severe acute malnutrition

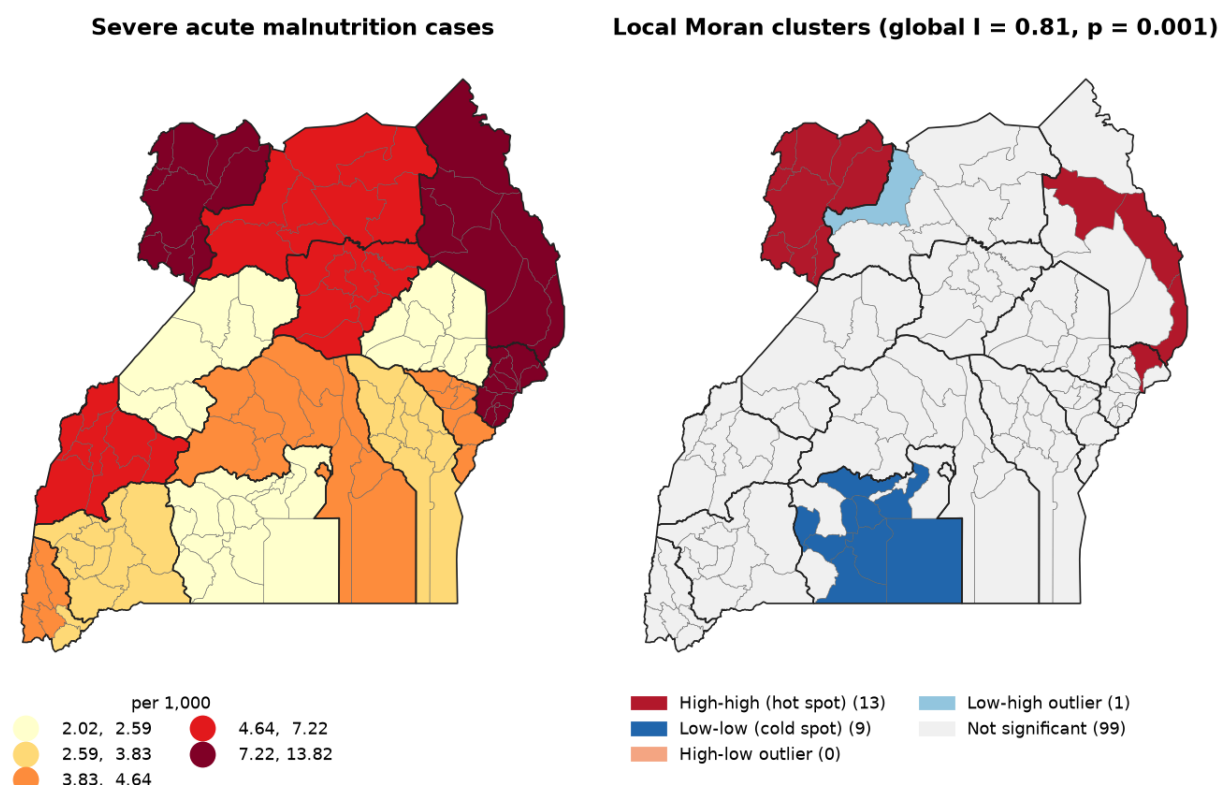


Figure 5.7: HM-02 - Severe acute malnutrition cases (per 1,000), by district, 2026; right: local Moran (LISA) clusters, 999 permutations

Source: HPRAS database, run uga-unconstrained-2026; quality tier imputed. Boundaries (c) OpenStreetMap contributors (ODbL).

SAM need (Figure 5.7) runs from 2.0 cases per 1,000 population in South Buganda to 13.8 in West Nile (Arua, Koboko, Maracha, Moyo, Pakwach, Zombo and the rest of the sub-region). The global Moran's I is 0.81 ($p = 0.001$).

- **The 13-district hot spot** is nine West Nile districts, three in Karamoja and one in Bugisu. These are the three sub-regions with the highest smoothed severe wasting.
- **The 9-district cold spot** is entirely South Buganda: Bukomansimbi, Gomba, Kalangala, Kalungu, Kyotera, Lwengo, Lyantonde, Masaka and Mpigi.
- **Amuru**, in Acholi, is a low-high outlier on the West Nile border.

The SAM map is almost the mirror image of the HIV map. The south-central districts carry the highest HIV need and the lowest malnutrition need, and West Nile the reverse. That is a strong argument against a single "burden" weight in allocation. The manual's principle of keeping dimensions separate applies to need as much as to gaps.

The level rests on the uncertain factor $K = 2.6$ and the shape on a 2016 survey smoothed with shrinkage weights of only 0.44–0.65, so the SAM plan should be checked against nutrition surveillance before commodities are committed.

5.5.4 Hypertension

Hypertension: people needing treatment

Local Moran clusters (global I = 0.70, p = 0.001)

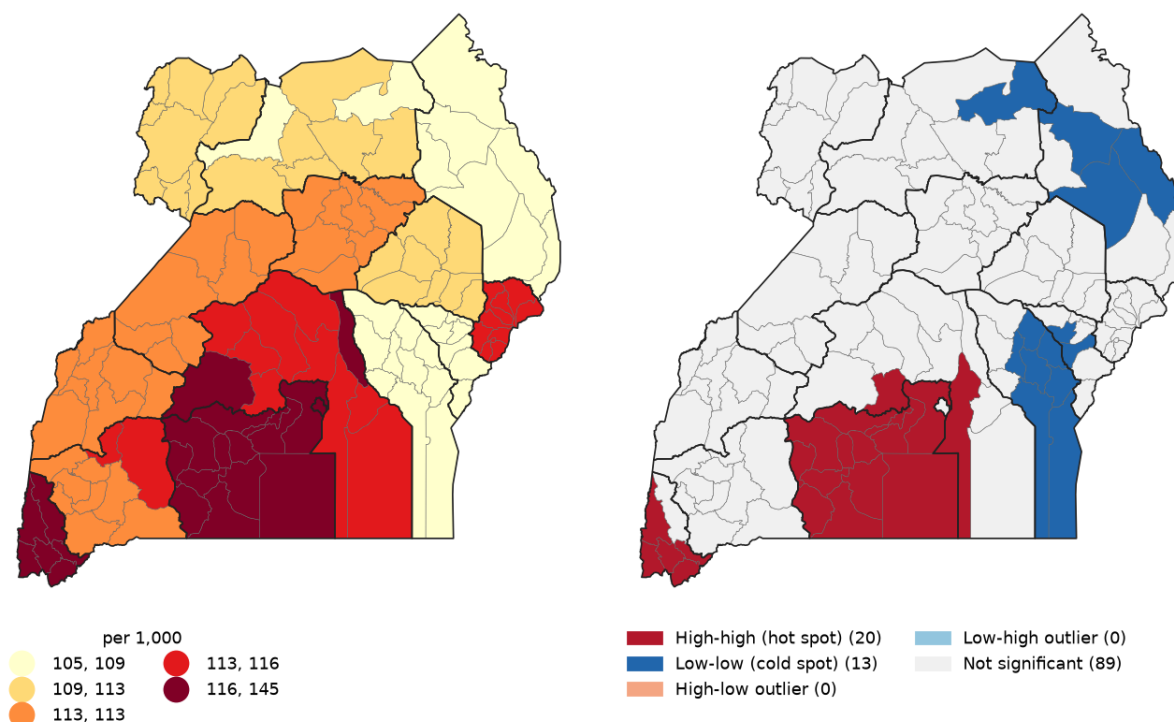


Figure 5.8: HM-02 - Hypertension: people needing treatment (per 1,000), by district, 2026; right: local Moran (LISA) clusters, 999 permutations

Source: HPRAS database, run uga-unconstrained-2026; quality tier imputed. Boundaries (c) OpenStreetMap contributors (ODbL).

Hypertension need (Figure 5.8) runs from 105.4 per 1,000 in Busoga to 124.3 in the South Buganda districts and 144.6 in Kampala. The global Moran's I is 0.70 ($p = 0.001$).

The rate is national, so the map shows adult age structure, not blood pressure:

- **Hot spot (20 districts):** South Buganda (13), Kigezi (5) and North Buganda (2), where adults are 51.6% to 55.2% of the population.
- **Cold spot (13 districts):** Busoga (7), Karamoja (3), Bukedi (2) and Acholi (1), where adults are 46.9% to 48.3%.

Any real sub-national difference in blood-pressure prevalence, for example between urban and rural populations, is not in the model. A regional STEPS analysis would be the obvious refinement.

5.5.5 Tuberculosis

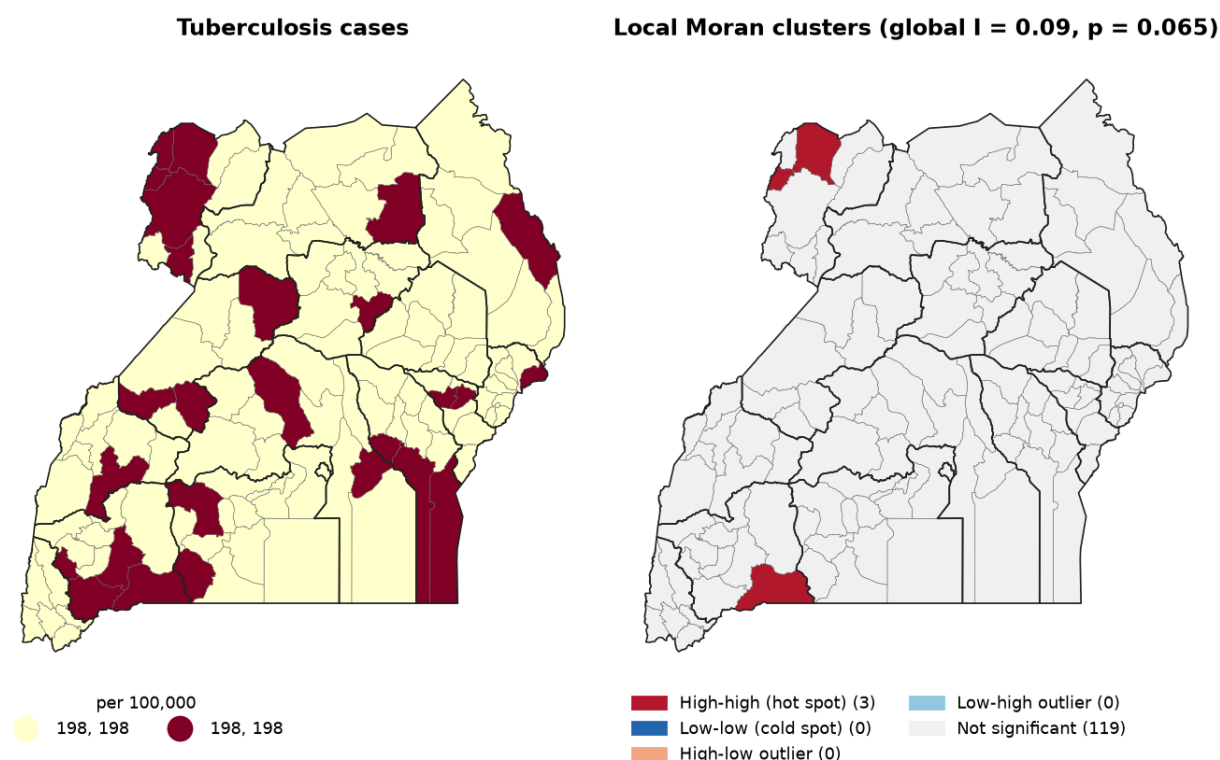


Figure 5.9: HM-02 - Tuberculosis cases (per 100,000), by district, 2026; right: local Moran (LISA) clusters, 999 permutations

Source: HPRAS database, run uga-unconstrained-2026; quality tier normed. Boundaries (c) OpenStreetMap contributors (ODbL).

The tuberculosis map (Figure 5.9) is flat. Every district carries the WHO national incidence of 198 per 100,000, because no sub-national incidence is loaded. Its global Moran's I of 0.09 is not significant ($p = 0.065$). The three districts flagged as a local hot spot (Isingiro, Maracha, Yumbe) are numerical artefacts of a constant surface, not evidence of clustering. The map shows where the evidence is missing, not where TB is. District notification data from the national TB programme, corrected for case detection, would be the natural source for a shape.

5.6 Data quality and limitations

Almost every need rate is normed, imputed or assumed (Table 5.1).

- **Normed** rates (vaccine schedules, TB incidence, the malaria anchor, caesarean need, surgery) are credible national levels but silent on geography.
- **Imputed** rates are national anchors apportioned by a survey covariate (malaria, ART, PMTCT, SAM), survey rates adapted to another population (hypertension, family planning, severe mental disorders) and the OPD floor. Their shapes are only as fine as the sub-region, or the UPHIA region for HIV, and they move between survey rounds.
- **Assumed** rates (HIV testing volume, severe childhood illness, sick newborns, obstetric complications, admissions per outpatient contact) have no Ugandan measurement and should be the first replaced with HMIS-derived rates, using the care-seeking correction.

Beyond the tiers, rates are held constant over the horizon, although the manual permits a trend or a link to HealthModelling's forecasts for HIV, TB and malaria; need therefore grows only with population. Apart from outpatient care, no rate varies below sub-region level. Structure, SAM and coverage rest on the DHS 2016. And the binomial smoothing variance is adequate, as the HealthModelling comparison shows, but it is not a design-based variance.

5.7 Implications for planning

- **Malaria, HIV and malnutrition have different maps; keep them apart.** The north and north-east carry malaria, south and central Uganda carry HIV, and West Nile and Karamoja carry severe malnutrition. A single burden index would average these into a meaningless middle. Programme budgets and commodity distribution keys should follow each map separately, not population or last year's issues: malaria need per head is two to almost six times higher in the hot spot than in the cold spot, and ART need per adult almost four times higher in South Buganda than in Karamoja.
- **Invest in the evidence behind the largest imputed and assumed rates.** District HIV estimates, TB notifications by district, a regional STEPS analysis and HMIS-based incidence (divided by the 72.3% care-seeking fraction) would each replace a flat or coarse rate with a district one. The most consequential is the OPD rate: moving from the utilisation floor to a condition build-up would change the second-largest cost line.
- **Use smoothed, not raw, sub-regional survey estimates in any formula.** The Fay–Herriot step changes little where samples are large but removes artefacts where they are small, such as South Buganda's zero severe wasting or Kigezi's DPT3 from 119 children.
- **Refresh the malaria shape with each survey round.** Sub-regional fever prevalence moved by as much as thirty percentage points between surveys; the hot and cold spots should be re-examined when the next MIS is published.

CHAPTER 6

6 Service demand and resource requirement (HM-03)

Chapter 5 established how many people need each service. This chapter answers the next question: what must be delivered, and what does it take to deliver it? HM-03 turns need into a required volume of services at a stated coverage target. It spreads that volume across the levels of the health system. It then expands every unit of service into the staff time, medicines, supplies, equipment and space it consumes. The engine manual calls this "the module that does the real work of the system". Every coefficient comes from the norms database, `service_norm_line`, and none is written in code.

The result is the **unconstrained requirement**. It is what the 28 modelled services would need in 2026 and 2030 if coverage rose along the target path, regardless of what exists today. Comparing it with what exists is the work of HM-04 and HM-05 (Chapters 7 and 8). Pricing it in detail is the work of HM-06 (Chapter 9). Two points frame everything that follows:

- **The requirement covers 28 modelled services, not the whole health sector.** It excludes administration, national referral and specialised hospitals, most non-communicable and surgical care beyond the modelled tracers, and all services outside the catalogue. The health budget covers everything. The ratio between the two is to be read, not closed.
- **The coverage targets are illustrative.** The run uses the target set UGA-NDP-ILLUSTRATIVE, an NDP-style trajectory built for this report to show how the engine works. It is not an approved government target. Every volume and cost below scales with it, and a Ministry target set would replace it.

6.1 The planning identity

6.1.1 Required volume

The required volume of service s in district d and year t is:

$$Q_{s,d,t} = N_{s,d,t} \times C_{s,t}^* \times \nu_s \quad (6.1)$$

where:

- $Q[s,d,t]$ is the required volume, in service units (visits, doses, deliveries, bed-days, treatment-years);
- $N[s,d,t]$ is the need from HM-02;
- $C[s,t]$ is the target coverage: the share of people in need who receive the service completely*;
- $\nu[s]$ is the number of units per complete case.

The coverage semantics matter. Coverage is the share who receive the complete package, such as four antenatal visits or three pentavalent doses. Partial coverage is a lower C^* , never a lower ν . Mixing the two double-counts the resource arithmetic. The units per case in the catalogue are:

- 4 antenatal visits per pregnancy;
- 3 doses each of pentavalent and pneumococcal vaccine, 4 of polio, 2 each of measles-rubella, rotavirus and HPV, and 1 of BCG;
- 3 postnatal contacts per birth;
- 7 bed-days per sick newborn and 3 per non-surgical obstetric complication;
- 4 bed-days per severe childhood illness admission and 6 per complicated SAM stabilisation;

- 4.2 bed-days per general admission, the general average length of stay;
- 1 for everything else.

For example, the 2.18 million pregnancies of 2026 need 8.7 million antenatal visits at full coverage. At the 2026 target of 62% they need 5.39 million.

6.1.2 Coverage targets

The target for each service rises linearly from a 2026 baseline to a 2030 target:

$$C_{s,t}^* = C_{s,2026} + (C_{s,2030} - C_{s,2026}) \times \frac{t-2026}{4} \quad (6.2)$$

where $C[s,2026]$ is the baseline and $C[s,2030]$ the end-of-horizon target, both from `scripts/seed_norms.py`. Table 6.2 shows both.

Where a survey measure exists, the baselines are measured:

- immunisation uses the DHS 2016 survey coverage of children aged 12–23 months where the survey measures it (DPT3 79.7%), not the administrative returns;
- postnatal care uses the DHS share of mothers checked *after* discharge, 15.0%;
- family planning uses demand satisfied, 63.5%, because need is total demand;
- hypertension treatment uses the 15.7% implied by STEPS 2023, where 84.3% of adults with raised blood pressure are not on medication.

Where nothing is measured, the baselines are assumptions and say so. SAM treatment starts at 35%, NCD screening at 25%, and the hospital services at stated assumptions.

The targets for 2030 are ambitious:

- 80% outpatient coverage of need, up from 62%;
- 85% ANC4 coverage, up from 62%;
- 90% facility delivery, up from 74%;
- 90% to 98% for the infant vaccines;
- 35% of hypertensive adults treated, up from 16%;
- 60% of sick newborns reached, up from 25%.

Those rises are why the requirement grows much faster than the population.

6.1.3 Level mix

A service is not delivered at one level. The required volume is split across facility levels by a normative mix:

$$Q_{s,d,l,t} = Q_{s,d,t} \times \mu_{s,l}, \quad \sum_l \mu_{s,l} = 1 \quad (6.3)$$

where:

- l is the facility level: HC II, HC III, HC IV, general hospital or regional referral hospital;
- $\mu[s,l]$ is the share of service s delivered at level l , from `service_level_mix`.

Some examples of the mix:

- outpatient consultations: 30% at HC II, 42% at HC III, 16% at HC IV and 12% at general hospitals;
- normal deliveries: 55% at HC III, 22% at HC IV and 23% at general hospitals;
- caesarean sections: 28% at HC IV, 52% at general hospitals and 20% at regional referral hospitals;
- ART: 45% at HC III, 30% at HC IV and 25% at general hospitals.

The mix is normative. It states where the service *should* be delivered, and it changes the cost, because the norm for a delivery at HC III is not the norm for a delivery at a general hospital. Planning to deliver 28% of caesareans at HC IV when some HC IVs have no functioning theatre is exactly the tension HM-05 is built to expose. The mix expresses policy, and the gap module tests it against reality.

6.1.4 Referral services

Three services have no need of their own. Their need arises from the planned volume of a parent service, so HM-03 resolves them after the parents are known:

$$N_{c,d,t} = Q_{p(c),d,t} \times \rho_c \quad (6.4)$$

where:

- c is the referral (child) service and $p(c)$ its parent;
- $\rho[c]$ is the referral rate from `service_norm`.

The required volume then follows from Equation (6.1), with the child's own target and units per case. The three pairs are:

- caesarean section, at 10% of planned deliveries (the WHO population need of 10–15% of births);
- inpatient admissions, at 0.0385 per planned outpatient contact. The all-admissions rate of 0.055 is reduced by the 30% under-five share that is planned separately as severe childhood illness. Each admission is multiplied by the average length of stay of 4.2 days;
- complicated SAM, at 12% of SAM cases treated.

The manual is explicit that referral runs off the **required volume** of the parent, not off its need. A plan that attends 74% of births in facilities generates caesarean demand from that 74%.

This design has a consequence that dominates the growth of the hospital requirement. When a parent's coverage target rises, the child's volume rises with it, and then rises again through its own target. Inpatient bed-days show the effect clearly:

- in 2026: 19.3 million planned outpatient contacts $\times$ 0.0385 $\times$ a 58% target $\times$ 4.2 days gives 1.81 million bed-days;
- in 2030: 27.9 million contacts and an 80% target give 3.61 million bed-days.

Bed-days double over the horizon, while population grows 12.1%.

6.1.5 From volumes to resources

Each unit of service at each level has a **norm**, a bill of materials listing every resource it consumes. The requirement for resource r is:

$$R_{r,s,d,l,t} = Q_{s,d,l,t} \times \eta_{r,s,l} \times \sigma_{r,s,l} \times (1 + \omega_{r,s,l}) \quad (6.5)$$

where:

- $R[r,s,d,l,t]$ is the quantity of resource r required for service s at level l ;
- $\eta[r,s,l]$ is the quantity of resource r per unit of service when it is used (minutes of a cadre's time, tablets, tests, bed-days);
- $\sigma[r,s,l]$ is the share of cases that use it;
- $\omega[r,s,l]$ is the wastage allowance.

The engine keeps both this disaggregated form and the sum over services and levels. The disaggregated form is what lets any number be traced back to its norm line, and what HM-08 needs to trade services off.

The norm for malaria diagnosis and treatment at a health centre III shows how the formula reads. Each suspected case uses:

- one rapid diagnostic test, with 5% wastage;
- adult artemether-lumefantrine for 45% of cases and paediatric for 50%, each with 3% wastage;
- injectable artesunate for 3% of cases, the severe cases;
- 9 minutes of a clinical officer, 5 minutes of an enrolled nurse, 4 minutes of a laboratory technician and 2 minutes of a records officer;
- allocations for supervision, referral transport (2% of cases), utilities, equipment and infrastructure.

The staff-time lines in this norm are flagged *assumed*, and the drug and test lines *normed*. A requirement is only as good as the worst tier among the lines it rests on. Chapter 9 prices the lines.

6.2 Workforce: the WISN conversion

6.2.1 Available working time

Staff norms are in minutes. Converting minutes to posts is the WHO Workload Indicators of Staffing Need (WISN) method. The first step is the time a full-time worker is actually available for service delivery in a year:

$$AWT_c = (W - L - H - T - A) \times h \times 60 \times (1 - \alpha_c) \quad (6.6)$$

where:

- AWT_c is the available working time of cadre c , in minutes per FTE per year;
- W is the number of working days in the year;
- L , H , T and A are the days of annual leave, public holidays, training and other absence;
- h is the number of working hours per day;
- α_c is the category allowance: the share of time taken by meetings, record-keeping, supervision and travel.

The manual's worked example makes the arithmetic concrete. Take 260 working days, less 21 days of leave, 12 public holidays, 5 training days and 8 days of absence. That leaves 214 service days. At 8 hours a day, 214 days give 102,720 minutes. After a 20% category allowance, the available working time is **82,176 minutes per FTE per year**.

If a district needs 500,000 consultations at 1.2 doctor-minutes each, that is 600,000 minutes, or 7.3 FTE. The naive calculation, 10,000 hours divided by a 2,080-hour year, gives 4.8 FTE. It understates the requirement by a third, entirely because it ignores leave, training and non-clinical time. The manual calls omitting the allowance "the most common workforce-planning error in the sector".

The Uganda norms (Table 6.1) use 261 working days less 49 days of leave, holidays, training and absence, and 8 hours a day. The category allowance varies by cadre group:

- 25% for clinical and nursing cadres, giving 76,320 minutes per FTE-year;
- 22% for allied health cadres, giving 79,373 minutes;
- 15% for support cadres, giving 86,496 minutes;
- 30% for village health team members, giving 71,232 minutes.

Table 6.1: Cadres, pay and WISN available working time

Cadre	Group	Training (yrs)	Scale	Basic pay UGX/month	Working days	Leave+hol.+train.+abs.	Hours/day	Allowance	AWT min/FTE-yr
Specialist / consultant	clinical	10.0	U2	5,000,000	261.0	49.0	8.0	25%	76,320
Medical officer	clinical	5.0	U4	3,000,000	261.0	49.0	8.0	25%	76,320
Clinical officer	clinical	3.0	U5	2,000,000	261.0	49.0	8.0	25%	76,320
Anaesthetic officer	clinical	3.0	U5	2,000,000	261.0	49.0	8.0	25%	76,320
Registered nurse	nursing	3.0	U5	2,000,000	261.0	49.0	8.0	25%	76,320
Enrolled nurse	nursing	2.0	U7	1,000,000	261.0	49.0	8.0	25%	76,320
Registered midwife	nursing	3.0	U5	2,000,000	261.0	49.0	8.0	25%	76,320
Enrolled midwife	nursing	2.0	U7	1,000,000	261.0	49.0	8.0	25%	76,320
Pharmacist	allied	4.0	U4	3,000,000	261.0	49.0	8.0	22%	79,373
Pharmacy technician	allied	2.0	U5	2,000,000	261.0	49.0	8.0	22%	79,373
Laboratory technologist	allied	3.0	U5	2,000,000	261.0	49.0	8.0	22%	79,373
Laboratory technician	allied	2.0	U7	1,000,000	261.0	49.0	8.0	22%	79,373
Radiographer	allied	3.0	U5	2,000,000	261.0	49.0	8.0	22%	79,373
Nutritionist	allied	3.0	U5	2,000,000	261.0	49.0	8.0	22%	79,373
Health records officer	support	2.0	U7	1,000,000	261.0	49.0	8.0	15%	86,496
Administrative officer	support	3.0	U5	2,000,000	261.0	49.0	8.0	15%	86,496
Support staff	support	0.0	U8	1,100,000	261.0	49.0	8.0	15%	86,496
Village health team member	community	0.2	VHT	50,000	261.0	49.0	8.0	30%	71,232

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_cadres.csv).

6.2.2 FTE required

The workload requirement of each cadre is the staff minutes of all modelled services, divided by the available working time:

$$\text{FTE}_{c,d,t} = \frac{\sum_s \sum_l Q_{s,d,l,t} \times \tau_{c,s,l} \times \sigma_{c,s,l}}{\text{AWT}_c} \quad (6.7)$$

where:

- $\tau_{c,s,l}$ is the minutes of cadre c per unit of service s at level l (the η of Equation (6.5) for a staff line);
- $\sigma_{c,s,l}$ is the share of cases on which that cadre's time is spent.

The manual also defines a minimum staffing floor. A facility that is open must be staffed even if its workload is low: a HC III cannot run on 0.3 of a midwife. The floor is applied when the requirement is compared with facilities in HM-04 and HM-05. The FTE figures in this chapter are the workload requirement before floors.

6.3 Results

6.3.1 Requirement by service

At the illustrative targets, the 28 modelled services require **1,966 bn UGX in 2026** (531 m USD at the plan rate of 3,700 UGX per USD). The requirement reaches **3,084 bn UGX in 2030** (834 m USD). That is a rise of 56.9% over a period in which the population grows 12.1%. The rest of the rise comes from the coverage targets, and from their compounding through the referral services. The 2026 requirement is 41,447 UGX per person (11.20 USD). Figure 6.1 and Table 6.2 give the service detail.

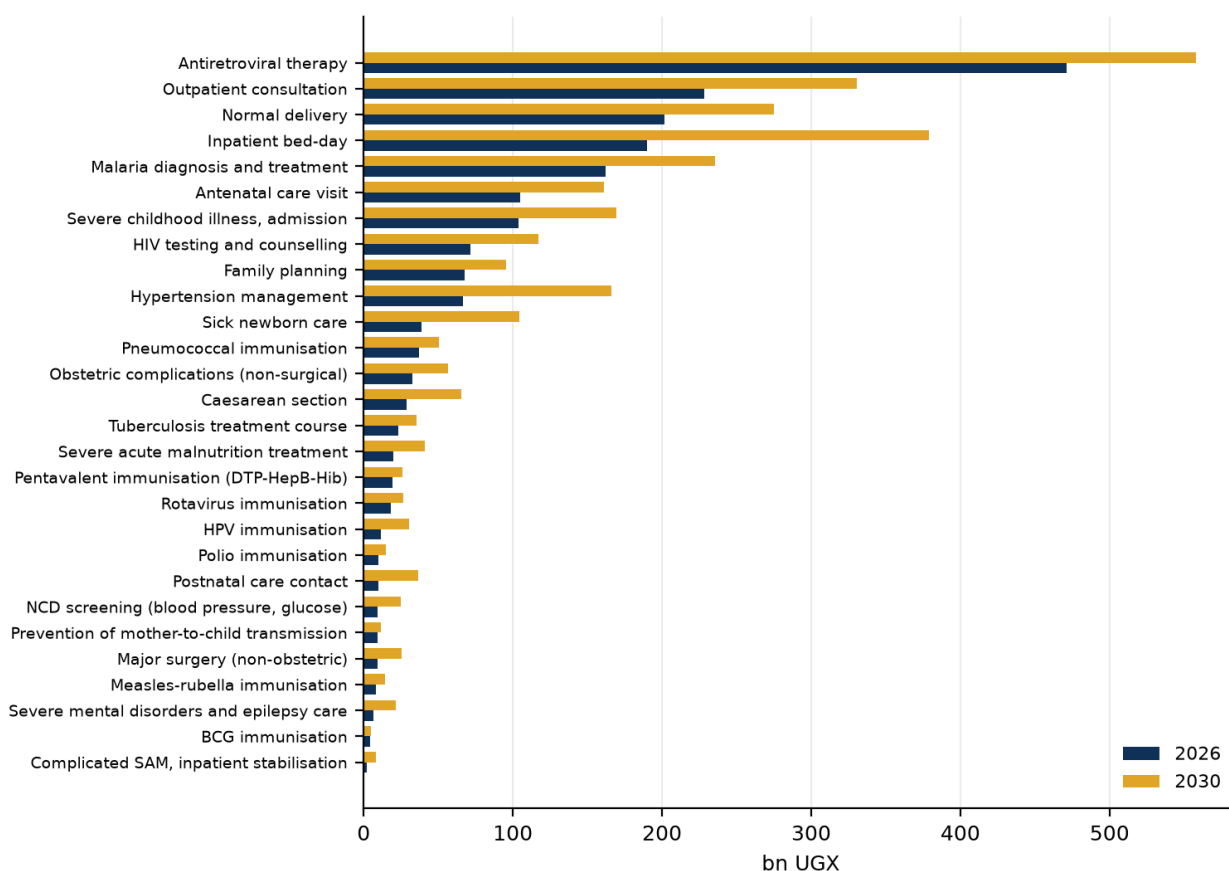


Figure 6.1: Requirement at target coverage by service, 2026 and 2030 (bn UGX)

Source: HPRAS database, run uga-unconstrained-2026

Table 6.2: Requirement by service at target coverage, 2026 and 2030

Service	Target 2026	Units 2026	Cost 2026 (bn UGX)	Share	Target 2030	Units 2030	Cost 2030 (bn UGX)
Antiretroviral therapy	90%	1,350,011	471.5	24.0%	95%	1,597,643	558.0
Outpatient consultation	62%	19,287,133	228.3	11.6%	80%	27,901,495	330.3
Normal delivery	74%	1,437,148	201.7	10.3%	90%	1,959,628	275.0
Inpatient bed-day	58%	1,808,863	190.0	9.7%	80%	3,609,337	379.1
Malaria diagnosis and treatment	71%	10,113,481	162.1	8.2%	92%	14,692,362	235.5
Antenatal care visit	62%	5,394,354	104.7	5.3%	85%	8,291,405	161.0
Severe childhood illness, admission	55%	1,112,001	103.7	5.3%	80%	1,813,401	169.2
HIV testing and counselling	55%	5,987,951	71.7	3.6%	80%	9,764,883	116.9
Family planning	64%	2,823,304	67.6	3.4%	80%	3,987,818	95.5
Hypertension management	16%	854,644	66.4	3.4%	35%	2,136,068	165.9
Sick newborn care	25%	339,866	38.8	2.0%	60%	914,493	104.3
Pneumococcal immunisation	79%	3,920,069	37.3	1.9%	95%	5,285,082	50.3
Obstetric complications (non-surgical)	55%	256,356	32.6	1.7%	85%	444,182	56.5
Caesarean section	42%	60,360	28.9	1.5%	70%	137,174	65.6
Tuberculosis treatment course	66%	61,994	23.3	1.2%	90%	94,778	35.6
Severe acute malnutrition treatment	35%	80,687	19.8	1.0%	65%	167,999	41.1
Pentavalent immunisation (DTP-HepB-Hib)	80%	3,954,804	19.4	1.0%	95%	5,285,082	25.9
Rotavirus immunisation	70%	2,315,652	18.3	0.9%	90%	3,337,946	26.4
HPV immunisation	35%	579,794	11.8	0.6%	80%	1,485,789	30.2
Polio immunisation	69%	4,565,143	10.0	0.5%	90%	6,675,893	14.6
Postnatal care contact	15%	873,941	9.8	0.5%	50%	3,266,047	36.6
NCD screening (blood pressure, glucose)	25%	1,874,459	9.2	0.5%	60%	5,043,693	24.8
Prevention of mother-to-child transmission	85%	54,408	9.2	0.5%	95%	68,176	11.5
Major surgery (non-obstetric)	8%	18,976	9.1	0.5%	20%	53,186	25.4
Measles-rubella immunisation	61%	2,004,693	8.3	0.4%	95%	3,523,388	14.5
Severe mental disorders and epilepsy care	10%	48,387	6.4	0.3%	30%	162,748	21.4
BCG immunisation	96%	1,592,838	4.3	0.2%	98%	1,817,326	4.9
Complicated SAM, inpatient stabilisation	40%	23,238	2.1	0.1%	75%	90,720	8.1

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_req_service.csv).

Five services account for almost two-thirds of the 2026 requirement:

- **Antiretroviral therapy:** 471.5 bn UGX (24.0%), for 1.35 million people on treatment at a 90% target. ART is expensive per person, and the target is already high, so its growth is modest. It rises to 558.0 bn in 2030, when its share falls to 18.1%.
- **Outpatient consultations:** 228.3 bn (11.6%), for 19.3 million visits.
- **Normal deliveries:** 201.7 bn (10.3%), for 1.44 million deliveries.
- **Inpatient bed-days:** 190.0 bn (9.7%), for 1.81 million bed-days.
- **Malaria diagnosis and treatment:** 162.1 bn (8.2%), for 10.1 million suspected cases.

By 2030 the order changes. Inpatient bed-days double to 379.1 bn (12.3%) and become the second-largest line, for the reason set out above.

The fastest-growing lines are the services whose targets rise furthest from low baselines:

- hypertension management, 66.4 bn to 165.9 bn;
- sick newborn care, 38.8 bn to 104.3 bn;
- postnatal care, 9.8 bn to 36.6 bn;
- HPV vaccination, 11.8 bn to 30.2 bn;
- caesarean sections, 28.9 bn to 65.6 bn;
- severe mental disorders, 6.4 bn to 21.4 bn.

These are the lines where the illustrative targets matter most. A slower target path would change them most.

At the other end, BCG vaccination, already at 96% coverage, barely moves, from 4.3 bn to 4.9 bn. Immunisation as a whole is a small share of cost, because doses are cheap relative to the clinical services. Pneumococcal vaccine is the largest immunisation line, at 37.3 bn in 2026.

6.3.2 Requirement by level

Figure 6.2 and Table 6.3 show where the requirement falls by facility level in 2026.

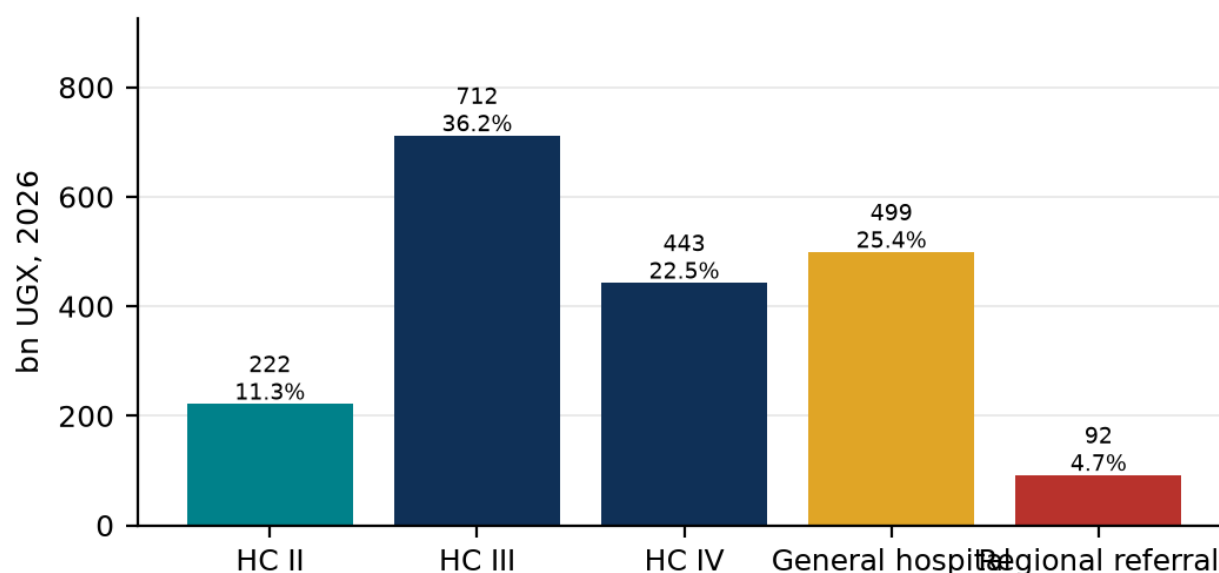


Figure 6.2: Requirement by the facility level at which services are delivered, 2026

Source: HPRAS database, run uga-unconstrained-2026

Table 6.3: Requirement by facility level where the service is delivered, 2026

Level	Cost 2026 (bn UGX)	Share
HC II	221.6	11.3%

Level	Cost 2026 (bn UGX)	Share
HC III	711.6	36.2%
HC IV	442.6	22.5%
General hospital	498.8	25.4%
Regional referral	91.6	4.7%

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_req_level.csv).

Health centre IIIs carry the largest share, 711.6 bn UGX (36.2%). General hospitals follow with 498.8 bn (25.4%), then HC IVs with 442.6 bn (22.5%), HC IIs with 221.6 bn (11.3%) and regional referral hospitals with 91.6 bn (4.7%). HC II to HC IV together hold 70.0% of the requirement.

The plan log's cross-check flags this as above the 35–60% range expected of a whole health budget. The flag is informative rather than alarming. The modelled catalogue is weighted toward primary care, and it omits national referral hospitals and specialised institutes entirely. A primary-care-heavy share is therefore what the catalogue should produce. It does, however, underline that the requirement cannot be compared line-for-line with the institutional budget (Chapter 13).

6.3.3 Workforce requirement

The WISN workload of the modelled services is **32,775 FTE in 2026**. It rises through 37,452 in 2027 and 42,440 in 2028 to **53,410 FTE in 2030** (Figure 6.3, Table 6.4). By cadre:

- nursing is the largest requirement: 7,698 registered nurses, 6,345 enrolled nurses, 3,663 registered midwives and 2,703 enrolled midwives in 2026;
- then 3,765 clinical officers, 3,003 support staff and 1,499 health records officers;
- then 1,417 village health team members, 1,382 medical officers and 738 pharmacy technicians.

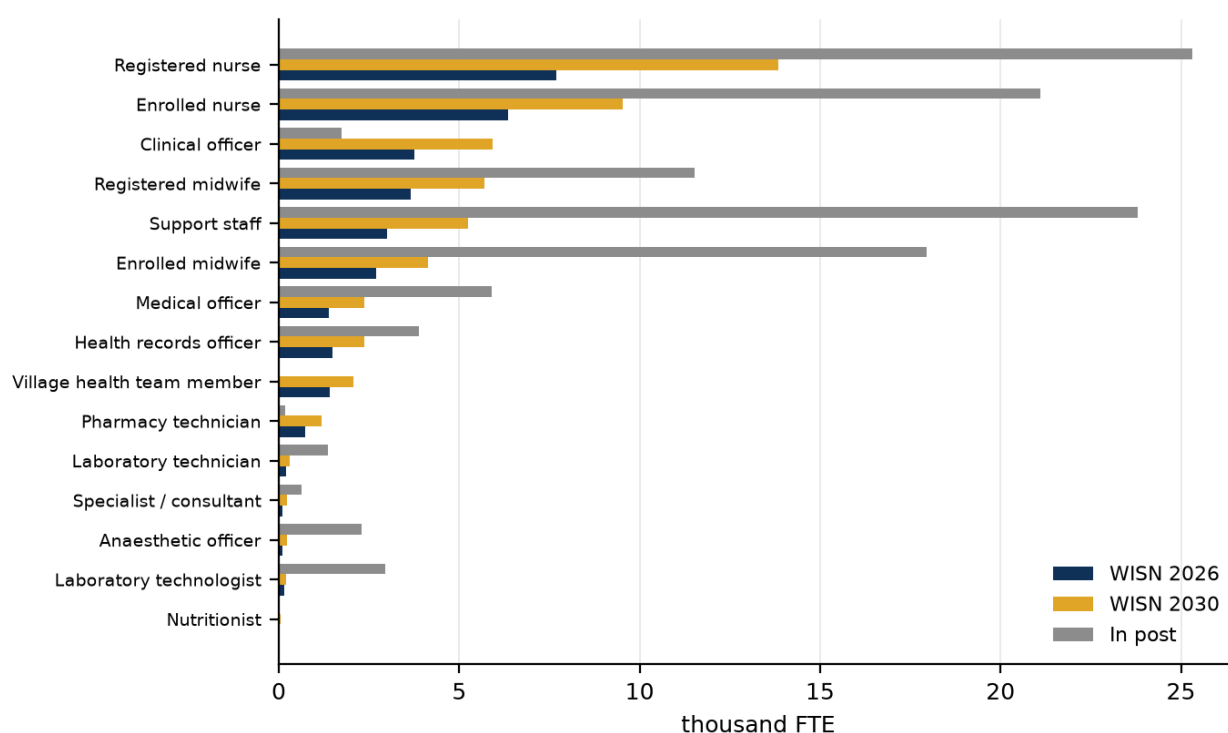


Figure 6.3: Workforce: WISN requirement of the modelled services (2026, 2030) against staff in post, by cadre

Source: HPRAS database, run uga-unconstrained-2026

Table 6.4: Workforce: WISN requirement of the modelled services against staff in post

Cadre	WISN FTE 2026	WISN FTE 2030	Established	In post	Required/in post 2030
Registered nurse	7,698	13,851	33,896	25,311	55%
Enrolled nurse	6,345	9,541	29,365	21,115	45%
Clinical officer	3,765	5,921	2,396	1,728	343%
Registered midwife	3,663	5,708	15,497	11,517	50%
Support staff	3,003	5,253	32,083	23,811	22%
Enrolled midwife	2,703	4,142	24,895	17,963	23%
Health records officer	1,499	2,365	5,415	3,892	61%
Village health team member	1,417	2,076	0	0	-
Medical officer	1,382	2,371	7,849	5,893	40%
Pharmacy technician	738	1,183	255	183	645%
Laboratory technician	204	296	1,886	1,361	22%
Laboratory technologist	143	207	3,925	2,946	7%
Specialist / consultant	108	229	834	628	36%
Anaesthetic officer	92	223	3,062	2,299	10%
Nutritionist	16	43	0	0	-
Pharmacist	0	0	221	167	0%
Radiographer	0	0	417	314	0%

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_workforce_req.csv).

The comparison with staff in post needs care, and the plan log states the caution directly. The WISN figure is the workload of the *modelled services only*. The staff in post, 119,127 across all cadres, are the whole establishment. They also deliver the services outside the catalogue, run administration and supervision, staff the national referral hospitals and carry the minimum staffing that small facilities need regardless of workload. A low ratio of required to in post is therefore **not a surplus**. It is the part of the workforce the modelled services do not account for.

- Registered nurses required in 2030 are 55% of those in post (13,851 against 25,311). That does not mean 45% of nurses are idle.
- Medical officers are at 40%, and registered midwives at 50%.

Where the ratio exceeds 100%, the signal is strong, because a partial catalogue already needs more staff than exist:

- clinical officers: 5,921 required in 2030 against 1,728 in post (343%);
- pharmacy technicians: 1,183 against 183 (645%).

These are real shortages on the modelled services alone. HM-07 (Chapter 10) puts the real workload gap on the partial catalogue at 7,312 FTE, in cadres already over-committed. It puts attrition replacement alone at 35,594 FTE of recruitment by 2030.

Two cadres show zero in post: village health team members and nutritionists. Those workers are not on the public payroll establishment the engine reads, so their ratio cannot be computed.

6.4 The geography of demand

6.4.1 Per-capita requirement

The requirement per person varies less between districts than the need maps of Chapter 5 might suggest. The plan log shows it runs from 36,611 UGX in the West Nile districts (Arua, Yumbe, Adjumani, Koboko and Moyo) to 48,334 UGX in Dokolo. The ratio of highest to lowest is 1.3. After Dokolo come Mpigi (47,008), Lyantonde (46,742), Gulu (46,575) and Butambala (46,455).

The pattern follows the two largest need geographies. Dokolo and Gulu combine the highest malaria index (Lango, Acholi) with high HIV prevalence (Mid North). Mpigi, Lyantonde and Butambala carry South Buganda's HIV prevalence. The West Nile districts combine low HIV prevalence with an average malaria index.

The spread is compressed for three reasons:

- the OPD floor lifts 94 of the 122 districts to the same outpatient requirement;
- most other need rates are national;
- the level mix and norms are the same everywhere.

Chapter 9 maps the per-capita cost.

6.4.2 Maps

The four HM-03 maps show volumes and staff per head in 2026. They are best read as the translation of the HM-01 and HM-02 maps into service units.

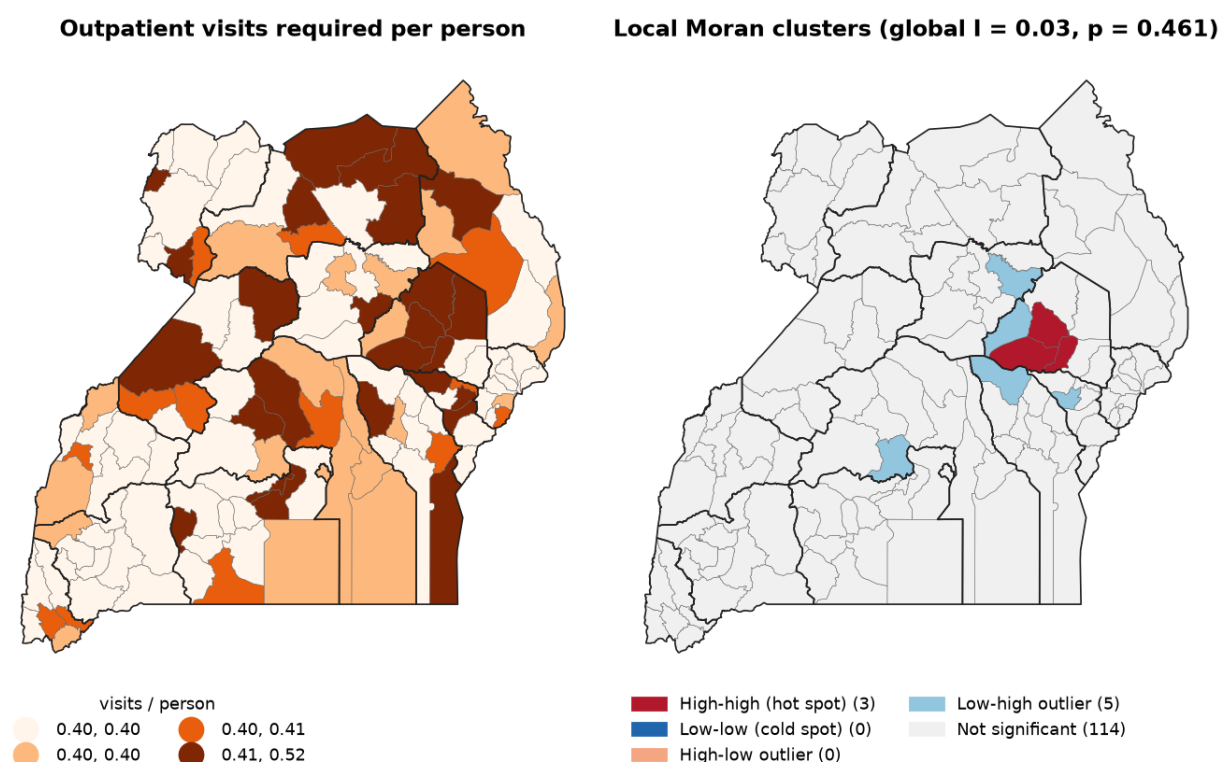


Figure 6.4: HM-03 - Outpatient visits required per person (visits / person), by district, 2026; right: local Moran (LISA) clusters, 999 permutations

Source: HPRAS database, run uga-unconstrained-2026; quality tier imputed. Boundaries (c) OpenStreetMap contributors (ODbL).

Outpatient visits (Figure 6.4) are 0.397 visits per person in 94 districts. Those are the 84 districts lifted to the 75th-percentile floor, plus the ten without an observation, all at the 62% target. The busiest districts rise above the floor: Butaleja (0.52), Kiboga (0.52), Dokolo (0.51), Kamuli (0.50), Serere (0.48) and Gulu (0.48).

The global Moran's I is 0.03 and not significant ($p = 0.461$). Above-floor utilisation is scattered, not regional. The three local hot-spot districts (Ngora, Serere, Soroti, in Teso) and five low-high outliers are the edges of isolated high-use districts, not a coherent zone.

This flat map is the visible cost of planning outpatient care from utilisation with a floor. It carries no epidemiological geography at all. It will stay that way until the condition build-up the manual prefers replaces the floor.

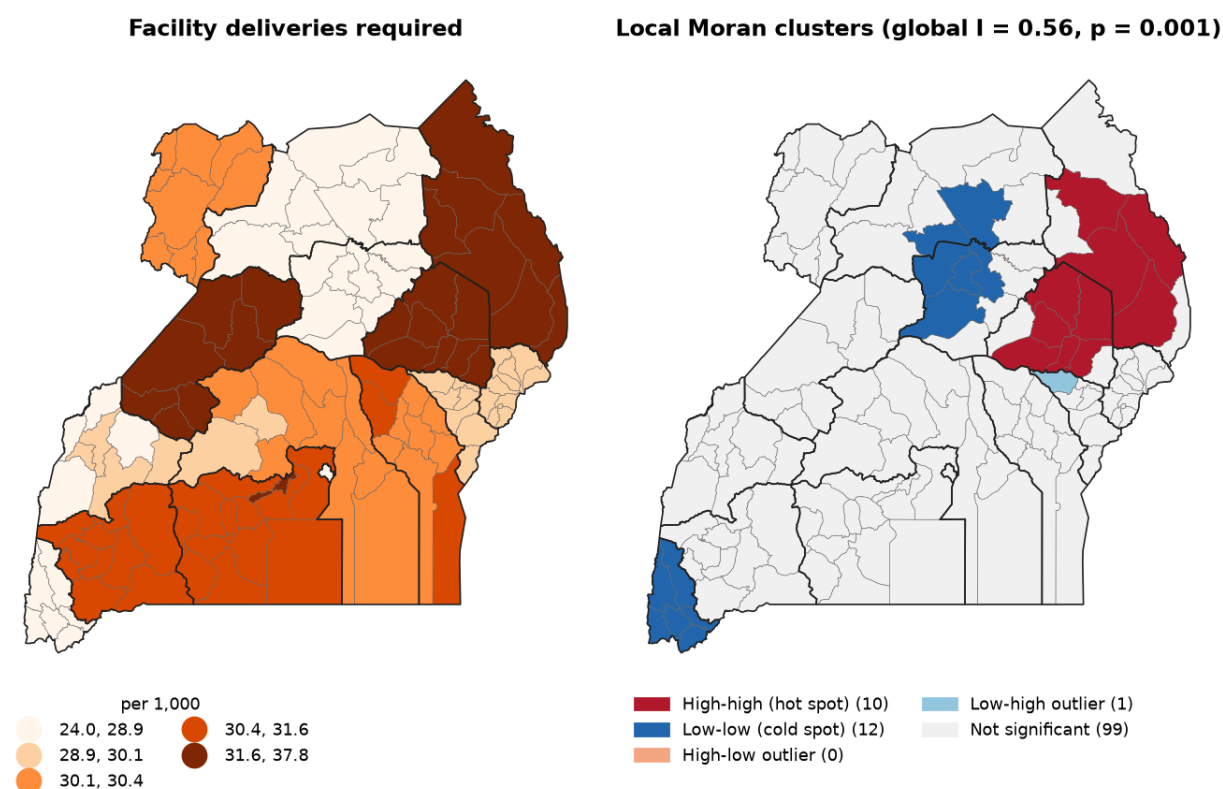


Figure 6.5: HM-03 - Facility deliveries required (per 1,000), by district, 2026; right: local Moran (LISA) clusters, 999 permutations

Source: HPRAS database, run uga-unconstrained-2026; quality tier normed. Boundaries (c) OpenStreetMap contributors (ODbL).

Facility deliveries (Figure 6.5) range from 24.0 per 1,000 population in the Kigezi districts to 37.8 per 1,000 in Teso. The global Moran's I is 0.56 ($p = 0.001$). The hot spot is the same ten Teso and Karamoja districts, and the cold spot the same twelve Kigezi, Lango and Acholi districts, as the births map of Chapter 4. That is because deliveries are births times a target that does not vary by district. The Teso–Karamoja belt needs more than half as many deliveries again per head as Kigezi, so midwives, delivery beds and maternal commodities should be distributed to match.

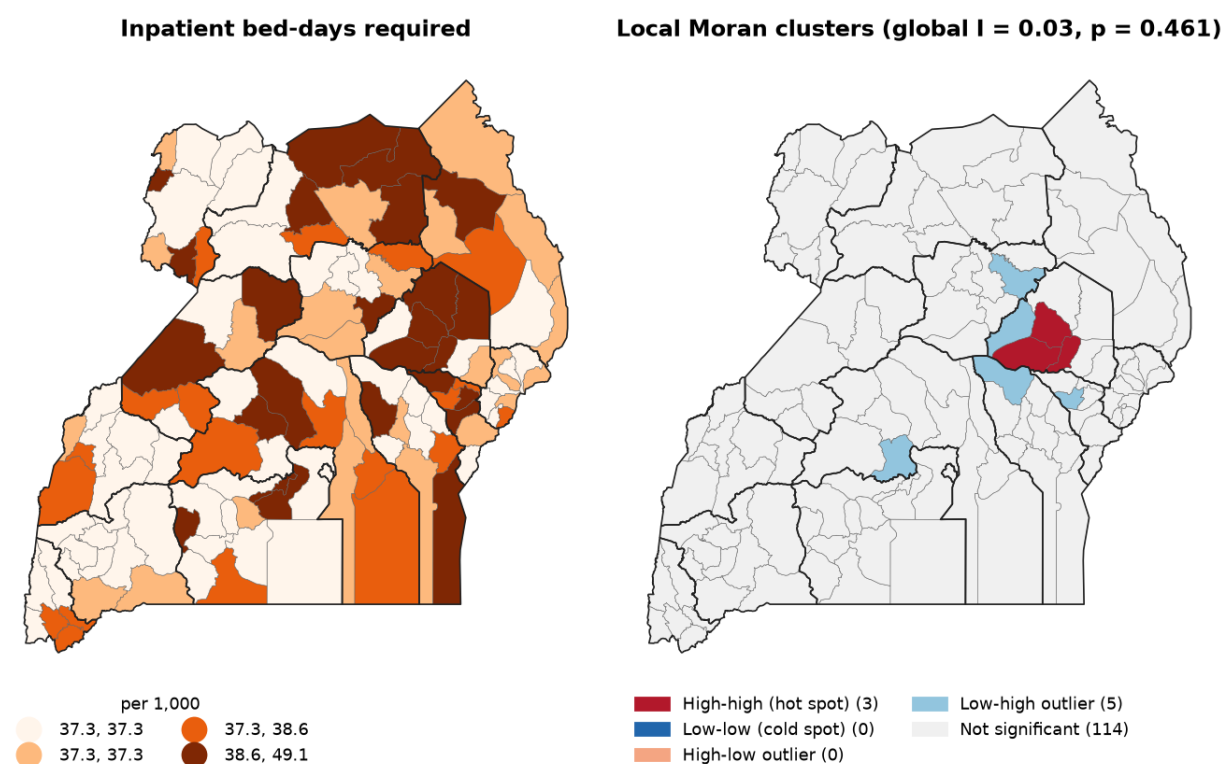


Figure 6.6: HM-03 - Inpatient bed-days required (per 1,000), by district, 2026; right: local Moran (LISA) clusters, 999 permutations

Source: HPRAS database, run uga-unconstrained-2026; quality tier assumed. Boundaries (c) OpenStreetMap contributors (ODbL).

Inpatient bed-days (Figure 6.6) range from 37.3 to 49.1 per 1,000 population. The Moran's I, 0.03 ($p = 0.461$), and the local clusters are the same as for outpatient visits, because admissions are derived from planned outpatient contacts. The layer is assumed quality: the admission rate per outpatient contact has no Ugandan measurement. Its geography is inherited from OPD utilisation rather than from the burden of severe disease. A better admission model would tie admissions to the malaria, HIV, maternal and child burdens directly.

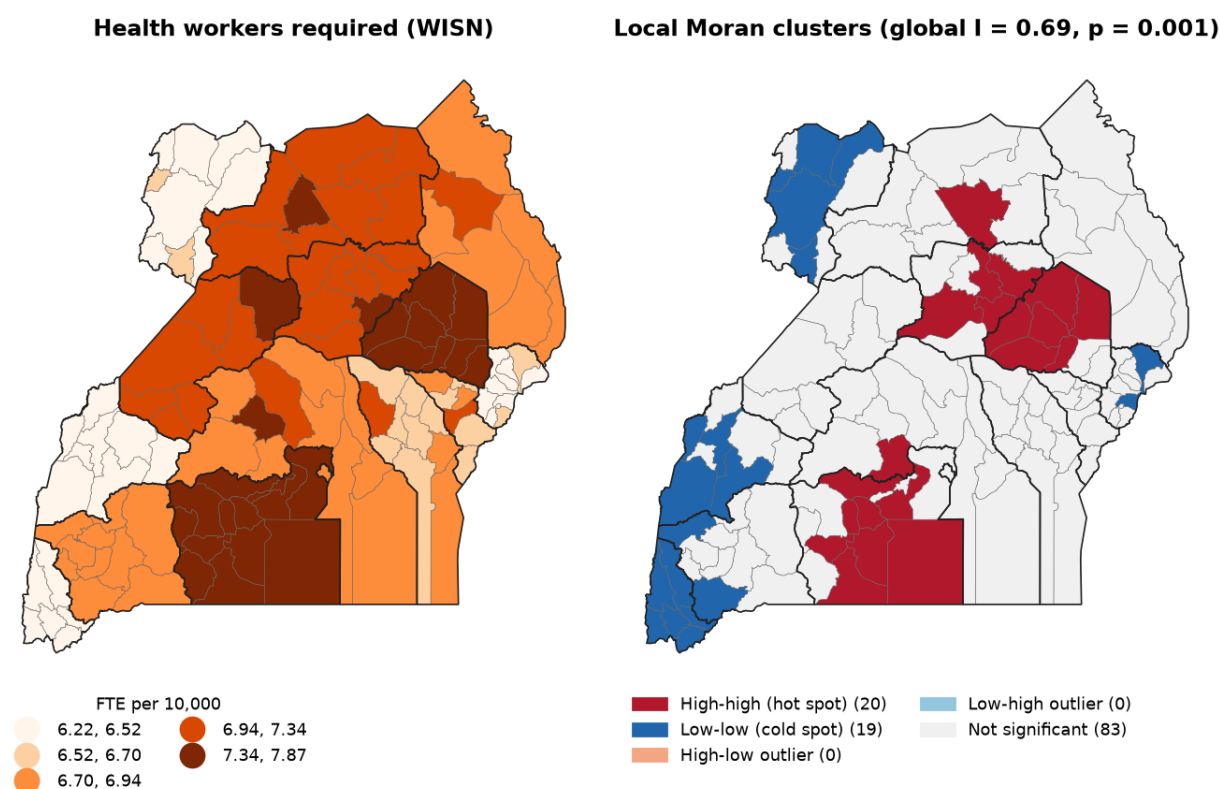


Figure 6.7: HM-03 - Health workers required (WISN) (FTE per 10,000), by district, 2026; right: local Moran (LISA) clusters, 999 permutations

Source: HPRAS database, run uga-unconstrained-2026; quality tier derived. Boundaries (c) OpenStreetMap contributors (ODbL).

Health workers required (Figure 6.7) range from 6.2 FTE per 10,000 population in the Kigezi districts to 7.9 in Serere. The global Moran's I is 0.69 ($p = 0.001$), the most clustered HM-03 layer.

- **The 20-district hot spot** has two arms. One is in South Buganda (Bukomansimbi, Gomba, Kalangala, Kalungu, Kyotera, Lwengo, Masaka, Mpigi) with Mityana, driven by HIV care. The other runs through Teso (Amuria, Kaberamaido, Katakwi, Ngora, Serere, Soroti), Lango (Alebtong, Apac, Dokolo, Lira) and Pader, driven by malaria and, in Teso, by high fertility.
- **The 19-district cold spot** covers Kigezi (six districts), West Nile (five), Tooro (four), Bugisu and Ankole. There, low malaria or low HIV, or both, reduce the clinical workload per head.

The staffing map is, in effect, the sum of the need maps weighted by staff minutes per unit. Unlike a composite index, it is a physical quantity: the posts required.

6.5 Data quality and limitations

- **Targets: illustrative.** UGA-NDP-ILLUSTRATIVE is not an approved target set. Every volume, cost and FTE scales with it, and the fastest-growing lines are the most sensitive.
- **Norms: mostly `assumed` for staff time.** The staff-minute lines, which drive the WISN requirement and the compensation cost, are largely assumptions. Medicine and test lines are more often *normed*.
- **Level mix: normative, national.** The same mix applies in every district. A district without a general hospital is still planned to deliver 23% of its deliveries at one; the gap appears in HM-05.
- **Referral services: `assumed`.** Admissions per outpatient contact, and hence bed-days, have no Ugandan measurement, and they inherit the flat geography of the OPD floor.
- **WISN before floors, and on a partial catalogue.** The FTE requirement excludes minimum staffing, administration and all non-modelled services. It cannot be read as the establishment Uganda needs.

6.6 Implications for planning

- **Most of the growth in the requirement is a policy choice, not demography.** Population adds 12.1% by 2030. The illustrative coverage targets take the requirement up 56.9%. The Ministry's own target set is the single most important input still to be supplied, and each target should be tested against the cost it implies.
- **Hospital demand compounds.** Because admissions and caesareans are driven by planned primary-care volumes, raising outpatient and delivery coverage doubles the bed-day requirement. Primary-care expansion without matching hospital capacity will move the bottleneck, not remove it.
- **The workforce shortage on the modelled services is concentrated in specific cadres.** Clinical officers and pharmacy technicians are needed beyond the numbers in post on the modelled services alone. Nursing and midwifery shortfalls, if any, lie in distribution and in the work outside the catalogue, not in national totals. Pre-service training and recruitment should be targeted accordingly.
- **Replace the OPD floor and the admission rate with burden-based estimates.** The two flattest maps in this chapter are the two built on utilisation. Moving outpatient and inpatient demand onto a condition build-up would give the largest volumes of care the same epidemiological geography as the rest of the plan.

CHAPTER 7

7 Supply, capacity and physical access (HM-04)

The previous chapter set out what Uganda's population requires from the 28 modelled services in 2026. This chapter asks the opposite question: what does the health system already have, and how much of the requirement can it actually deliver? The answer is not a count of facilities or a head-count of staff. A district with twenty health centres, half of them without a clinician and several without power, does not have the capacity of twenty health centres. HM-04 therefore converts stocks (facilities, rooms, beds, theatres and staff in post) into **throughput capacity** measured in the same service units as the requirement, so that the gaps in the next chapter compare like with like.

The chapter answers four questions that matter for Uganda's planning cycle:

- What is the stock of facilities and health workers, and how is it distributed across the 122 plan districts?
- How much of each service can that stock deliver in a year, and which resource (space or staff) is the one that limits it?
- Where does observed delivery exceed what the norms say the facilities can do, and what does that tell us about the norms?
- How far are people from a facility, by road and on foot, and where are the long referral journeys?

Physical access is reported beside capacity throughout, never folded into it. Capacity that people cannot reach is a planning problem, but it is a different problem from capacity that does not exist, and it has different remedies.

7.1 The facility register

7.1.1 Source and coverage

The count of facilities comes from the Ministry of Health's National Health Facility Registry (NHFR), downloaded by `scripts/fetch_nhfr.py` from the registry's public master facility list. The registry is the authority on what exists, at what level and under whose ownership. The download deliberately drops the contact names, telephone numbers and e-mail addresses of individual staff that the public list carries: the engine has no use for them and they are personal data.

The registry holds **6,800 facilities**: 3,535 government, 1,012 private not-for-profit (PNFP) and 2,253 private for-profit (PFP). Table 7.1 gives the breakdown by level and ownership, and Figure 7.1 shows the same information graphically. Two mappings are made when the registry is loaded by `scripts/load_supply.py`. Clinics, which are outpatient-only points, are treated as the functional equivalent of an HC II; 381 of the 432 clinics are private for-profit. The nine national referral hospitals are folded into the referral tier, because no service in the catalogue has a national-only level mix. This is why the referral row of Table 7.1 shows 25 facilities.

Table 7.1: Health facilities by level and ownership (MoH National Health Facility Registry)

Level	Government	Private	Private Not For Profit	Total	Located (lat/lon)
HC II	1,745	1,866	490	4,101	1,492
HC III	1,490	278	396	2,164	1,358
HC IV	212	40	43	295	202
General hospital	63	69	83	215	102
Regional referral	25	0	0	25	15

Source: HPRAS database, run `uga-unconstrained-2026 (report/build/data/t_facilities.csv)`.

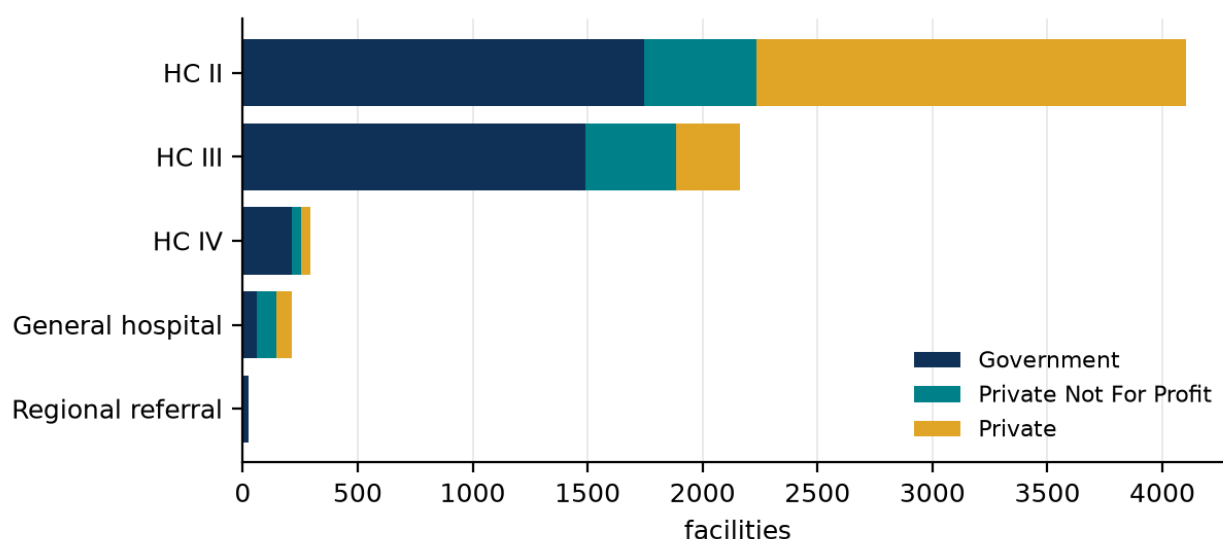


Figure 7.1: Health facilities by level and ownership

Source: MoH National Health Facility Registry (6,800 facilities)

Private for-profit facilities are loaded but not counted as planning capacity. The switch `INCLUDE_PFP_IN_CAPACITY` in `load_supply.py` is set to false. The 2,253 PFP facilities, most of them HC II-level clinics, remain visible in the facility table and on the maps, but they are not treated as capacity that a public plan can direct. The planning stock is therefore the 4,547 government and PNFP facilities. This choice matters most in Kampala and Wakiso, where private provision is dense. It also matters for how the capacity results should be read: a shortfall against the public and PNFP network is not a statement that the service is unavailable to anyone, but that the network the plan can budget for cannot deliver it at the target.

The registry publishes no coordinates. `scripts/facility_geo.py` attaches them by matching facility names, within the same district, to two sources in turn: the 2010 MoH facility register, whose GPS points are official but fifteen years old, and the OpenStreetMap extract of August 2026. Names are reduced to their distinctive core, level tokens are compared separately so that "Kitgum HC IV" is never matched to "Kitgum Hospital", and a match requires a similarity score of at least 90 with a lead of at least 5 points over the next candidate. An ambiguous match is left unlocated rather than guessed. The result is **3,169 located facilities**, fewer than half of the register. Located facilities are used for the facility map (Figure 7.2) and for the referral-distance analysis later in this chapter; the capacity calculation itself uses the full register counts by district and level, so the location gap does not reduce capacity.

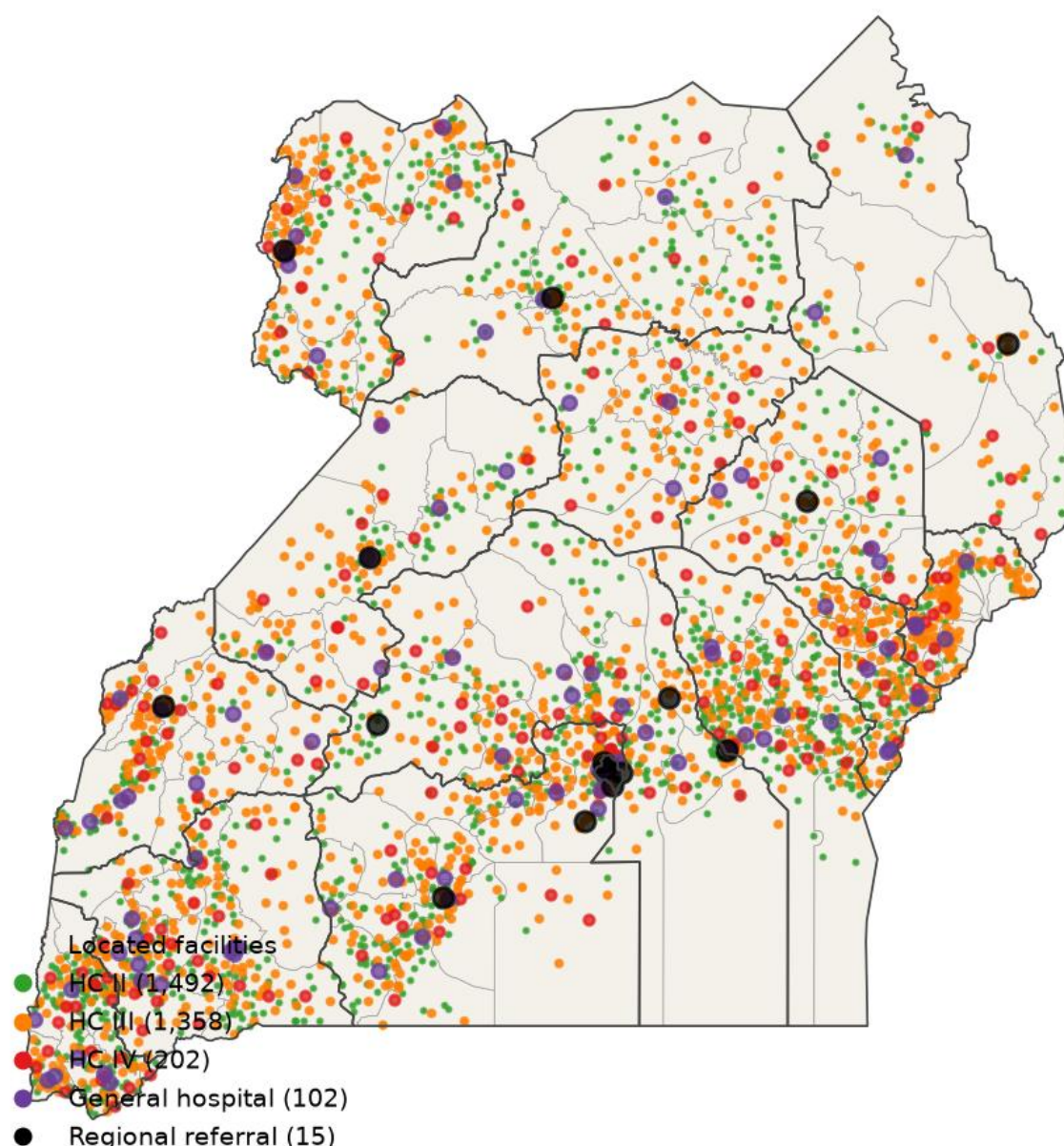


Figure 7.2: Located health facilities by level (all ownerships, operational)

Source: MoH National Health Facility Registry, geocoded by facility_geo.py. Boundaries (c) OpenStreetMap contributors (ODbL).

7.1.2 Facility density

Figure 7.3 maps public and PNFP facilities per 10,000 people. The district median is 1.0 facility per 10,000. The lowest densities are in Wakiso (0.38) and Kampala (0.46), followed by Kyegegwa, Serere, Kyenjojo and Kole, all close to 0.5. The highest are Kalangala (2.78), Moyo (2.58), Rukiga (2.48) and Rukungiri (2.27). The layer is moderately clustered (Moran's $I = 0.34$, $p = 0.001$). The significant hot spot (high density among high-density neighbours) runs through the south-west, taking in Kabale, Rukiga, Rukungiri, Rubanda, Kanungu and Rubirizi, extends to Masaka, Kalungu and Kyotera, and has a northern arm in Kitgum and Adjumani. The only cold spots are Pallisa, Kaberamaido and Kibaale.

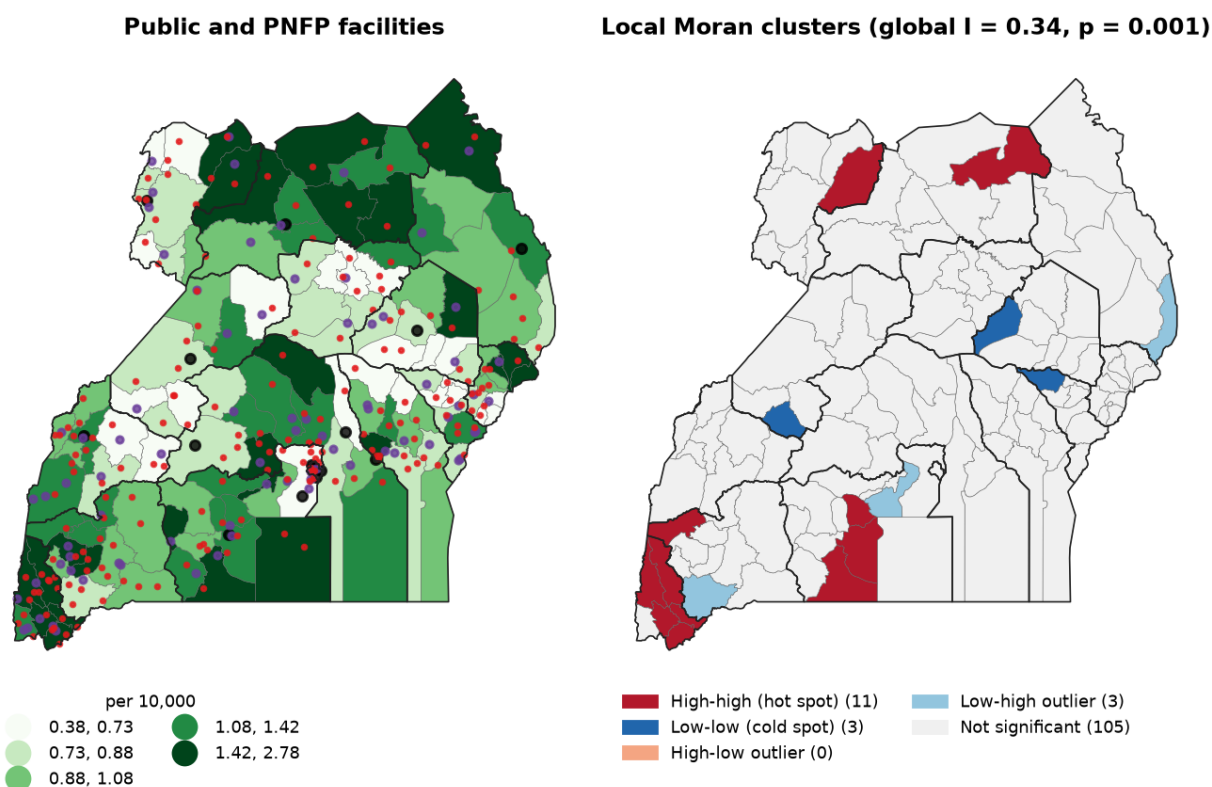


Figure 7.3: HM-04 - Public and PNFP facilities (per 10,000), by district, 2026; right: local Moran (LISA) clusters, 999 permutations

Source: HPRAS database, run uga-unconstrained-2026; quality tier measured. Boundaries (c) OpenStreetMap contributors (ODbL).

The low figures for Kampala and Wakiso are not evidence of an under-built capital. They combine the largest populations in the country (2.0 million and 3.0 million people in 2026) with the exclusion of private for-profit facilities, which dominate urban provision. Density per person is a descriptive layer only: under principle P4 facility requirements are never derived from people-per-facility ratios.

Hospitals are mapped separately (Figure 7.4). The median district has 0.33 general or referral hospitals per 100,000 people, and many districts have none in the public and PNFP count, among them Alebtong, Budaka, Bukomansimbi, Bukwo, Bulambuli and Bunyangabu. The highest values are in Kitgum (1.12), Kamwenge (1.04), Kampala and Kabale (1.0 each). Unlike health centres, hospitals show **no overall spatial pattern** (Moran's $I = -0.03$, $p = 0.699$): hospital provision is an idiosyncratic district-by-district inheritance rather than a regional one. A small cold spot of Kakumiro, Kaliro, Mubende and Iganga stands out, and Kotido and Kaabong form a small hot spot in Karamoja, where hospital counts are high relative to comparatively small populations.

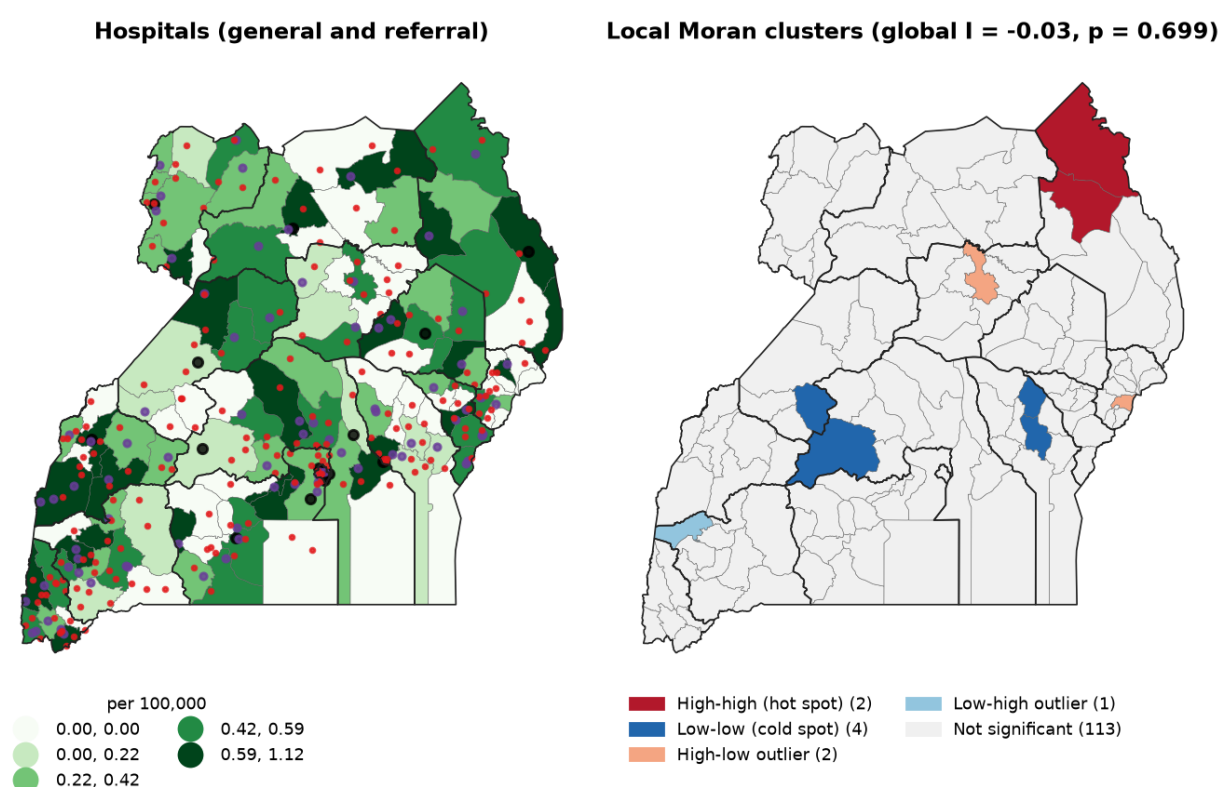


Figure 7.4: HM-04 - Hospitals (general and referral) (per 100,000), by district, 2026; right: local Moran (LISA) clusters, 999 permutations

Source: HPRAS database, run uga-unconstrained-2026; quality tier derived. Boundaries (c) OpenStreetMap contributors (ODbL).

7.1.3 Catchment populations against policy catchments

Table 7.2 sets the population per public or PNFP facility against the Ministry's policy catchment for each level. It is descriptive: the Master Command (§37) forbids people-per-facility ratios as a planning method, and capacity in this engine comes from throughput norms. The comparison is nonetheless revealing about the shape of the network.

Table 7.2: Catchment population per public/PNFP facility, by level

Level	Districts	Median persons per facility	Lowest	Highest	Policy catchment
General hospital	80	225,499	89,203	685,046	500,000
HC II	122	21,996	5,868	246,742	5,000
HC III	122	23,074	9,784	94,919	20,000
HC IV	115	200,423	37,772	589,139	100,000
Regional referral	17	553,064	138,643	3,011,310	2,000,000

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_catchment.csv).

At the lowest tier the network is far thinner than policy. The median district has 21,996 people per HC II against a policy catchment of 5,000, and in the worst district an HC II serves 246,742 people. The HC III tier is close to policy (median 23,074 against 20,000). The HC IV tier is roughly twice as stretched as policy (median 200,423 against 100,000). At the top of the pyramid the picture reverses: in the 80 districts that have a general hospital, the median catchment is 225,499 against a policy catchment of 500,000, and the 17 districts with a referral hospital have a median of 553,064 against 2,000,000. In short, the lowest tier is thin, and hospitals are more numerous than the catchment norms imply. The private for-profit sector, which holds 1,866 of the 4,101 HC II-level facilities in the registry, is outside this count, so the thin public lowest tier sits beside a dense private one.

7.2 The workforce in post

7.2.1 Why the workforce is derived

No extract from the Human Resource Information System or the payroll is available to the engine. Rather than leave the staff constraint empty, `load_supply.py` derives the workforce in post from three things that are observed or normed:

$$E_{c,d} = \sum_l N_{d,l} \times m_{l,c} \times \mu_{l,c} \quad (7.1)$$

$$F_{c,d} = f_d \times E_{c,d} \quad (7.2)$$

where:

- $E_{\{c,d\}}$ is the establishment (approved posts) of cadre c in district d , in FTE;
- $N_{\{d,l\}}$ is the number of operational public and PNFP facilities of level l in district d , from the registry;
- $m_{\{l,c\}}$ is the minimum staffing norm for cadre c at level l (Table 7.3);
- $\mu_{\{l,c\}}$ is the shift multiplier: 4.4 for posts the norm marks as staffed 24 hours a day, 7 days a week (for example, enrolled nurses and midwives at an HC III, and medical officers at a general hospital), and 1 otherwise;
- f_d is the district's observed "approved posts filled" rate from the MoH league tables;
- $F_{\{c,d\}}$ is the FTE in post.

The fill rate is the strongest district-level workforce signal in the data estate. It is a real observation, it varies from 38.5% to 100% across districts, and it is measured in all 122. The establishment side, by contrast, is normative: it assumes each facility carries its minimum staffing. The result is best read as "the staff the network would have if every facility held its establishment and the district filled posts at its observed rate".

Table 7.3: Minimum staffing norms (FTE per facility)

Cadre	HC II	HC III	HC IV	General hospital	Regional referral
Anaesthetic officer	0.0	0.0	1.0	3.0	8.0
Clinical officer	0.0	1.0	2.0	0.0	0.0
Medical officer	0.0	0.0	2.0	8.0	20.0
Specialist / consultant	0.0	0.0	0.0	4.0	10.0
Laboratory technician	0.0	1.0	0.0	0.0	0.0
Laboratory technologist	0.0	0.0	1.0	4.0	10.0
Enrolled midwife	0.0	3.0	0.0	0.0	0.0
Registered midwife	0.0	0.0	4.0	12.0	30.0
Enrolled nurse	2.0	3.0	0.0	0.0	0.0
Registered nurse	0.0	1.0	4.0	30.0	75.0
Pharmacist	0.0	0.0	0.0	1.0	3.0
Pharmacy technician	0.0	0.0	1.0	0.0	0.0
Radiographer	0.0	0.0	0.0	2.0	5.0
Health records officer	1.0	1.0	2.0	4.0	8.0
Support staff	1.0	3.0	6.0	25.0	60.0

Source: HPRAS database, run `uga-unconstrained-2026 (report/build/data/t_min_staffing.csv)`.

7.2.2 What the derivation gives

The derived establishment is 161,996 FTE and the workforce in post is **119,127 FTE**, a national fill rate of 73.5%. Table 7.4 gives the figures by cadre. Registered nurses (25,311 in post), support staff (23,811), enrolled nurses (21,115) and enrolled midwives (17,963) make up the bulk. Medical officers number 5,893 and clinical officers

only 1,728. The small clinical-officer figure is a direct consequence of the minimum staffing norm, which places clinical officers only at HC IIIs (one each) and HC IVs (two each). It will reappear in the workforce gap and in the recruitment plan.

Table 7.4: Health workforce in post by cadre (public and PNFP)

Cadre	Established FTE	In post FTE	Fill rate
Registered nurse	33,896	25,311	75%
Support staff	32,083	23,811	74%
Enrolled nurse	29,365	21,115	72%
Enrolled midwife	24,895	17,963	72%
Registered midwife	15,497	11,517	74%
Medical officer	7,849	5,893	75%
Health records officer	5,415	3,892	72%
Laboratory technologist	3,925	2,946	75%
Anaesthetic officer	3,062	2,299	75%
Clinical officer	2,396	1,728	72%
Laboratory technician	1,886	1,361	72%
Specialist / consultant	834	628	75%
Radiographer	417	314	75%
Pharmacy technician	255	183	72%
Pharmacist	221	167	75%

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_workforce_post.csv).

Figure 7.5 maps the result per 10,000 people. The median district has 22.7 health workers in post per 10,000. The highest values are in Gulu (63.0), Kabarole (60.9), Kampala (60.3), Kabale (58.3), Moyo (53.5) and Jinja (51.5), which are districts that host regional referral or large general hospitals: because hospital establishments are large, the hospital map largely drives the workforce map. The lowest are Buyende (6.2), Namutumba (8.5), Namayingo (8.6), Sembabule (8.7), Serere (8.8) and Kakumiro (9.0). The layer is not significantly clustered overall (Moran's I = 0.06, $p = 0.263$), but there is a cold spot of low staffing among low-staffed neighbours in Kakumiro, Bugiri, Mubende, Kaliro, Iganga and Pallisa.

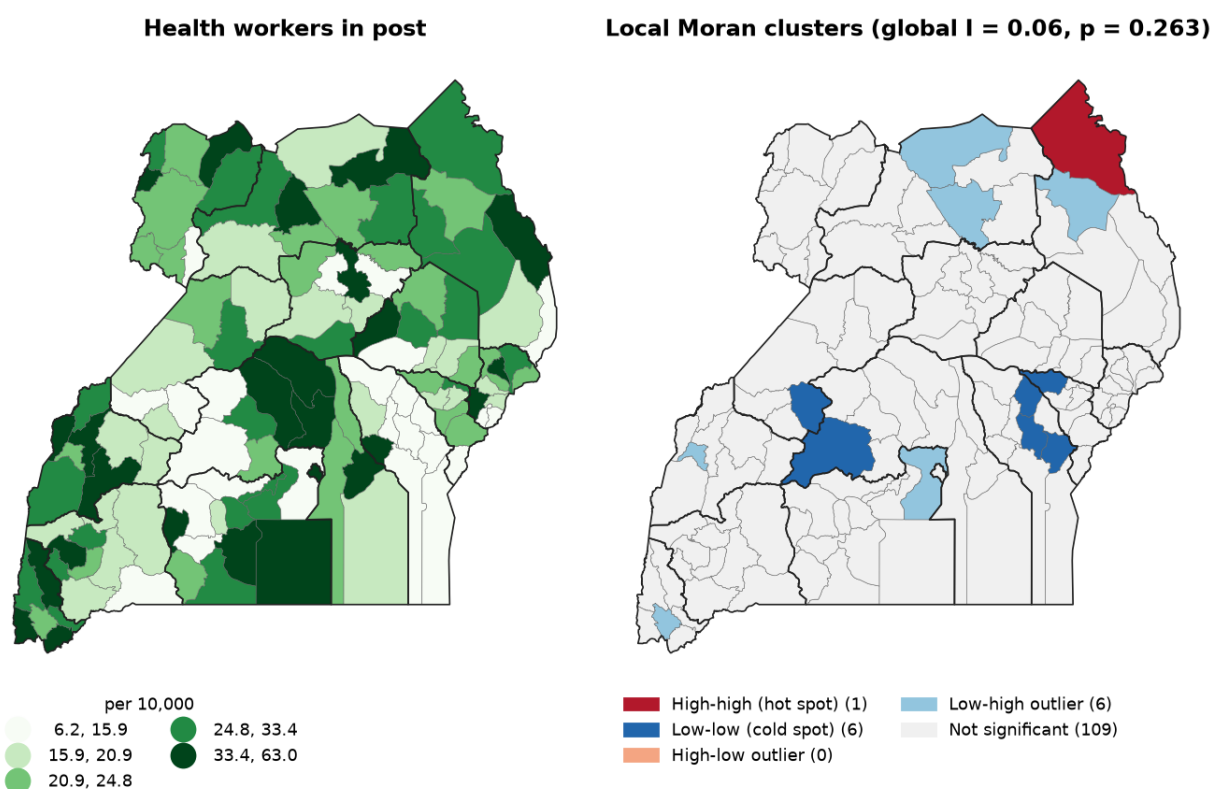


Figure 7.5: HM-04 - Health workers in post (per 10,000), by district, 2026; right: local Moran (LISA) clusters, 999 permutations

Source: HPRAS database, run uga-unconstrained-2026; quality tier measured. Boundaries (c) OpenStreetMap contributors (ODbL).

The GIS module also asks whether supply sits where need is. The concentration index of health workers in post against the need-driven workload is -0.042 , and of public and PNFP facilities -0.049 . Both are negative: existing supply is slightly concentrated where need is **lower**. The effect is modest, but it runs the wrong way, and it is the empirical case for the need-weighted allocation scenarios of Chapter 11.

7.3 From stocks to capacity

7.3.1 The capacity formula

For every service s , district d and facility level l the engine computes two throughput constraints, takes the smaller of them, and discounts it for facility readiness. This is implemented in `compute_capacity!` in `src/SupplyGaps.jl`.

Space. Rooms, beds and theatres are shared between services. Handing each service the full room stock would count the same consulting room several times over, and an earlier version of the engine that did so produced apparent surpluses for antenatal care and delivery. The physical stock is therefore **allocated, not replicated**. The engine first computes the room-days (or bed-days, or theatre-days) that each service would need at its own throughput norm, and then gives each service its share of the available stock in proportion:

$$\pi_{s,d,l} = \frac{Q_{s,d,l}/\theta_{s,l}}{\sum_{s' \in g} Q_{s',d,l}/\theta_{s',l}} \quad (7.3)$$

$$K_{s,d,l}^{\text{space}} = N_{d,l} \times P_{l,g} \times D_l \times \pi_{s,d,l} \times \theta_{s,l} \quad (7.4)$$

where:

- $Q_{s,d,l}$ is the required volume of service s at level l in district d , from HM-03;
- $\theta_{s,l}$ is the throughput norm, in service units per room-day (or bed-day, or theatre-day);

- g is the physical pool the service occupies: beds for services measured in bed-days, theatres for procedures, and consulting rooms (service points) for everything else;
- $P_{l,g}$ is the number of rooms, beds or theatres per facility of level l in pool g ;
- D_l is the number of operating days a year at level l ;
- $\pi_{s,d,l}$ is the share of the pool allocated to service s .

The establishment norms behind P and D are set out in Table 7.5, below. An HC II has one service point and no beds, and operates 250 days a year. An HC III has two service points and six beds. An HC IV has four service points, 24 beds and a theatre, and operates 300 days. A general hospital has eight service points, 100 beds and two theatres, and a regional referral hospital has 14 service points, 300 beds and four theatres; both operate 365 days. Outpatient throughput ranges from 28 consultations per room-day at an HC II to 36 at a general hospital. These are normative establishments, because the registry gives levels and locations but not room or bed counts.

Table 7.5: Capacity standards by facility level

Level	Service	Metric	Value	Unit
HC II	all	operating days per year	250.0	days
HC III	all	operating days per year	250.0	days
HC IV	all	operating days per year	300.0	days
General hospital	all	operating days per year	365.0	days
Regional referral	all	operating days per year	365.0	days
HC II	Outpatient consultation	consultations per room day	28.0	consultations
HC III	Outpatient consultation	consultations per room day	30.0	consultations
HC IV	Outpatient consultation	consultations per room day	34.0	consultations
General hospital	Outpatient consultation	consultations per room day	36.0	consultations
HC III	all	bed occupancy target	0.8	proportion
HC IV	all	bed occupancy target	0.82	proportion
General hospital	all	bed occupancy target	0.85	proportion
Regional referral	all	bed occupancy target	0.85	proportion
HC IV	Caesarean section	theatre cases per day	3.0	cases
General hospital	Caesarean section	theatre cases per day	6.0	cases
Regional referral	Caesarean section	theatre cases per day	9.0	cases
HC IV	Major surgery (non-obstetric)	theatre cases per day	3.0	cases
General hospital	Major surgery (non-obstetric)	theatre cases per day	5.0	cases
Regional referral	Major surgery (non-obstetric)	theatre cases per day	8.0	cases
General hospital	all	alos days	4.2	days
Regional referral	all	alos days	5.6	days
HC II	all	service points per facility	1.0	rooms
HC III	all	service points per facility	2.0	rooms
HC IV	all	service points per facility	4.0	rooms
General hospital	all	service points per facility	8.0	rooms
Regional referral	all	service points per facility	14.0	rooms
HC II	all	beds per facility	0.0	beds
HC III	all	beds per facility	6.0	beds
HC IV	all	beds per facility	24.0	beds
General hospital	all	beds per facility	100.0	beds
Regional referral	all	beds per facility	300.0	beds
HC IV	all	theatres per facility	1.0	theatres
General hospital	all	theatres per facility	2.0	theatres
Regional referral	all	theatres per facility	4.0	theatres

Source: HPRAS database, run *uga-unconstrained-2026 (report/build/data/t_capacity_standards.csv)*.

Staff. Each cadre's available working time is shared across the services it delivers, and the capacity for a service is set by the cadre that runs out first:

$$\alpha_{c,s,d,l} = \frac{Q_{s,d,l} \tau_{c,s,l}}{\sum_{s',l'} Q_{s',d,l'} \tau_{c,s',l'}} \quad (7.5)$$

$$K_{s,d,l}^{\text{staff}} = \min_c \frac{F_{c,d} \times A_c \times \alpha_{c,s,d,l}}{\tau_{c,s,l}} \quad (7.6)$$

$$A_c = (W - L - H - T - B) \times h \times 60 \times (1 - a_c) \quad (7.7)$$

where:

- $\tau_{c,s,l}$ is the minutes of cadre c per unit of service s at level l (the norm's quantity $\times$ share of cases $\times$ (1 + wastage));
- $\alpha_{c,s,d,l}$ is the share of cadre c 's time allocated to service s ;
- $F_{c,d}$ is the FTE in post from Equation (7.2);
- A_c is the WISN available working time in minutes per FTE-year;
- W, L, H, T and B are working days (261), annual leave (21), public holidays (13), training days (5) and absence days (10);
- h is hours per day (8);
- a_c is the category allowance for non-service time: 0.25 for clinical and nursing cadres, 0.22 for allied, 0.15 for support and 0.30 for community cadres.

For a clinician or nurse this gives 212 working days $\times$ 8 hours $\times$ 60 minutes $\times$ 0.75 = 76,320 minutes a year. The allocation share follows the **required** time mix rather than observed output, because no service-level output by district exists in the data estate. The capacity therefore reads as "what the staff in post could deliver if their time followed need". The engine manual prefers observed output, and the substitution is recorded as a documented deviation. Village health team members are excluded from the staff constraint: they have no facility establishment by design, and treating their zero establishment as zero capacity would wrongly zero out immunisation and TB.

Capacity and readiness. The two constraints are combined as follows:

$$K_{s,d,l} = \min \left(K_{s,d,l}^{\text{space}}, K_{s,d,l}^{\text{staff}} \right) \times \rho_d \quad (7.8)$$

where ρ_d is the district readiness index. No Service Availability and Readiness Assessment (SARA) or Harmonised Health Facility Assessment is available by district. The engine therefore uses HMIS reporting completeness as a readiness proxy (manual ch.19 §19.10, option 2), and flags it *imputed*. Across districts it averages 0.83 and ranges from 0.49 in Kampala to 0.92.

The engine also records which constraint bound and the **slack ratio**, the second-tightest constraint divided by the tightest. The slack ratio tells a planner whether relieving the binding constraint helps. The worked example in the engine documentation makes the point: a district whose staff constraint binds with a slack of 1.002 against commodities would gain almost nothing from hiring clinicians unless drug supply moved with them.

7.3.2 Revealed capacity

Norms can be wrong, and delivered volume is a proven lower bound on capacity. A district that delivered a given number of deliveries last year can deliver at least that many. Where the engine has an observed coverage series for a service and district, it computes the volume demonstrably delivered and uses it as a floor:

$$\tilde{K}_{s,d,l} = \max \left(K_{s,d,l}, Q_{s,d,l} \times \frac{C_{s,d}^{obs}}{C_{s,d}^*} \right) \quad (7.9)$$

where C^{obs} is the latest observed coverage and C^* is the target coverage. The target cancels, so revealed capacity does not move when the target does. The **raw, uncapped** coverage is used. Coverage above 100% of the resident population is real service flow from outside the district, not an error: Kampala's delivery coverage of 260% is referral inflow. When the floor lifts capacity, the binding constraint is recorded as *revealed*, which is a signal that the throughput norms are conservative in that district.

Revealed capacity only operates for the services with a district coverage series: antenatal care, facility delivery, pentavalent vaccination, malaria treatment, ART, postnatal care and TB treatment. Every other service rests on the normative calculation alone. This distinction explains much of the pattern in the next section.

7.4 What the system can deliver

Table 7.6 and Figure 7.6 compare national capacity with the 2026 requirement for each of the 28 services. A ratio below 1 means the public and PNFP network cannot deliver the target volume; above 1 means it can, in aggregate. National aggregates hide district shortfalls, which Chapter 8 takes up, but the national picture sorts the services into three groups.

Table 7.6: Capacity against requirement by service, 2026

Service	Required 2026	Capacity	Capacity / requirement
Severe mental disorders and epilepsy care	48,387	8,813	0.18
Hypertension management	854,644	168,721	0.20
Outpatient consultation	19,287,133	8,795,525	0.46
BCG immunisation	1,592,838	1,081,700	0.68
Rotavirus immunisation	2,315,652	1,572,565	0.68
Measles-rubella immunisation	2,004,693	1,361,392	0.68
Pneumococcal immunisation	3,920,069	2,662,128	0.68
Polio immunisation	4,565,143	3,100,199	0.68
Family planning	2,823,304	1,940,881	0.69
Severe acute malnutrition treatment	80,687	56,456	0.70
Prevention of mother-to-child transmission	54,408	38,298	0.70
HIV testing and counselling	5,987,951	4,218,036	0.70
NCD screening (blood pressure, glucose)	1,874,459	1,332,554	0.71
HPV immunisation	579,794	416,476	0.72
Antenatal care visit	5,394,354	4,292,226	0.80
Normal delivery	1,437,148	1,411,979	0.98
Malaria diagnosis and treatment	10,113,481	10,203,005	1.01
Antiretroviral therapy	1,350,011	1,374,428	1.02
Tuberculosis treatment course	61,994	67,465	1.09
Postnatal care contact	873,941	993,975	1.14
Sick newborn care	339,866	404,315	1.19
Pentavalent immunisation (DTP-HepB-Hib)	3,954,804	4,823,174	1.22
Complicated SAM, inpatient stabilisation	23,238	28,789	1.24
Severe childhood illness, admission	1,112,001	1,412,839	1.27
Inpatient bed-day	1,808,863	2,564,910	1.42
Obstetric complications (non-surgical)	256,356	376,847	1.47
Caesarean section	60,360	114,631	1.90
Major surgery (non-obstetric)	18,976	38,538	2.03

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_capacity_ratio.csv).

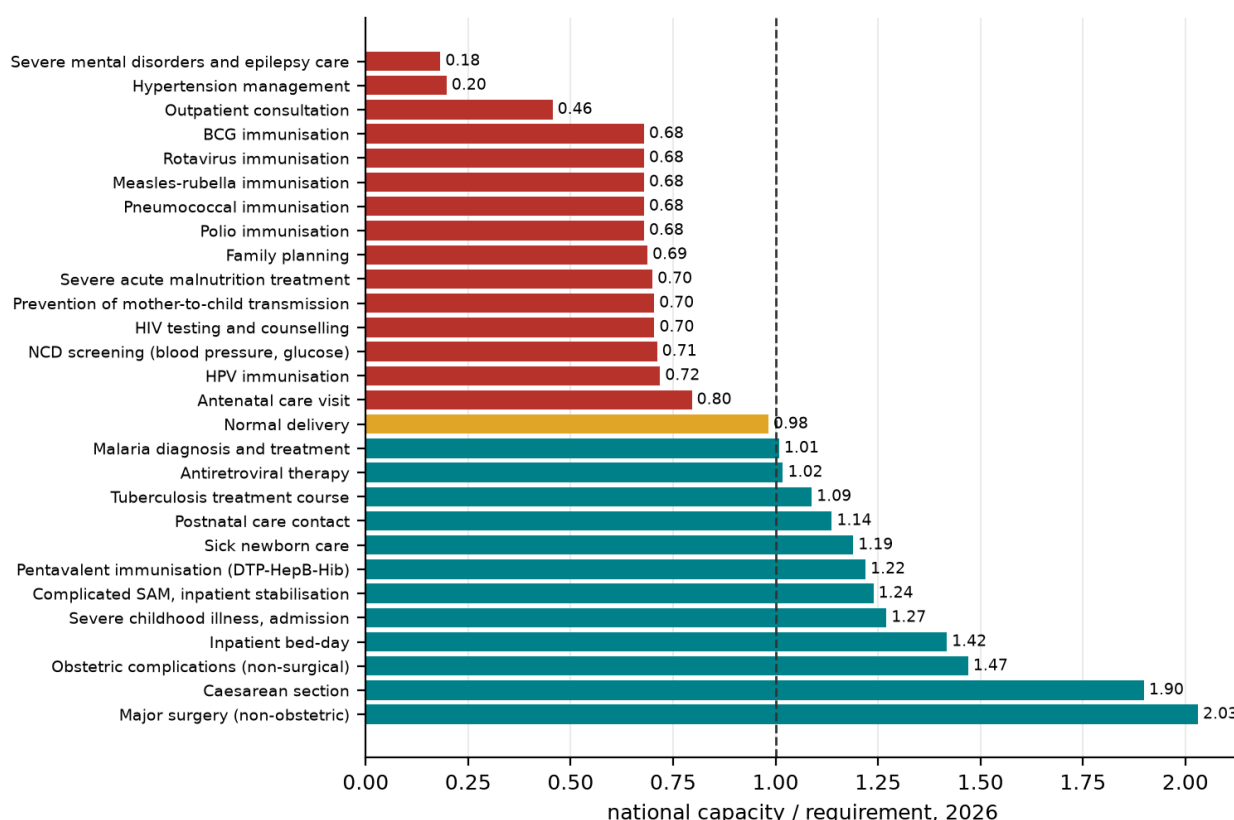


Figure 7.6: Capacity against requirement by service, 2026 (below 1: the system cannot deliver the target volume)

Source: HPRAS database, run uga-unconstrained-2026

Services the network cannot deliver at scale. Care for severe mental disorders and epilepsy (0.18) and hypertension management (0.20) are the furthest from their targets. Their requirement is large relative to the staff time the minimum staffing norms provide, and there is no observed coverage to lift them. Outpatient consultation, the largest single service by volume, stands at 0.46: the network can deliver 8.8 million of the 19.3 million consultations required.

A band of services at around 0.7. BCG, measles-rubella, pneumococcal, polio and rotavirus immunisation all sit at exactly 0.68. Family planning, SAM treatment, PMTCT, HIV testing, NCD screening and HPV immunisation fall between 0.69 and 0.72, and antenatal care is at 0.80. The identical ratio across five vaccines is the signature of a common normative constraint, the same staff time shared across the same sessions. The contrast with pentavalent vaccination, which has an observed coverage series, is instructive. Pentavalent capacity is lifted by revealed delivery to 1.22. Because the same staff deliver the same sessions, the normative immunisation capacity is probably understated, and the 0.68 figures should be read as a lower bound.

Services at or above requirement. Normal delivery (0.98), malaria treatment (1.01), ART (1.02), TB treatment (1.09) and postnatal care (1.14) are close to or above requirement, and these are the services where revealed capacity operates. Hospital services stand above 1 because the normative hospital establishment is large: inpatient bed-days 1.42, obstetric complications 1.47, caesarean section 1.90 and major surgery 2.03. The bed and theatre stock implied by 100 beds per general hospital and 300 per referral hospital, at occupancy targets of 0.85, is ample in aggregate. The district maps below show that it is not evenly spread.

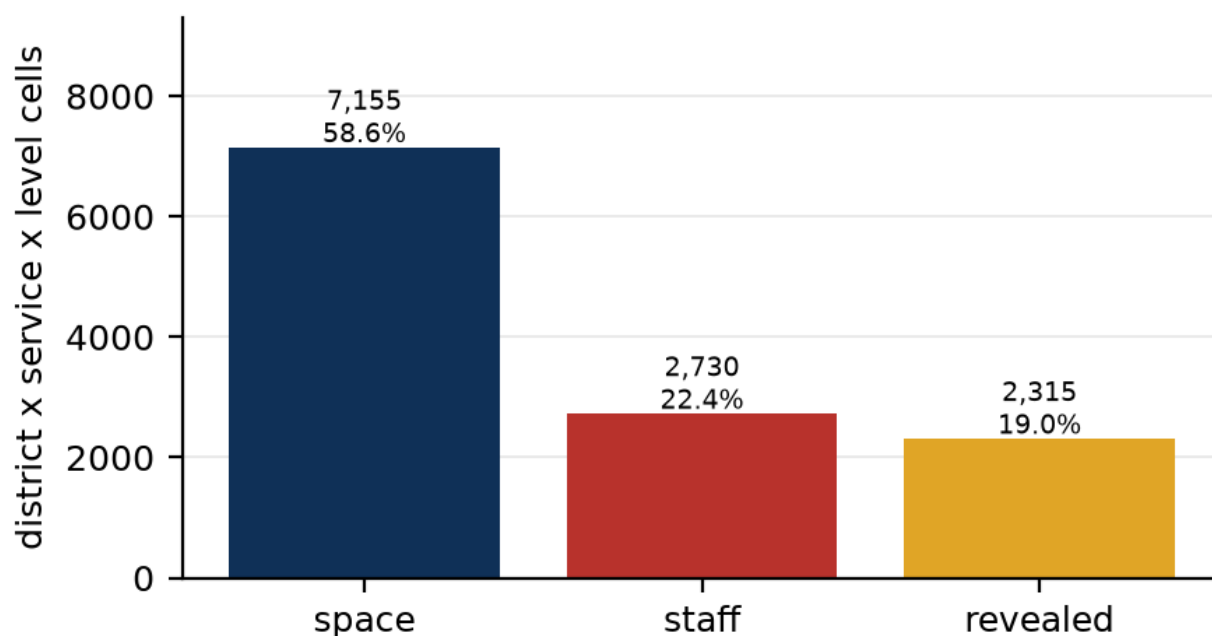
7.5 What binds

Table 7.7 and Figure 7.7 count, across all 12,200 district × service × level cells, which constraint set capacity.

Table 7.7: What binds capacity: the limiting constraint

Binding constraint	District x service x level cells	Share	Mean slack to next constraint
space	7,155	58.6%	4.02
staff	2,730	22.4%	37.18
revealed	2,315	19.0%	n/a

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_binding.csv).

**Figure 7.7:** What limits capacity: the binding constraint across all district, service and level cells, 2026

Source: HPRAS database, run uga-unconstrained-2026

Space binds most often, in 7,155 cells (58.6%). Staff binds in 2,730 (22.4%), and revealed delivery exceeds both normative constraints in 2,315 (19.0%). The slack ratios qualify this picture. Where space binds, the next constraint (staff) is on average only 4.02 times higher, so relieving space would soon run into staff. Where staff binds, space is on average 37.18 times more generous, so adding staff would buy a great deal of output before rooms became the limit. Put simply, **the network is short of rooms in many places, but short of staff in the places where adding people would unlock the most output.**

The pattern differs by level. At HC IIs space always binds (1,505 cells) unless revealed delivery lifts capacity (325 cells); staff never binds there, because the HC II establishment is one room and a small team. At HC IVs staff binds in 1,218 cells against 1,466 for space, and at general hospitals in 971 against 1,875. At referral hospitals space binds in 840 cells and staff in 136. By service, staff binds more often than space for outpatient consultation (304 cells against 184), hypertension (315 against 51), mental health (332 against 156) and caesarean section (210 against 156). Revealed delivery dominates for malaria (445 cells), ART (366) and normal delivery (216).

The 2,315 revealed cells matter for how the norms are read. In each of them the facilities are observed to deliver more than their normed throughput allows. Either the facilities are larger than the normative establishment assumes, or staff work above the WISN standard, or both. The engine does not choose between these explanations. It raises capacity to what is demonstrably delivered and records the fact, so that the norm owner can review the throughput standards where the gap between norm and observation is largest.

7.6 Capacity by district

Two layers map capacity against requirement district by district.

Outpatient capacity (Figure 7.8) has a median ratio of 0.46, the same as the national figure. It is lowest in Kampala (0.13), Kakumiro (0.18), Wakiso and Serere (0.19 each) and Kileleshya (0.20), and highest in Moyo (1.60), Rukiga (1.35), Kalangala (1.34), Rukungiri (1.25), Kabale (1.07) and Kween (1.01). This is the most clustered of the HM-04 layers (Moran's $I = 0.35$, $p = 0.001$). The hot spot lies in the south-west (Kabale, Rukiga, Rukungiri, Rubanda, Kanungu and Kyotera, with Adjumani in the north), mirroring the facility-density hot spot. The cold spot lies in Teso and Busoga: Serere, Pallisa, Buyende, Kaberamaido and Kibaale. The reading is direct. Where there are many health centres per person, outpatient capacity approaches requirement; where there are few, it falls well short. Kampala and Wakiso are the exception that proves the rule: their very low ratios reflect the exclusion of private clinics from the planning count and the national outpatient floor that lifts every district's requirement to the national 75th percentile.

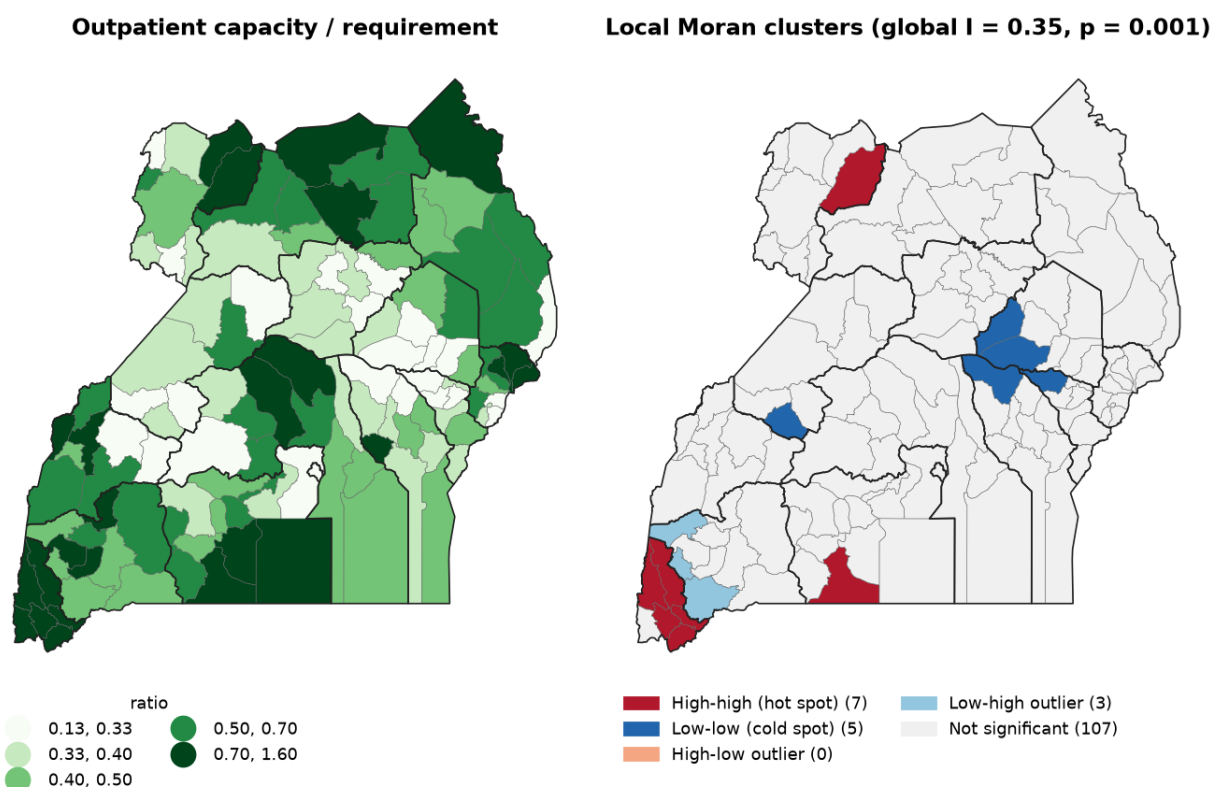


Figure 7.8: HM-04 - Outpatient capacity / requirement (ratio), by district, 2026; right: local Moran (LISA) clusters, 999 permutations
 Source: HPRAS database, run uga-unconstrained-2026; quality tier measured. Boundaries (c) OpenStreetMap contributors (ODbL).

Inpatient bed capacity (Figure 7.9) is far more uneven. The median district has 1.28 times the bed-days it requires, but the range runs from about 0.02 in Luuka, Kyankwanzi, Namayingo, Kileleshya and Gomba to 5.32 in Kabale, 5.10 in Jinja, 4.42 in Kabarole, 4.07 in Gulu and 4.05 in Kamwenge. The layer has no overall spatial structure (Moran's $I = -0.05$, $p = 0.499$), because beds follow hospitals and hospitals follow history. The one cold spot, Kaliro, Kakumiro and Mubende, is also the hospital cold spot. For bed capacity the national ratio of 1.42 is almost meaningless: the question is whether a patient in Kyankwanzi can reach the surplus beds in a neighbouring district, and that is a question of referral and transport, which the next section takes up.

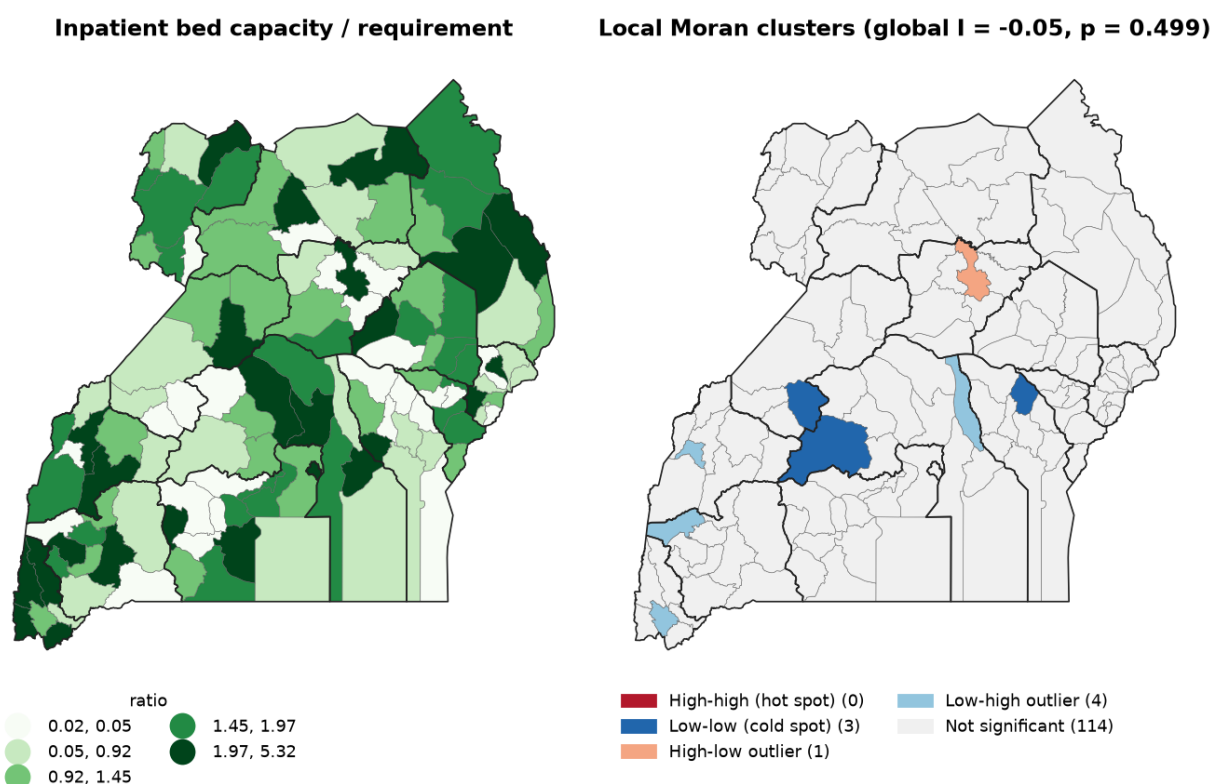


Figure 7.9: HM-04 - Inpatient bed capacity / requirement (ratio), by district, 2026; right: local Moran (LISA) clusters, 999 permutations

Source: HPRAS database, run uga-unconstrained-2026; quality tier measured. Boundaries (c) OpenStreetMap contributors (ODbL).

7.7 Physical access

7.7.1 Referral distance

For every located, operational public or PNFP health centre, `referral_distance` in `src/GIS.jl` computes the straight-line (great-circle) distance to the nearest located general or referral hospital using the haversine formula:

$$d = 2R \arcsin \sqrt{\sin^2 \left(\frac{\Delta\phi}{2} \right) + \cos \phi_1 \cos \phi_2 \sin^2 \left(\frac{\Delta\lambda}{2} \right)} \quad (7.10)$$

where:

- $R = 6,371$ km is the Earth's radius;
- ϕ_1 and ϕ_2 are the latitudes of the health centre and the hospital, in radians;
- $\Delta\phi$ and $\Delta\lambda$ are the differences in latitude and longitude.

Distances are summarised by district as the median, the 90th percentile and the share of centres more than 50 km from a hospital. A straight line is a **lower bound** on the journey, because roads are longer than straight lines and rivers and hills lengthen them further. The measure of travel is the SDI's network-based access layer, discussed next. The referral measure uses only located facilities, so districts where few centres could be geocoded rest on small numbers.

The national median distance from a health centre to its nearest hospital is 16.6 km. Table 7.8 and Figure 7.10 show the districts where it is longest. They are concentrated in Karamoja and the north-east. In Amudat the median is 62.1 km and two-thirds of located centres are more than 50 km from a hospital. In Nakapiripirit the median is 54.2 km with 71% beyond 50 km, and in Kotido 49.4 km. Nakasongola (47.4 km), Agago (46.9 km) and Kalangala (46.2 km) follow. In these districts a referral from a health centre for an obstetric emergency or a

severely ill child is a long journey even as the crow flies. The Kotido figure rests on only two located centres and should be read with that in mind.

Table 7.8: Longest straight-line referral distances, health centre to nearest hospital

District	Median km	90th percentile km	Centres beyond 50 km	Centres located
Amudat	62.1	72.2	67%	6
Nakapiripirit	54.2	61.5	71%	17
Kotido	49.4	59.4	50%	2
Nakasongola	47.4	58.9	46%	24
Agago	46.9	57.9	34%	32
Kalangala	46.2	58.4	30%	10
Otuke	42.4	49.0	0%	14
Pader	41.9	53.1	22%	27
Kakumiro	39.1	45.2	0%	12
Lamwo	38.3	48.2	11%	19
Pakwach	37.9	43.0	0%	18
Amuria	37.1	43.4	5%	21
Yumbe	35.4	45.0	0%	34
Buyende	35.0	39.6	0%	13
Sembabule	34.5	45.6	0%	16

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_referral_far.csv).

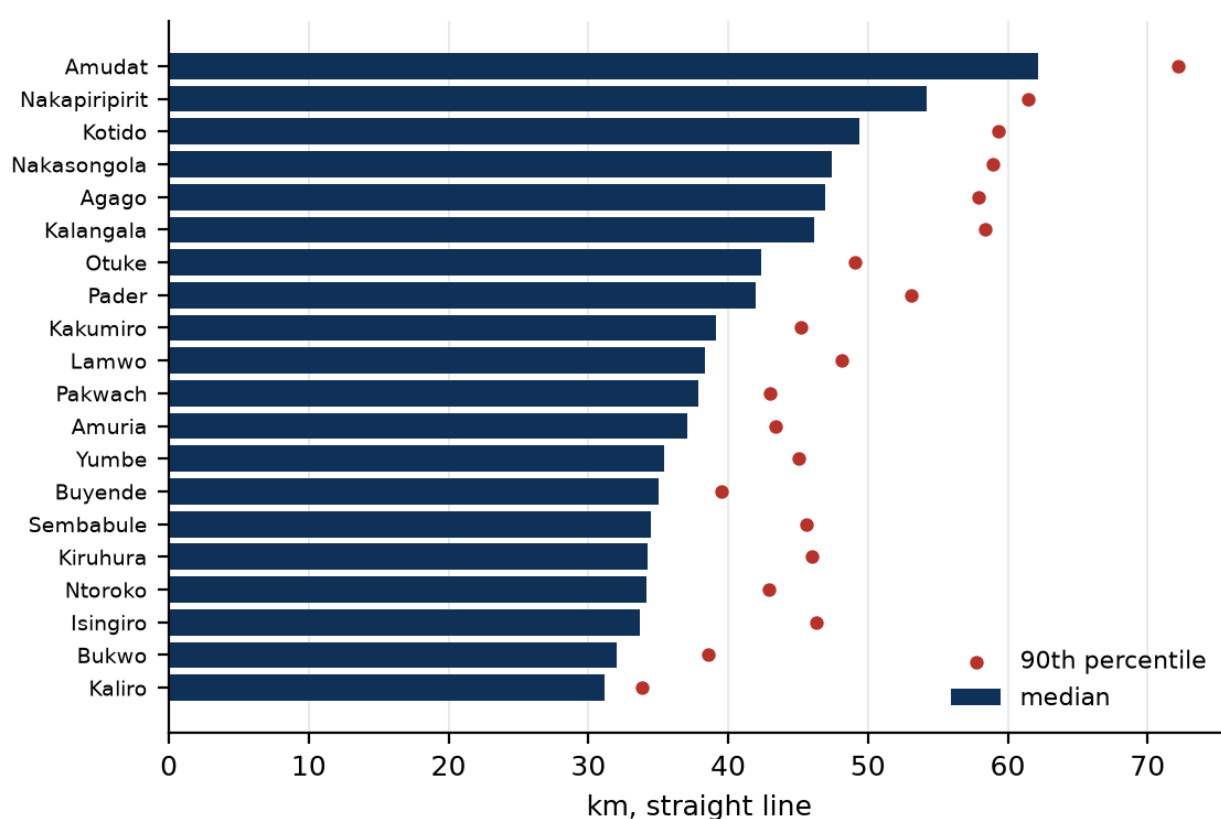


Figure 7.10: Referral distance: health centre to nearest hospital, the 20 furthest districts (a lower bound on travel)

Source: HPRAS database, run uga-unconstrained-2026

7.7.2 Travel time to a facility

Travel-time access is not computed in this repository. Under the Master Command (§5, §37), routing and travel-time surfaces belong to the Spatial Data Infrastructure (SDI). The engine reads the SDI's health_accessibility layer: the population within 30, 60 and 120 minutes' drive and within 60 minutes' walk of a functional facility, by

district. The file in use is the 2020 layer vendored from HealthModelling and folded onto the 122 plan districts with population weights. Every run reports this interface as a **snapshot**, not a live feed, and the layer carries the imputed quality tier.

Nationally, **87.5% of the population lives within 60 minutes' walk of a facility and 98.9% within 60 minutes' drive**. The 12.5% beyond an hour's walk amount to 5.3 million people (on the SDI's 2020 population). Table 7.9 and Figure 7.11 break this down by sub-region.

Table 7.9: Physical access by sub-region

Sub-region	60 min walk	60 min drive	People beyond 60 min walk
Karamoja	69.1%	84.8%	364,049
Lango	72.6%	99.4%	682,629
Acholi	73.0%	98.3%	491,107
Bunyoro	74.4%	99.7%	679,864
Teso	79.3%	98.9%	466,486
North Buganda	85.3%	98.2%	652,510
Tooro	85.5%	99.8%	463,623
Ankole	89.6%	99.6%	350,699
West Nile	89.7%	99.5%	329,855
Busoga	92.9%	99.2%	303,797
South Buganda	93.9%	99.2%	342,868
Kampala	94.4%	100.0%	95,584
Kigezi	98.3%	100.0%	25,125
Bugisu	98.8%	99.1%	26,010
Bukedi	99.6%	100.0%	10,147

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_access_subregion.csv).

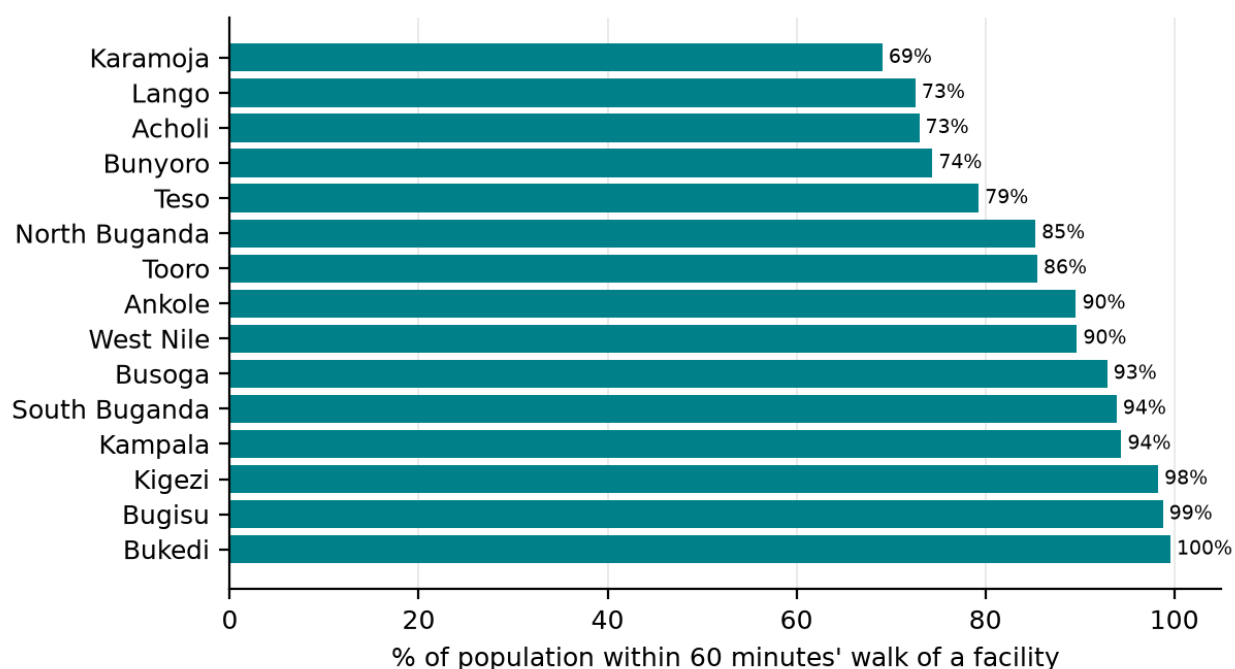


Figure 7.11: Walking access by sub-region

Source: SDI health_accessibility (2020, vendored)

Karamoja is the outlier on both measures: 69.1% within an hour's walk and only 84.8% within an hour's drive. It is the only sub-region where a vehicle does not reach almost everyone. Lango (72.6%), Acholi (73.0%) and Bunyoro (74.4%) follow on walking access, but in each of them more than 98% of people are within an hour's drive, so their

problem is distance on foot, not the absence of roads. At the other end, Bukedi (99.6%), Bugisu (98.8%) and Kigezi (98.3%) have almost universal walking access. In absolute numbers the sub-regions with the most people beyond an hour's walk are Lango (682,629), Bunyoro (679,864) and North Buganda (652,510), not Karamoja (364,049), because their populations are larger.

Table 7.10 lists the fifteen districts with the lowest walking access. **Buvuma (35.9%), Amudat (36.2%) and Kalangala (41.5%)** are lowest, followed by Napak (47.7%). Buvuma and Kalangala are island districts in Lake Victoria, where the barrier is water and only about two-thirds of people are within an hour's drive either. Amudat and Napak are in Karamoja. The rest of the list shows a different pattern. Otuke, Lamwo, Nwoya, Kibaale, Kiruhura, Buyende, Kakumiro, Kyankwanzi, Bukedea, Kyegegwa and Apac all have more than 95% of their people within an hour's drive but only 54–68% within an hour's walk. These are dispersed rural populations on flat land with a road network but sparse facilities.

Table 7.10: The fifteen districts with the lowest walking access to a facility

District	Sub-region	Within 30 min drive	60 min drive	60 min walk	People beyond 60 min walk
Buvuma	North Buganda	59.6%	67.8%	35.9%	83,879
Amudat	Karamoja	78.7%	80.3%	36.2%	91,746
Kalangala	South Buganda	66.5%	66.5%	41.5%	39,043
Napak	Karamoja	68.1%	69.8%	47.7%	85,244
Otuke	Lango	92.9%	98.5%	53.6%	63,488
Lamwo	Acholi	97.3%	98.6%	53.7%	66,898
Nwoya	Acholi	90.1%	95.7%	55.9%	102,277
Kibaale	Bunyoro	99.6%	99.7%	56.1%	85,193
Kiruhura	Ankole	96.9%	97.8%	56.6%	177,489
Buyende	Busoga	97.2%	97.2%	59.8%	167,413
Kakumiro	Bunyoro	100.0%	100.0%	60.8%	161,568
Kyankwanzi	North Buganda	96.6%	97.1%	62.8%	106,269
Bukedea	Teso	98.5%	98.8%	64.3%	87,057
Kyegegwa	Tooro	99.9%	100.0%	64.8%	155,578
Apac	Lango	98.4%	98.4%	67.5%	146,297

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_access_lowest.csv).

Table 7.11 ranks districts by the **number** of people beyond an hour's walk, which is what a siting decision has to reach. The ranking differs markedly from the percentage ranking. Hoima (182,260 people), Mubende (179,170), Kiruhura (177,489), Kyenjojo (171,321) and Buyende (167,413) head the list, and even Kampala has 95,584 people beyond an hour's walk despite 94.4% access, simply because of its size. A planner who targets the lowest percentages will go to the islands and Karamoja; a planner who targets the largest numbers will go to Bunyoro, Tooro and Buganda. Both are legitimate criteria and the report shows both.

Table 7.11: Where most people live beyond an hour's walk of a facility

District	Population (2020)	60 min walk	People beyond 60 min walk
Hoima	741,092	75.4%	182,260
Mubende	875,677	79.5%	179,170
Kiruhura	408,522	56.6%	177,489
Kyenjojo	532,052	67.8%	171,321
Buyende	416,451	59.8%	167,413
Kakumiro	412,162	60.8%	161,568
Kyegegwa	441,982	64.8%	155,578
Apac	450,108	67.5%	146,297
Oyam	464,652	69.0%	144,042
Arua	926,940	87.3%	117,907

District	Population (2020)	60 min walk	People beyond 60 min walk
Kyankwanzi	285,670	62.8%	106,269
Nwoya	231,920	55.9%	102,277
Yumbe	672,706	85.0%	100,906
Kampala	1,706,854	94.4%	95,584
Amudat	143,802	36.2%	91,746

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_access_most_beyond.csv).

7.7.3 Walking access, driving access and facility density

Figure 7.12 and Figure 7.13 map the two access measures. Driving access is almost uniform: the median district has 99.7% of its people within an hour's drive. The only significant cluster is a cold spot in Karamoja and its fringe: Napak, Nakapiripirit, Amudat, Moroto, Abim, Kotido and Katakwi (Moran's $I = 0.17$, $p = 0.003$). Kalangala (66.5%) and Buvuma (67.8%) are the lowest individual values, as islands.

Population within 60 minutes' drive of a facility Local Moran clusters (global $I = 0.17$, $p = 0.003$)

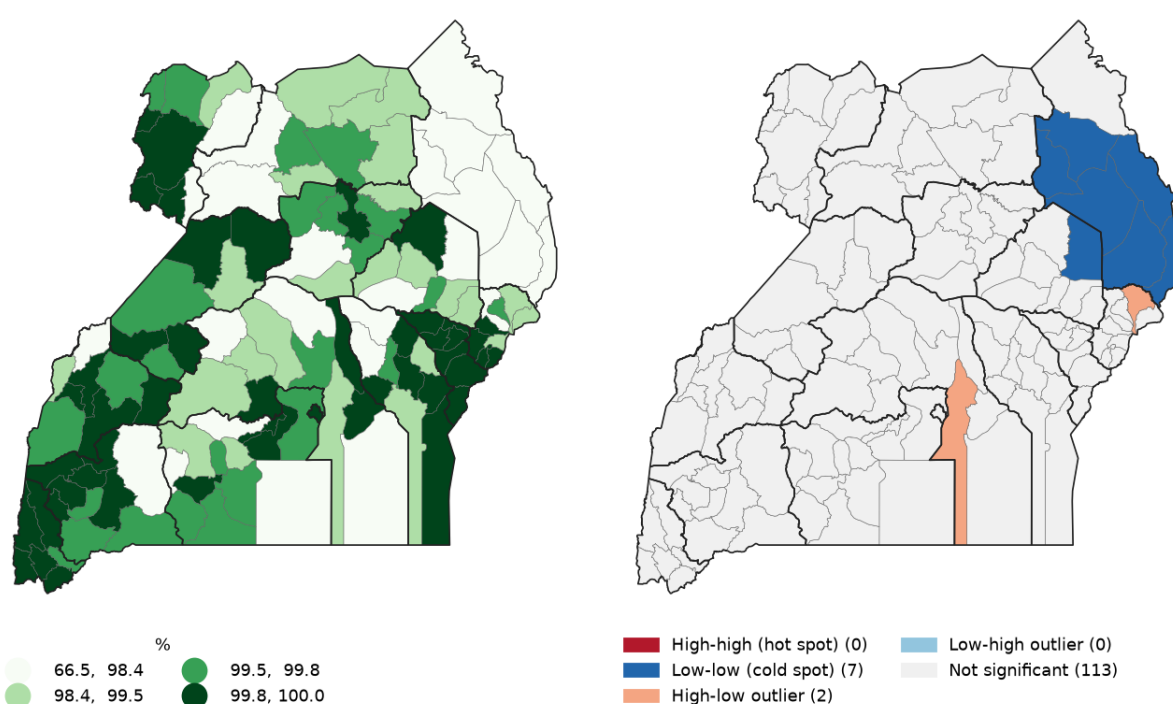


Figure 7.12: HM-04 - Population within 60 minutes' drive of a facility (%), by district, 2026; right: local Moran (LISA) clusters, 999 permutations

Source: HPRAS database, run uga-unconstrained-2026; quality tier imputed. Boundaries (c) OpenStreetMap contributors (ODbL).

Walking access is more strongly structured (Moran's $I = 0.32$, $p = 0.001$). The cold spot is large, 16 districts in two belts. One runs across the mid-west: Hoima, Kagadi, Kibaale, Kakumiro, Kyegegwa, Mubende and Kiryandongo. The other runs across the north and north-east: Otuke, Pader, Kitgum, Amolatar, Kaberamaido, Amuria, Abim, Moroto and Nakapiripirit. The hot spot lies in the densely settled east (Tororo, Butaleja, Bugiri, Budaka, Kibuku, Manafwa and Bududa) and in Rubanda and Rukungiri in the south-west.

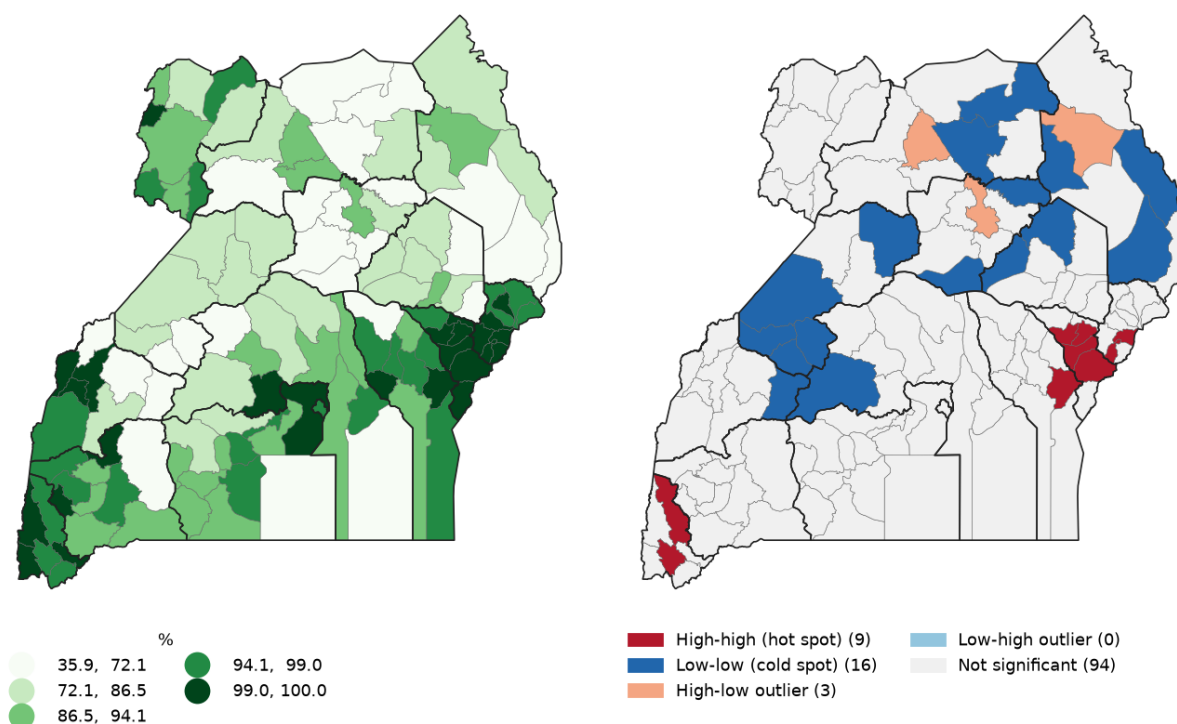
Population within 60 minutes' walk of a facility Local Moran clusters (global I = 0.32, p = 0.001)


Figure 7.13: HM-04 - Population within 60 minutes' walk of a facility (%), by district, 2026; right: local Moran (LISA) clusters, 999 permutations

Source: HPRAS database, run uga-unconstrained-2026; quality tier imputed. Boundaries (c) OpenStreetMap contributors (ODbL).

In a few districts a higher share of people can walk to a facility within an hour than can drive to one: Bududa (99.6% walking against 98.7% driving), Bundibugyo (99.8% against 99.4%), Bulambuli (94.8% against 94.7%) and Rukiga (99.6% against 99.5%). This is not an error. These are mountainous districts on the slopes of Mount Elgon and the Rwenzori and in the Kigezi highlands. There, footpaths reach settlements that roads do not, and a road journey that must follow contours can take longer than a direct walk. The engine's tests therefore check that walking access lies between 0 and 100 and that driving access rises with the time threshold, but deliberately do not require walking access to be below driving access.

Figure 7.14 sets walking access against facility density. The relationship is weak. Wakiso and Kampala, the two largest bubbles, have the lowest facility densities in the country and nearly universal walking access, because urban populations live close together. Kalangala has the highest density of all and one of the lowest walking access shares, because its facilities are spread across islands. Among rural districts, districts with similar densities of around one facility per 10,000 people are spread across almost the whole range of walking access. **Facility counts per person are a poor guide to physical access**, which is why the engine reads access from a travel-time model rather than inferring it from counts.

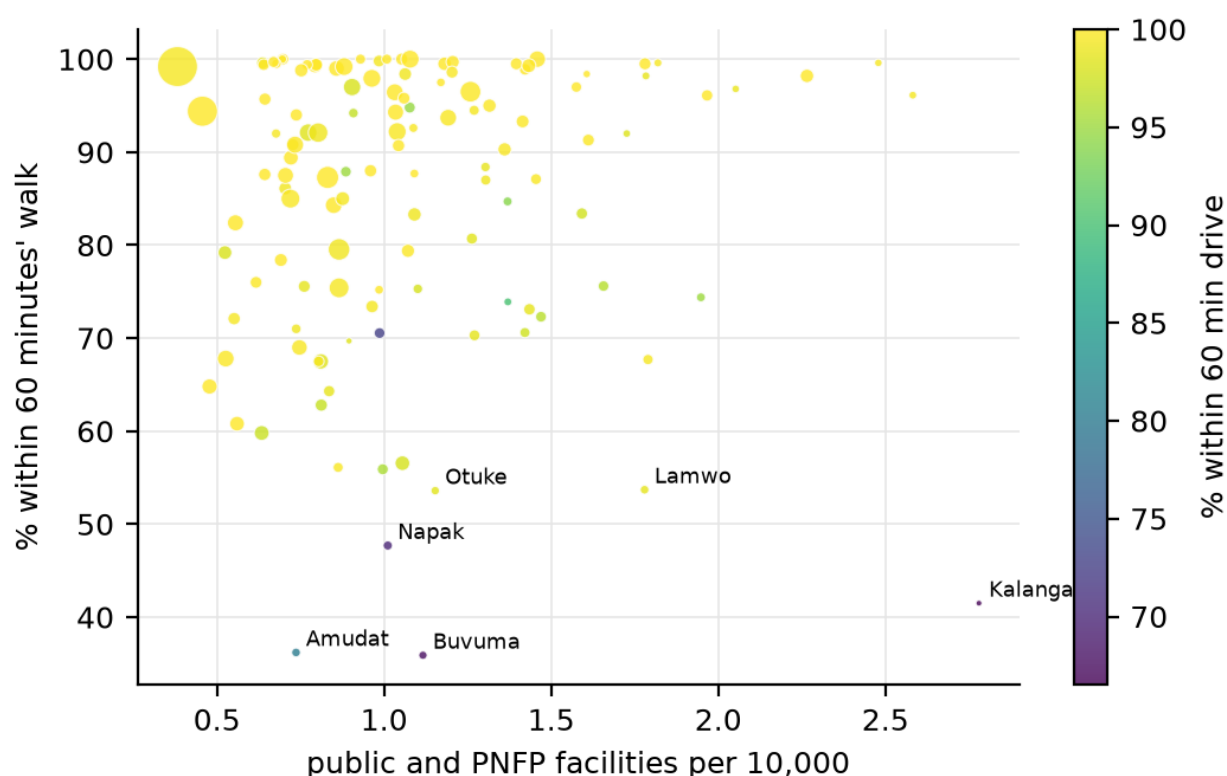


Figure 7.14: Facility density and walking access by district (bubble size: population)

Source: SDI health_accessibility (2020, vendored); NHFR

7.8 Data quality and limitations

The quality tiers run measured < normed < imputed < assumed, and every result carries the worst tier of its inputs.

- **Facility counts are measured.** They come from the current MoH registry and cover all 122 districts. The 2010 register and the OpenStreetMap-based imputation in `scripts/fill_supply_gaps.py` are no longer needed for counts; with the registry, no district relies on an imputed facility count. The plan log confirms that supply evidence is measured for all 122 districts.
- **Physical establishments are normed.** Rooms, beds and theatres per facility are normative (Table 7.5), not an infrastructure inventory. A general hospital is assumed to have 100 beds whether it has 60 or 200. An infrastructure inventory by facility would replace these values without any change to the code.
- **The workforce is derived.** Establishment × fill rate is a reasoned construction, not a count of people. The fill rate is measured, but the establishment is normative, and staff absence beyond the WISN allowance is not observed. An HRIS extract would replace the derivation.
- **Readiness is imputed.** HMIS reporting completeness is a proxy for facility functionality, not a measure of it. A facility can report on time and still lack water or a functioning autoclave. No SARA or HHFA survey is available by district.
- **Commodity availability is not a capacity constraint yet.** The manual's commodity constraint, issued quantities discounted by stockout days, requires LMIS data that the engine does not have. Capacity is therefore the minimum of space and staff only. The commodity dimension enters as a separate gap in Chapter 8.
- **Access is imputed and dated.** The SDI layer is a 2020 snapshot, folded from 135 to 122 districts, and it measures travel to any functional facility, not to a facility of a given level.
- **Referral distance is a lower bound,** computed on the 3,169 located facilities only.

7.9 Implications for planning

Staff unlock more output than buildings where staff bind. Staff bind in 22.4% of cells, but there the slack to the next constraint averages 37: each added health worker converts directly into services until the rooms fill. Space binds in 58.6% of cells, but with a slack of only 4, so adding rooms there soon runs into staff. For outpatient, hypertension and mental health services, the three with the lowest capacity ratios, staff binds more often than space. Recruitment and deployment of clinical staff should precede construction in those programmes.

The throughput norms need review where revealed capacity binds. In 2,315 cells, and across most districts for malaria, ART and delivery, observed delivery exceeds normed throughput. The identical 0.68 capacity ratio for five vaccines, against 1.22 for pentavalent where delivery is observed, suggests the normative immunisation capacity is understated. The norm owner should review room throughput and staff minutes for these services before the capacity shortfalls in Chapter 8 are used to justify investment.

Hospitals and beds are unevenly spread, not scarce. Nationally there are more hospital beds and theatre slots than the modelled services require, but a cluster of districts in the mid-west and Busoga (Kakumiro, Mubende, Kaliro) has little hospital capacity, and districts such as Kyankwanzi and Luuka have almost none. Referral transport and district hospital designation may close more of this gap than new building.

Access has two geographies and needs two responses. Karamoja and the island districts lack roads as well as facilities; there, outreach, water transport and referral transport are the relevant instruments. The mid-west and northern belts have roads but sparse facilities, and there the case for additional health centres is strongest. Which to prioritise, the lowest shares or the largest numbers of people beyond an hour's walk, is a choice this report makes visible and does not make.

Three data investments would sharpen every number in this chapter: an HRIS extract by facility and cadre, an infrastructure inventory of rooms, beds and theatres by facility, and a district readiness survey. Each would replace a normative or imputed input with a measured one, and none requires any change to the engine.

CHAPTER 8

8 Health gaps: four dimensions, never combined (HM-05)

Chapter 6 set out what the 28 modelled services require in 2026, and Chapter 7 what the public and PNFP network can deliver. This chapter sets the two against each other and asks where Uganda's health system falls short. It is the module planners will use most, and it is where the engine's principle against composite scores (P3) matters most.

The answer is given in **four separate dimensions**: services that cannot be delivered, health workers who are missing, commodities that are not assured, and physical capacity that would have to be added. Each has its own unit, its own remedy and its own map. Physical access, the share of people beyond an hour's walk of a facility, is shown beside the four as geography. It is not a fifth gap, and none of the five is ever added to another. A district short of nurses is not in the same position as a district short of rooms, and an average of the two tells a planner nothing they can act on.

The chapter answers three questions:

- How large is each gap nationally, and for which services and cadres?
- Which districts carry the largest gaps on each dimension, and do the dimensions coincide?
- What does each gap measure, and what does it not yet measure?

8.1 The four dimensions

All gaps follow one sign convention: **positive is a shortfall, negative is a surplus, and surpluses are preserved**. A district with spare capacity for a service keeps its negative gap in the results. The spare capacity is not netted against another district's shortfall, because a surplus of delivery rooms in Kabale does not deliver babies in Serere. This is implemented in `compute_gaps!` and `build_gap_matrix!` in `src/SupplyGaps.jl`.

8.1.1 Gap 1: the service gap

For each service s and district d , the service gap is the required volume less the capacity from Chapter 7:

$$G_{s,d}^{\text{svc}} = Q_{s,d} - K_{s,d} \quad (8.1)$$

$$\text{Gap1}_d = \sum_s \max(0, G_{s,d}^{\text{svc}}) \quad (8.2)$$

where:

- $Q_{\{s,d\}}$ is the service volume required at the target coverage, summed over facility levels (HM-03);
- $K_{\{s,d\}}$ is the capacity summed over facility levels, including the revealed-capacity floor (HM-04);
- Gap1_d is the district's total service units that existing capacity cannot deliver.

The district total sums only the positive parts. A surplus in outpatient consultations cannot be spent on immunisation any more than it can be moved between districts. Across the 3,416 district-service combinations, 2,105 show a shortfall, and together they sum to **23,782,948 service units** that existing capacity cannot deliver in 2026. The remaining combinations hold a surplus of 5,849,257 units. That surplus is kept in the results for reallocation analysis but is not subtracted from the shortfall.

The service gap has a companion measure, the **coverage gap**:

$$\Gamma_{s,d} = C_{s,d}^* - C_{s,d}^{\text{obs}} \quad (8.3)$$

where C^* is the target coverage and C^{obs} the latest observed coverage. The coverage gap measures policy distance, while the capacity shortfall measures the physical ability to deliver. They answer different questions. If a district has a positive coverage gap but no capacity shortfall, it could deliver the service but does not, which points to an access, demand, quality or management problem that construction will not fix. If a district has a capacity shortfall, it cannot deliver the target volume even if every eligible person came forward.

Table 8.1 reports both measures by service. The coverage gap exists only for the seven services with an observed district coverage series. In the table it is the sum over the 122 districts of the gap expressed as a proportion, so it is read by dividing by 122. Averaged over districts, the coverage gap is 23.6 percentage points for antenatal care (four visits), 17.0 points for facility delivery and 1.4 points for pentavalent vaccination. It is slightly negative (current coverage above target on average) for malaria treatment (-2.1 points), ART (-0.2), postnatal care (-0.7) and TB treatment (-5.8).

Table 8.1: Gap by service, 2026: capacity shortfall (cannot deliver) and coverage gap (could deliver, does not)

Service	Required	Capacity	Capacity shortfall	Coverage gap	Districts short
Outpatient consultation	19,287,133	8,795,525	10,611,786	-	116
HIV testing and counselling	5,987,951	4,218,036	2,039,727	-	94
Polio immunisation	4,565,143	3,100,199	1,611,856	-	96
Pneumococcal immunisation	3,920,069	2,662,128	1,384,094	-	96
Antenatal care visit	5,394,354	4,292,226	1,329,025	29	88
Family planning	2,823,304	1,940,881	991,984	-	94
Malaria diagnosis and treatment	10,113,481	10,203,005	883,029	-3	42
Rotavirus immunisation	2,315,652	1,572,565	817,608	-	96
Measles-rubella immunisation	2,004,693	1,361,392	707,815	-	96
Hypertension management	854,644	168,721	685,923	-	122
NCD screening (blood pressure, glucose)	1,874,459	1,332,554	630,523	-	94
BCG immunisation	1,592,838	1,081,700	562,398	-	96
Inpatient bed-day	1,808,863	2,564,910	455,450	-	54
Severe childhood illness, admission	1,112,001	1,412,839	276,696	-	55
Normal delivery	1,437,148	1,411,979	218,477	21	71
HPV immunisation	579,794	416,476	187,128	-	92
Sick newborn care	339,866	404,315	88,670	-	61
Postnatal care contact	873,941	993,975	71,357	-1	38
Obstetric complications (non-surgical)	256,356	376,847	58,422	-	50
Severe mental disorders and epilepsy care	48,387	8,813	39,574	-	122
Antiretroviral therapy	1,350,011	1,374,428	39,121	-0	40
Severe acute malnutrition treatment	80,687	56,456	27,242	-	94
Pentavalent immunisation (DTP-HepB-Hib)	3,954,804	4,823,174	20,468	2	13
Prevention of mother-to-child transmission	54,408	38,298	18,773	-	94
Caesarean section	60,360	114,631	13,785	-	49
Complicated SAM, inpatient stabilisation	23,238	28,789	5,443	-	59
Major surgery (non-obstetric)	18,976	38,538	4,240	-	46
Tuberculosis treatment course	61,994	67,465	2,333	-7	37

Source: HPRAS database, run `uga-unconstrained-2026 (report/build/data/t_gap_service.csv)`.

The capacity shortfall is dominated by outpatient consultation: **10.6 million consultations** that the network cannot deliver, in 116 of the 122 districts. HIV testing (2.0 million tests), four vaccines (polio, pneumococcal, rotavirus and measles-rubella, together 4.5 million doses), antenatal care (1.3 million visits) and family planning (1.0 million user-years) follow. Hypertension management and severe mental disorders are short in **all 122 districts**.

The table also shows why national ratios mislead. Malaria treatment has a national capacity ratio of 1.01, yet 883,029 cases cannot be treated, in 42 districts. Inpatient bed-days stand at 1.42 nationally, yet 54 districts are short by a total of 455,450 bed-days. Caesarean capacity is nearly twice the national requirement, yet 49 districts cannot perform all the caesareans their populations need. These are the surpluses that the sign convention refuses to net: the capacity exists, but in other districts.

For antenatal care and normal delivery both measures are positive. Antenatal care has a capacity shortfall of 1.3 million visits and a coverage gap of 23.6 points; normal delivery has a shortfall of 218,477 deliveries and a gap of 17.0 points. Closing the coverage gap for these services needs both more capacity and more use of the capacity that exists.

8.1.2 Gap 2: the workforce gap

The workforce gap compares full-time equivalents on both sides. The requirement, in minutes of each cadre's time from the service norms, is converted to FTE with the WISN available working time; the supply is the FTE in post from Chapter 7:

$$G_{c,d}^{\text{wf}} = \frac{M_{c,d}}{A_c} - F_{c,d} \quad (8.4)$$

$$\text{Gap}2_d = \sum_c \max(0, G_{c,d}^{\text{wf}}) \quad (8.5)$$

where:

- $M_{\{c,d\}}$ is the minutes of cadre c required by the modelled services in district d ;
- A_c is the available working time per FTE-year (76,320 minutes for clinical and nursing cadres);
- $F_{\{c,d\}}$ is the FTE of cadre c in post in district d .

The national workforce gap is **5,054 FTE** in 2026. It is concentrated in a few cadres. Clinical officers account for 2,048 FTE, short in 117 districts. Village health team members account for 1,417 FTE; they have no facility establishment, so the whole requirement appears as a gap. Registered nurses account for 610 FTE (29 districts), pharmacy technicians 555 FTE (120 districts), medical officers 201 FTE (34 districts) and registered midwives 178 FTE (25 districts). The resource-class view is in Table 8.2, in the next section.

Two cautions govern how this gap is read. First, the requirement covers **the modelled services only**, 32,775 FTE of WISN workload in 2026, while the 119,127 FTE in post also deliver everything outside the catalogue. A negative gap for a cadre is therefore not a surplus. It is the part of that cadre's time the modelled services do not account for. Only a positive gap, where the partial catalogue alone already exceeds the establishment, is a real shortfall. This is why the district total sums positive parts only. Second, the registered nurse figure shows the value of district resolution. Nationally, the modelled services need 7,698 registered-nurse FTE against 25,311 in post, yet 29 districts are short of registered nurses for the modelled workload alone.

The engine manual asks for the workforce gap **with and without substitution**. The cadre catalogue records permitted task-shifting: work of an enrolled nurse may be done by a registered nurse, that of a clinical officer by a medical officer, and that of a pharmacy technician by a pharmacist. With substitution, spare time in a higher cadre can cover part of a lower cadre's gap. The gap matrix carries both columns, but in this run the substitution rules have not yet been applied, and the two columns hold the same value. The 5,054 FTE is therefore the **unsubstituted**, establishment view. The substituted view can only be smaller. Because in-post time that the modelled services do not use is not idle, any substitution would need to be tested against the work those staff already do outside the catalogue.

8.1.3 Gap 3: the commodity gap

The commodity gap values the medicines, vaccines, diagnostics and consumables required by the modelled services, less what is assured, at the plan's prices:

$$\text{Gap}3_d = \sum_{r \in \mathcal{R}} (R_{r,d} - S_{r,d}) \times p_r \quad (8.6)$$

where:

- $\mathcal{R}$ is the set of commodity resources (medicine, vaccine, diagnostic and consumable classes);
- $R_{\{r,d\}}$ is the quantity of resource r required in district d ;
- $S_{\{r,d\}}$ is the quantity assured by the supply chain;
- p_r is the unit price (price vintage UGA-2026Q1).

No logistics management information system (LMIS) extract on issues and stockouts is available to the engine. Rather than assume that commodities are available, the engine sets $S_{\{r,d\}}$ to zero and flags every commodity gap assumed. **The commodity gap is therefore the full commodity requirement: 858 bn UGX in 2026.** Of this, medicines account for 546 bn, diagnostics 137 bn, consumables 95 bn and vaccines 80 bn. The gap matrix also records the positive quantity gap in each resource's own unit, and Table 8.2 lists these by class. Those totals add doses, tests and tablets together and are useful only for tracing, not for comparison.

Table 8.2: Resource gaps by class and dimension, 2026

Resource class	Gap dimension	Total gap (resource units)	Districts
consumable	commodity	104,809,328	122
diagnostic	commodity	47,530,918	122
equipment	infrastructure	91,739,155	122
infrastructure	infrastructure	101,820,465	122
medicine	commodity	495,691,254	122
other	service	3,799,364	122
staff	workforce	5,054	122
supervision	service	56,987,368	122
transport	service	2,213,582	122
utility	service	88,736,646	122
vaccine	commodity	24,351,306	122

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_gap_resource.csv).

The manual distinguishes two causes of a commodity gap: a **quantification gap** (not enough was procured) and a **supply-chain gap** (enough was procured but did not arrive, or expired). The first is closed with money and the second with logistics. Without LMIS data the engine cannot separate them, and the 858 bn UGX should be read as the value of commodities the modelled services consume, not as evidence that 858 bn UGX of commodities is missing today. The budget reconciliation in Chapter 13 compares this line with the 1,254 bn UGX of medicines and supplies in the approved FY2025/26 budget.

8.1.4 Gap 4: the facility gap

The facility gap measures the physical capacity that would have to be added where space is the binding constraint. It is expressed in **facility-equivalents**:

$$\text{Gap}4_d = \frac{\sum_{(s,l) \in B_d} \max(0, G_{s,d}^{\text{svc}})}{\sum_{(s,l) \in B_d} K_{s,d,l}^{\text{space}}} \quad (8.7)$$

where:

- B_d is the set of service-level cells in district d where space binds;
- $K^{\text{space}}_{\{s,d,l\}}$ is the space capacity of those cells (Equation (7.4) in Chapter 7).

A value of 1 means that the unmet volume of the space-bound services equals the physical capacity the district already devotes to them. The district would need that physical capacity again. The measure scales the physical shortfall to the district's own existing space, so it is comparable across districts of different sizes. It is not yet a count of buildings by type. The manual's intended formulation divides the shortfall by the capacity of one facility of the relevant level and classifies each unit of shortfall as rehabilitate, upgrade or construct; that classification is not yet implemented. The facility gap is positive in 121 districts and sums to **260 facility-equivalents** nationally.

8.1.5 Access: shown beside the gaps, never folded in

Physical access is reported with the four gaps but is not one of them:

$$B_d^{\text{walk}} = P_d \times \left(1 - \frac{w_d}{100}\right) \quad (8.8)$$

where P_d is the district population and w_d the percentage within 60 minutes' walk of a facility (SDI, 2020). The measure is kept in absolute persons, because that is the number a siting decision has to reach. Access is geography, not capacity. A district can have ample capacity that a fifth of its people cannot reach on foot, or near-universal access to facilities that cannot deliver. Adding the two would hide both.

8.2 Why the four are never added

Principle P3 forbids a composite gap index, and the results show why. The four gaps are measured in incommensurable units: service units, FTE, shillings and facility-equivalents. Any weighting that combined them would be an arbitrary judgement disguised as a measurement. More importantly, they call for different responses. A service gap driven by staff calls for recruitment and deployment. A commodity gap calls for procurement or logistics. A facility gap calls for construction, upgrading or rehabilitation. An access gap calls for siting, outreach or transport.

Two districts illustrate the point. Serere has the largest service gap per person in the country (1,217 units per 1,000 people), the largest facility gap (9.9 facility-equivalents), 103 FTE missing, and 79% of its people within an hour's walk. Wakiso has a smaller service gap per person (819 per 1,000) but the largest workforce gap (375 FTE) and the largest commodity gap (64.5 bn UGX) in absolute terms, a facility gap that is small relative to its population, and 99% walking access. An index would rank both "high". The matrix shows that Serere needs physical capacity and Wakiso needs staff and supplies for a very large population.

Ranking is still possible, but only on an explicit criterion the user chooses: service units not deliverable, people affected, cost to close or deaths avertable. When two criteria disagree, the difference is information, not a defect.

8.3 The district gap matrix

The gap matrix has one row per district, with the four dimensions in separate columns, the cost to close in recurrent and capital terms (Chapters 9 and 10), and the supply quality tier. In absolute terms the plan log's matrix is headed by the two largest districts: Wakiso (2,465,333 service units, 375 FTE, 64.5 bn UGX of commodities) and Kampala (1,669,452 units, 234 FTE, 38.6 bn UGX). Mubende (685,415 units), Hoima (533,604), Serere (487,946), Arua (476,159), Yumbe (451,310) and Mayuge (424,753) follow. Absolute gaps largely reflect population. The per-person view in Table 8.3 and Figure 8.1 is the better guide to where the system is thinnest.

Table 8.3: The 25 districts with the largest service gap per person, 2026 (four dimensions, never added)

District	Population	Gap 1: units per 1,000	Gap 2: FTE	Gap 3: commodities (m UGX)	Gap 4: facility-eq.	Bounds
Serere	400,846	1,217	103	7,438	9.9	space
Budaka	286,839	949	52	4,737	5.7	space
Kakumiro	464,197	858	107	8,356	7.8	space
Namisindwa	298,780	857	62	4,809	6.0	space
Pallisa	332,341	846	27	5,596	3.8	space
Kampala	1,993,294	838	234	38,604	3.5	space
Wakiso	3,011,310	819	375	64,510	6.7	space
Kole	326,434	804	78	6,890	7.9	space
Alebtong	307,956	801	67	6,500	7.3	space
Buyende	457,535	789	109	7,487	6.6	space
Soroti	410,902	785	40	7,528	2.8	space
Kaliro	326,559	767	66	5,343	5.8	space
Dokolo	248,628	767	57	5,439	5.8	space
Kagadi	486,194	756	54	8,752	5.7	space
Kibuku	281,309	753	44	4,585	5.6	space
Ngora	192,064	749	19	3,494	3.6	space
Kaberaido	302,174	735	26	5,435	2.8	space
Manafwa	176,981	732	13	2,849	4.3	space
Mubende	959,190	715	104	17,830	4.2	space
Luuka	315,749	687	81	5,167	2.7	space
Kumi	326,559	684	35	5,874	4.1	space
Kiryandongo	361,629	677	39	6,667	3.7	space
Butaleja	338,752	677	32	5,818	2.0	space
Kibaale	208,656	676	33	3,756	3.5	space
Sembabule	342,271	671	78	7,332	3.2	space

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_gap_top.csv).

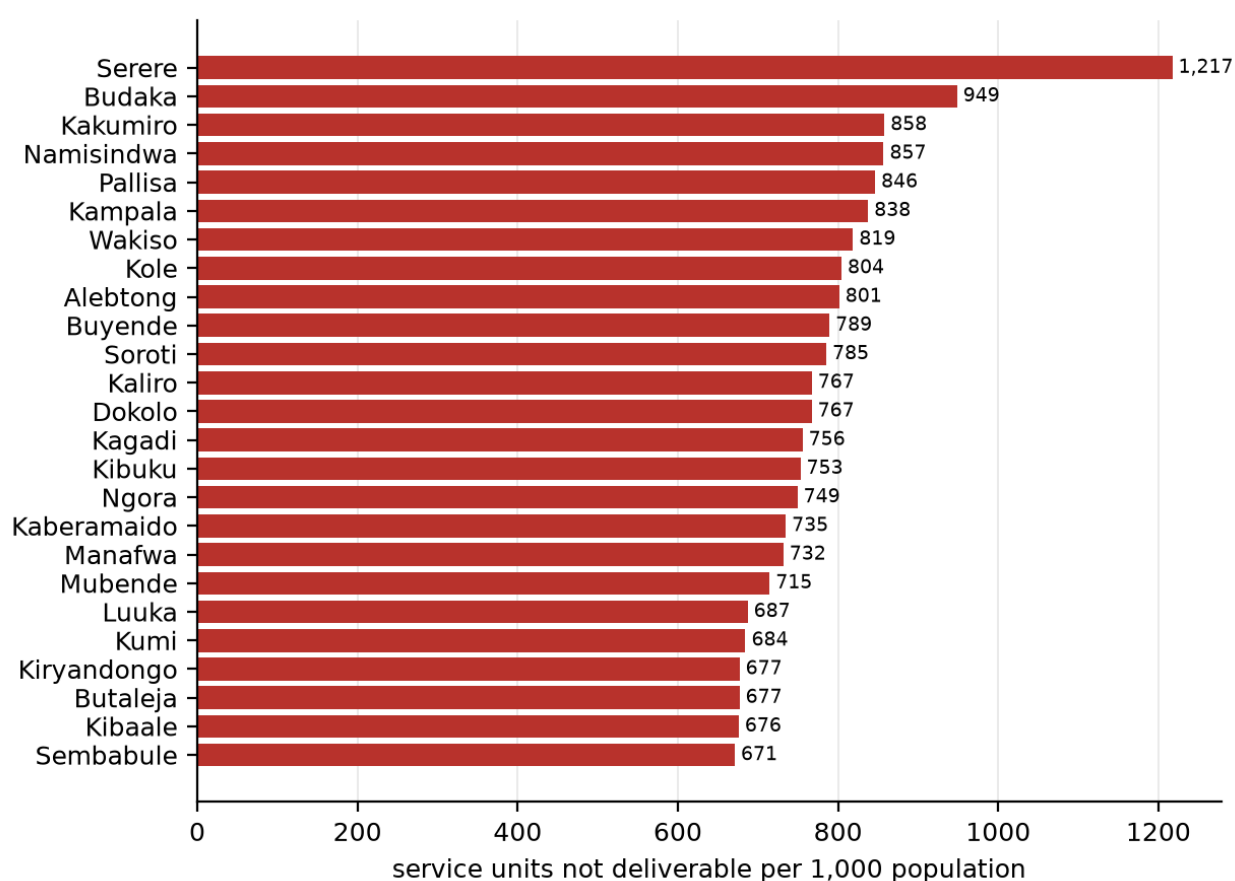


Figure 8.1: Gap 1: the 25 districts with the most service units per person that existing capacity cannot deliver, 2026

Source: HPRAS database, run uga-unconstrained-2026

The 25 districts with the largest service gap per person are concentrated in the east and the mid-west. Serere (1,217 units per 1,000), Budaka (949), Kakumiro (858), Namisindwa (857) and Pallisa (846) head the list, and Teso, Bukedi, Busoga and Lango districts make up most of the rest. Kampala (838) and Wakiso (819) appear because their outpatient capacity ratio is so low. Several districts combine a large service gap with large gaps on the other dimensions. Kakumiro (107 FTE, 7.8 facility-equivalents) and Buyende (109 FTE, 6.6 facility-equivalents) also have some of the lowest walking access in the country: 60.8% and 59.8% of people within an hour's walk, respectively. In these districts the dimensions coincide, and so does geography.

The **Binds** column of Table 8.3 gives each district's most frequent binding constraint, counted over its capacity cells. Space is the most frequent binding constraint in all 122 districts. In Serere, for example, space binds in 59 cells, revealed delivery in 24 and staff in 17. While this report was being prepared, an ordering defect in `build_gap_matrix!` made the column report the least frequent constraint instead. It was corrected and the plan re-run, and a regression test now checks the column against the cell counts. The column is a summary: the cell-level counts in Chapter 7 show where staff or revealed delivery binds for particular services.

Figure 8.2 shows the distribution of each dimension across the 122 districts, each in its own panel and on its own scale.

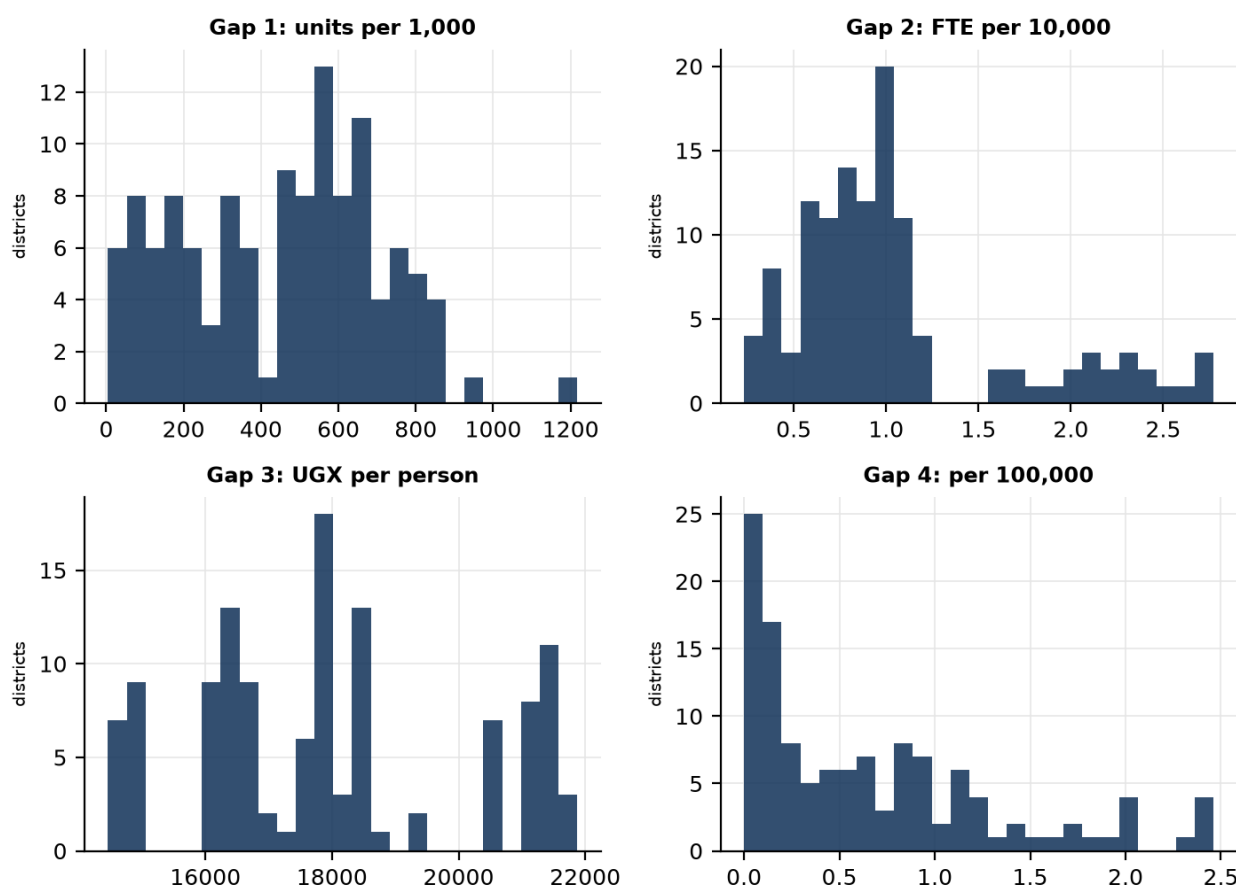


Figure 8.2: Distribution of the four gap dimensions across the 122 districts, 2026 (each shown separately)

Source: HPRAS database, run uga-unconstrained-2026

The four distributions have different shapes. The service gap per 1,000 is broad, running from almost nothing in Moyo (4.6) and Kabale (11.4) to over 1,000 in Serere, around a median of 489. The workforce gap per 10,000 is concentrated between about 0.2 and 2.8 FTE, around a median of 0.91. The commodity gap per person is narrow, from 14,461 to 21,875 UGX, because it is the full commodity requirement and so varies only with the need profile. The facility gap per 100,000 is skewed, with a median of 0.49 and a tail of eastern and Lango districts above 2.

8.4 Where the gaps are: the five maps

Each gap dimension is mapped separately, each with its local Moran (LISA) cluster map. Access is mapped beside them.

Gap 1, the service gap (Figure 8.3), is clearly clustered (Moran's $I = 0.43$, $p = 0.001$). The hot spot is a contiguous block across Teso, Bukedi and Busoga: Serere, Soroti, Ngora, Kaberamaido, Pallisa, Butebo, Kibuku, Kaliro, Namutumba and Buyende, joined by Kibaale and Kakumiro in the mid-west. The cold spot lies in Kigezi and Ankole: Kabale, Rukungiri, Rukiga, Rubanda, Kanungu, Kisoro, Mitooma and Rubirizi. The map is close to the inverse of the facility-density map in Chapter 7. The south-west has many health centres per person and its outpatient capacity approaches requirement, while Teso and Busoga have few and cannot meet outpatient demand. Outpatient consultation, the largest single gap, drives the pattern.

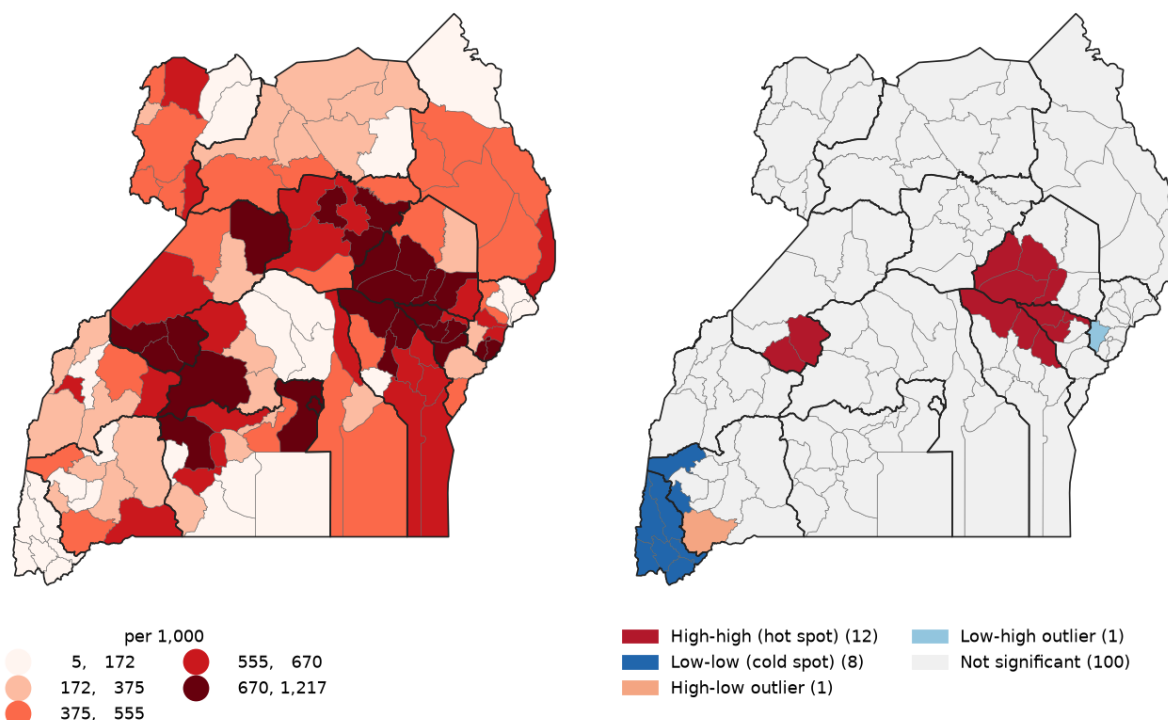
Gap 1: service units not deliverable**Local Moran clusters (global I = 0.43, p = 0.001)**

Figure 8.3: HM-05 - Gap 1: service units not deliverable (per 1,000), by district, 2026; right: local Moran (LISA) clusters, 999 permutations

Source: HPRAS database, run uga-unconstrained-2026; quality tier measured. Boundaries (c) OpenStreetMap contributors (ODbL).

Gap 2, the workforce gap (Figure 8.4), is more weakly clustered (Moran's I = 0.22, p = 0.001). The highest values per 10,000 are in Gomba (2.77), Kyankwanzi (2.76), Namayingo (2.69), Serere (2.58), Luuka (2.57) and Kole (2.40); the lowest are in Moyo (0.23), Maracha (0.28) and Ntoroko (0.31). The hot spot runs through the central-west, in Mubende, Sembabule, Bukomansimbi, Kaliro and Buyende, where the derived workforce in post is thinnest (Chapter 7). Moroto and Yumbe form a small cold spot. Because the gap is computed cadre by cadre, it largely follows the clinical-officer and pharmacy-technician shortfalls, which are widespread, and the registered-nurse and medical-officer shortfalls, which are local.

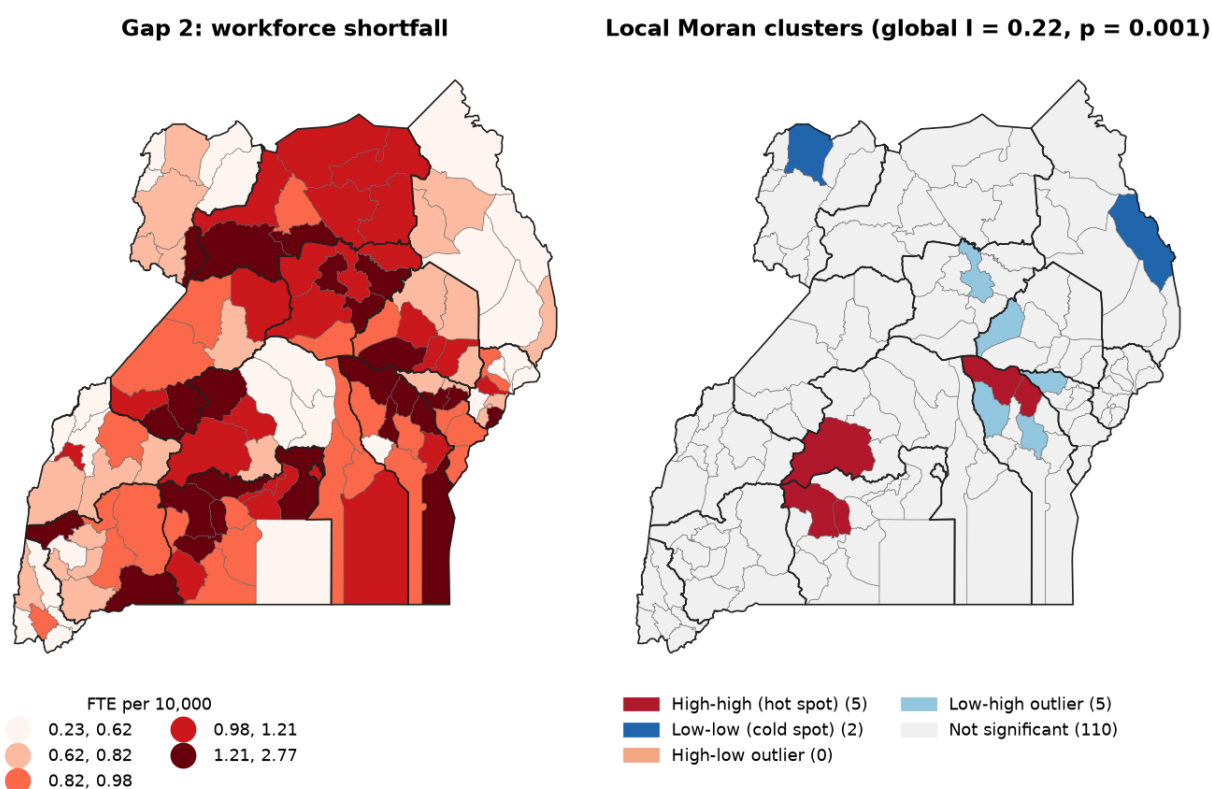


Figure 8.4: HM-05 - Gap 2: workforce shortfall (FTE per 10,000), by district, 2026; right: local Moran (LISA) clusters, 999 permutations

Source: HPRAS database, run uga-unconstrained-2026; quality tier measured. Boundaries (c) OpenStreetMap contributors (ODbL).

Gap 3, the commodity gap (Figure 8.5), is the most clustered of the HM-05 layers (Moran's I = 0.74, p = 0.001), with 24 hot-spot and 10 cold-spot districts. The hot spot covers Lango and Acholi (Lira, Apac, Oyam, Kole, Alebtong, Dokolo, Gulu, Omoro, Pader and Lamwo) and a southern belt from Masaka to Wakiso, taking in Mpigi, Butambala, Lyantonde, Kyotera, Rakai and Kalangala. The cold spot is West Nile (Arua, Koboko, Moyo, Yumbe, Maracha and Nebbi) and Karamoja (Moroto, Amudat and Nakapiripirit). Because the commodity gap is the full commodity requirement, this map shows where the modelled services consume most commodities per person. That is driven by the need for ART and for malaria treatment, the two largest commodity-consuming services, and by the sub-regional age structure. It is not a map of stockouts.

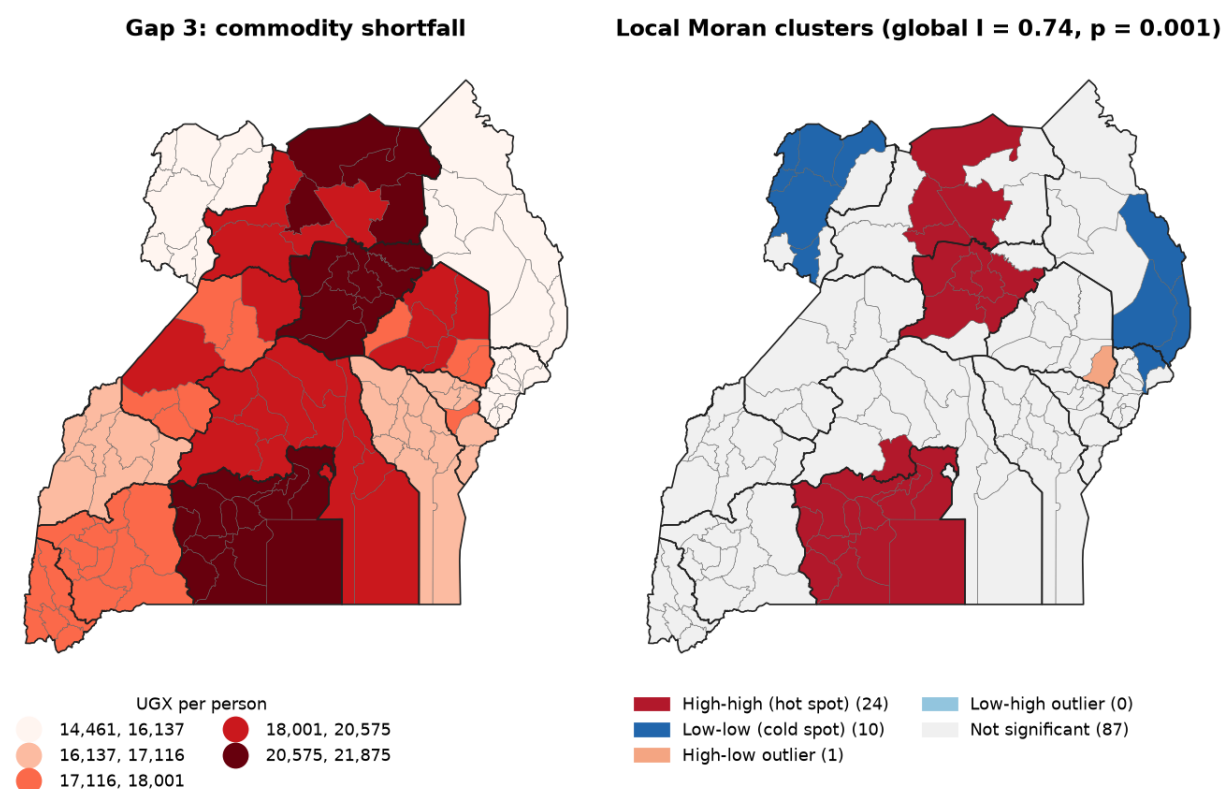


Figure 8.5: HM-05 - Gap 3: commodity shortfall (UGX per person), by district, 2026; right: local Moran (LISA) clusters, 999 permutations

Source: HPRAS database, run uga-unconstrained-2026; quality tier measured. Boundaries (c) OpenStreetMap contributors (ODbL).

Gap 4, the facility gap (Figure 8.6), is positive almost everywhere but concentrated. The highest values per 100,000 are in Serere (2.46), Manafwa (2.43), Kole (2.42), Alebtong (2.39), Dokolo (2.33) and Namisindwa (2.02). Kabale, Moyo, Rukungiri and Kanungu have none. The hot spot is again Teso and Bukedi (Serere, Soroti, Kaberamaido, Pallisa, Butebo, Kibuku and Buyende) (Moran's I = 0.27, p = 0.001). The cold spot of Wakiso, Mpigi, Ntungamo and Rubanda reflects either ample space relative to requirement or, in Wakiso, a population so large that the facility gap per 100,000 is small even where the absolute gap is not.

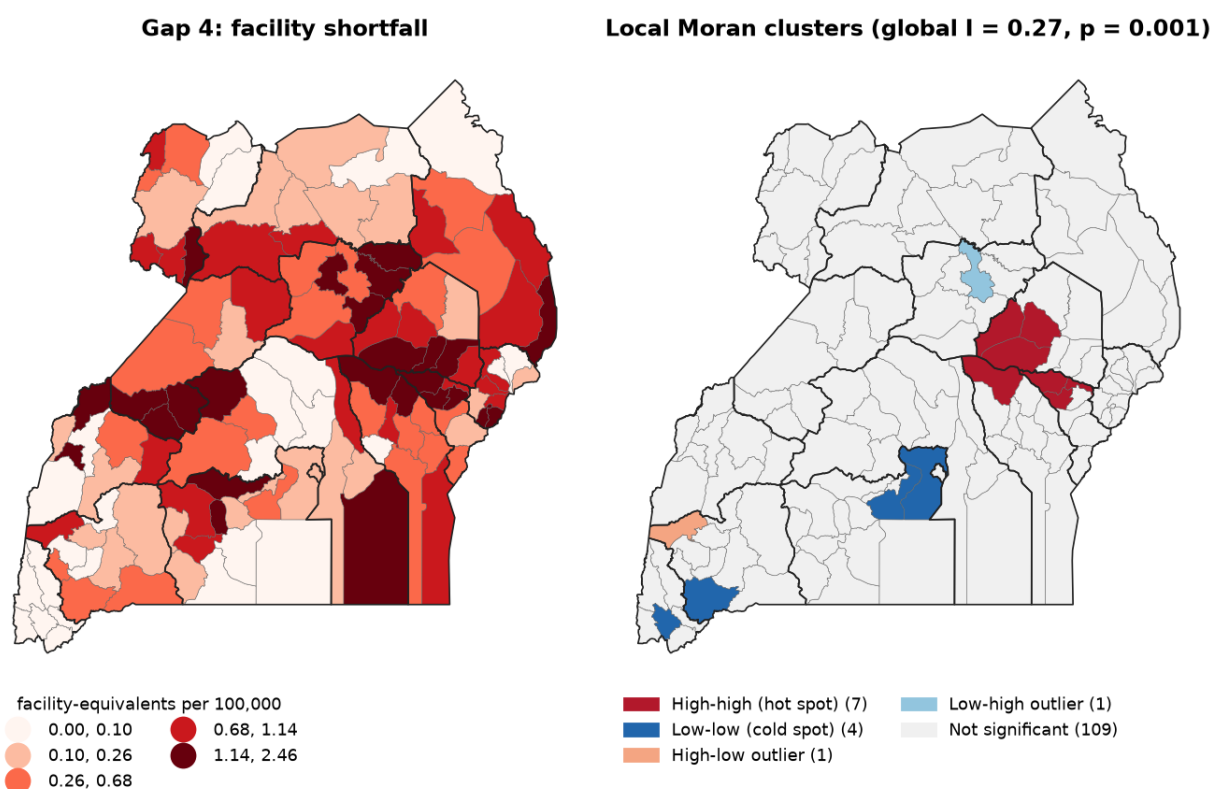


Figure 8.6: HM-05 - Gap 4: facility shortfall (facility-equivalents per 100,000), by district, 2026; right: local Moran (LISA) clusters, 999 permutations

Source: HPRAS database, run uga-unconstrained-2026; quality tier measured. Boundaries (c) OpenStreetMap contributors (ODbL).

Access (Figure 8.7) is mapped in thousands of people beyond an hour's walk, on the 2026 population. It is clustered (Moran's $I = 0.37$, $p = 0.001$), with a large hot spot of 16 districts across Bunyoro, Tooro, north Buganda and Lango. Hoima, Kiruhura, Mubende, Kyenjojo, Buyende and Kakumiro each have more than 180,000 people beyond an hour's walk. The cold spot lies in the densely settled east (Tororo, Mbale, Manafwa, Bududa, Butaleja and Bugiri) and in Rukungiri and Rubanda.

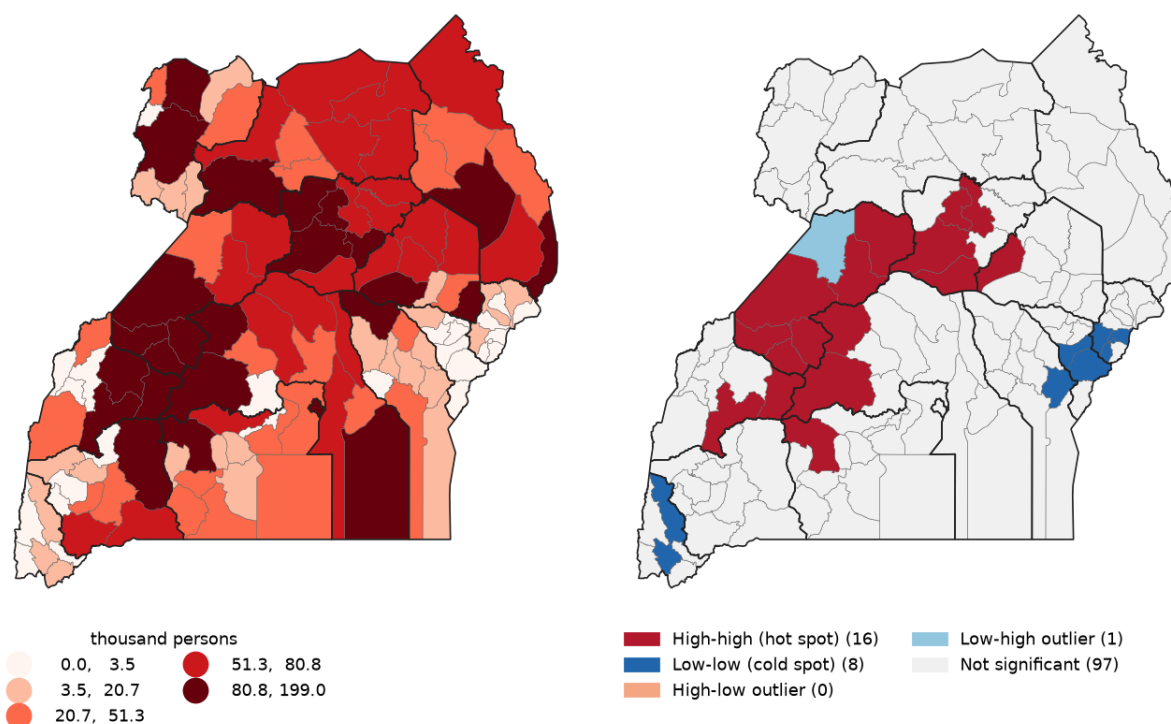
People beyond 60 minutes' walk of a facility**Local Moran clusters (global I = 0.37, p = 0.001)**

Figure 8.7: HM-05 - People beyond 60 minutes' walk of a facility (thousand persons), by district, 2026; right: local Moran (LISA) clusters, 999 permutations

Source: HPRAS database, run uga-unconstrained-2026; quality tier imputed. Boundaries (c) OpenStreetMap contributors (ODbL).

Read together, the five maps show two patterns. **Teso, Bukedi and Busoga** carry the largest service and facility gaps per person, but their populations are mostly within walking distance of a facility. Their problem is too little capacity close to people. **Bunyoro, Tooro and the Mubende-Kakumiro-Kyankwanzi belt** combine large access gaps with workforce gaps and, in Kakumiro and Buyende, large service and facility gaps. Their problem is sparse facilities as well as thin staffing. The south-west is well supplied on every dimension. The two patterns call for different instruments, which is exactly what a composite index would conceal.

8.5 Data quality and limitations

- **Gap 1 inherits the quality of capacity.** Its facility counts are measured, its establishments normed, its workforce derived and its readiness imputed (Chapter 7). Where revealed capacity binds, the gap rests on observed coverage, which is measured. The gap matrix reports supply quality measured for all 122 districts because facility counts and fill rates are measured, but the normative elements should be kept in mind.
- **Gap 2 is partial and unsubstituted.** It covers the modelled services only, and substitution between cadres is not yet applied. The in-post side is derived, not counted.
- **Gap 3 is assumed.** Without LMIS data, availability is set to zero and the gap equals the full commodity requirement. The quantification and supply-chain gaps cannot be separated.
- **Gap 4 is an index of physical scale, not a construction list.** It is not yet classified into rehabilitate, upgrade and construct, and it is not linked to a capital standard per facility type.
- **Access is imputed.** It is the SDI's 2020 snapshot, modelled rather than observed, and it measures travel to any functional facility.
- **The Binds column is a modal summary.** It names the most frequent constraint in a district, not the only one; staff binds for particular services in many districts where space binds overall.

8.6 Implications for planning

Target the service gap in Teso, Bukedi and Busoga through physical capacity close to people. The largest service and facility gaps per person form one contiguous block in the east, where walking access is already good. Expanding and upgrading existing health centres there is likely to close more of the gap per shilling than new sites. The rehabilitate-upgrade-construct classification the manual specifies would confirm this, and it should be implemented before the investment programme is finalised.

Treat the mid-west belt as a combined access and staffing problem. In Kakumiro, Buyende, Mubende, Kyankwanzi and their neighbours, large access gaps coincide with thin staffing. New facilities without staff would not close the service gap, and staff without facilities within reach would not close the access gap. Investment here has to move both together.

Clinical officers are the binding cadre for the modelled services. Clinical officers account for two-fifths of the workforce gap and are short in almost every district, because the minimum staffing norms establish very few posts for them. The Ministry should decide whether to raise the establishment of clinical officers or to shift outpatient workload to medical officers and nurses. The substituted gap, once computed, will show how much task-shifting can absorb.

Invest in an LMIS link before using the commodity gap for procurement. At present the commodity gap is a requirement valued at price, not a measured shortfall. A link to issues and stockout data would turn it into a true gap and separate the funding problem from the distribution problem.

Read the binding constraint service by service. Space binds most often in every district, so the district summary alone cannot say where staff are the limit. Before investing, look at the cell-level constraints in Chapter 7 for the services concerned.

CHAPTER 9

9 Costing the requirement and the gap (HM-06)

This chapter puts prices on the quantities of the previous three. It answers two questions that the Ministry of Finance and the Ministry of Health will ask of any health plan: what would full delivery of the modelled services at target cost, and what would closing the gaps of Chapter 8 cost on top of what is already spent? The two questions have different answers and must not be confused. The first is the **requirement**; the second is the **increment**. Presenting one as the other is the most common error in health costing, and the engine keeps them apart by design.

The method is activity-based and built from the bottom up. Activity gives a quantity, the quantity is multiplied by a price, and the products are summed. The cost is never derived as a share of GDP, a per-capita benchmark or last year's budget with a growth rate. Those appear at the end of the chapter as cross-checks, never as methods. The requirement covers the **28 modelled services**, not the whole health sector. Its ratio to the health budget is therefore read, not closed.

9.1 The unit cost

9.1.1 The standard resource package

Every modelled service has a bill of materials at each facility level, its **standard resource package**: minutes of each cadre, doses, tests, tablets, consumables, and allocations for equipment, space, utilities, supervision and transport. The unit cost of a service is the priced sum of that package. It is implemented in `unit_cost` in `src/HealthPlanning.jl`:

$$c_{s,l} = \sum_r \eta_{r,s,l} \times \sigma_{r,s,l} \times (1 + \omega_{r,s,l}) \times p_r \quad (9.1)$$

$$X_{s,d,t} = \sum_l Q_{s,d,l,t} \times c_{s,l} \quad (9.2)$$

where:

- $c_{s,l}$ is the unit cost of service s at facility level l , in UGX per service unit;
- $\eta_{r,s,l}$ is the quantity of resource r per unit of service (minutes for staff);
- $\sigma_{r,s,l}$ is the share of cases that consume the resource (for example, the share of antenatal clients given a syphilis test);
- $\omega_{r,s,l}$ is wastage on the resource, not on the service volume (for example, the open-vial wastage of a multi-dose vaccine);
- p_r is the unit price of resource r at the price vintage UGA-2026Q1;
- $Q_{s,d,l,t}$ is the required volume from HM-03, and $X_{s,d,t}$ the cost of service s in district d and year t .

A missing norm or a missing price is a fatal error, never a silent zero. A service costed at zero because a line was missing is the failure that most quickly destroys trust in a planning model, and the pre-run gates abort the run if any required resource lacks a price.

9.1.2 Staff prices

Staff quantities are held in minutes, so staff prices are held in UGX per minute. The price is derived from the public service salary scale and the WISN available working time:

$$p_c = \frac{b_c \times 12 \times m}{A_c} \quad (9.3)$$

where:

- b_c is the monthly basic salary of cadre c on the public service scale (Ministry of Public Service, Circular Standing Instruction No. 1 of 2022);
- $m = 1.35$ is the allowance multiplier, which covers allowances and the employer's NSSF contribution. It is an assumption awaiting confirmation;
- A_c is the available working time in minutes per FTE-year (Equation (7.7) in Chapter 7).

A **medical officer** on scale U4 has a monthly basic salary of 3,000,000 UGX. The total employment cost is therefore $3,000,000 \times 12 \times 1.35 = \mathbf{48.6 \text{ million UGX per FTE-year}}$. Divided by 76,320 available minutes, this gives 637 UGX per minute. A clinical officer or registered nurse (U5, 2,000,000 UGX a month) costs 32.4 million UGX a year, or 425 UGX per minute. An enrolled nurse or enrolled midwife (U7, 1,000,000 UGX a month) costs 16.2 million UGX a year, or 212 UGX per minute. A village health team member, at a 50,000 UGX monthly stipend, costs 810,000 UGX a year. The prices are recorded as **total employment cost**, not basic salary: the engine manual lists basic-salary costing as the first of three traps that have derailed real costings.

9.1.3 Capital in the unit cost

Equipment and facility space enter the unit cost as **annualised allocations per service-unit-equivalent**. One unit is the HC III basis, and higher levels carry a larger quantity in the norm line. The allocations are clinical equipment (600 UGX per unit, useful life 10 years), theatre equipment (9,500 UGX per theatre-case equivalent, 10 years), cold-chain capacity (4,200 UGX per litre-year, 10 years) and facility space (1,000 UGX per unit, 30 years). All four prices are planning assumptions (*assumed tier*). The manual's annualisation of a capital cost K over a useful life of n years at discount rate p is:

$$a(n, \rho) = \frac{\rho}{1 - (1 + \rho)^{-n}} \quad (9.4)$$

with the annualised capital given by $K \times a(n, \rho)$. In this run the allocations are entered already annualised, so no discount rate is applied inside the engine. When an all-in capital standard per asset type is loaded, with construction, equipment, fees and contingency, the annualisation will be computed from it. Annualised capital is a reporting view, never a budget line: a budget needs the cash profile of what is built, which Chapter 10 provides.

9.1.4 The unit cost catalogue

Because the unit cost is computed rather than assumed, the engine publishes a catalogue of the cost of each service at each level. Figure 9.1 shows six tracer services, and the full catalogue is in Annex B.

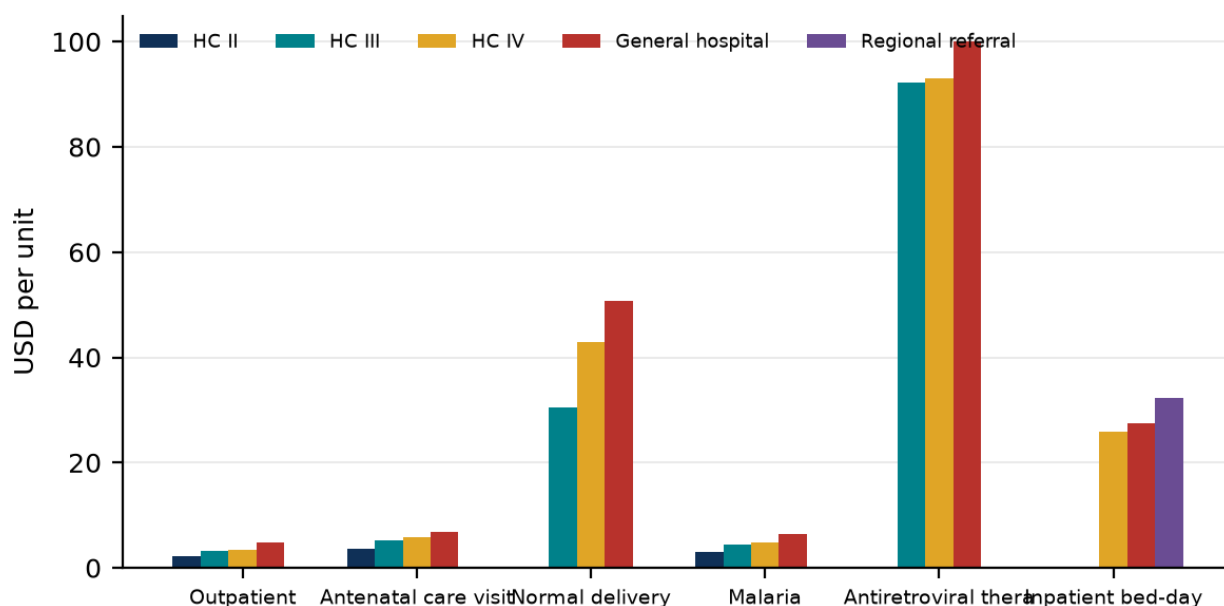


Figure 9.1: Unit cost of selected services by facility level (USD, price vintage UGA-2026Q1)

Source: HPRAS database, run uga-unconstrained-2026

The catalogue shows three patterns. First, **cost rises with facility level**, because hospitals use more clinician time and more equipment per contact. An outpatient consultation costs 8,379 UGX (2.26 USD) at an HC II, 12,152 at an HC III, 12,900 at an HC IV and 17,983 (4.86 USD) at a general hospital. An antenatal visit costs 13,532 UGX at an HC II and 25,313 UGX at a general hospital. A normal delivery costs 113,078 UGX at an HC III, 158,698 at an HC IV and 187,974 at a general hospital. The level mix in HM-03 therefore drives cost as well as access. Second, **the cost structure differs sharply by service**. Staff account for 62–70% of the cost of a normal delivery and 70–73% of hypertension management, but only 23–28% of ART, where antiretroviral medicines account for 59–64%. For HPV vaccination, 92–93% of the cost is the vaccine itself. Third, **the high-cost services are chronic or surgical**. A patient-year of ART costs 341,062–369,849 UGX (about 92–100 USD), a TB course 356,073–396,098 UGX, and a caesarean section 466,914–494,987 UGX.

9.2 Costing the requirement and the gap

9.2.1 Two bases

The engine costs two quantities, and never presents one as the other:

- The **requirement basis** prices the full required quantity of every resource: what full delivery at target would cost.
- The **gap basis** prices only the positive resource gaps from HM-05: the **incremental** cost of closing the gap on top of what is already in place.

For staff the gap is in FTE and the price is per minute, so the gap is converted back to minutes. For all other resources the gap is already in resource units:

$$X_d^{\text{gap}} = \sum_c \max(0, G_{c,d}^{\text{wf}}) A_c p_c + \sum_{r \notin \text{staff}} \max(0, G_{r,d}) p_r \quad (9.5)$$

where $G_{c,d}^{\text{wf}}$ is the workforce gap of Chapter 8 in FTE, and $G_{r,d}$ is the gap in resource r .

9.2.2 The results

Table 9.1 gives the result for 2026.

Table 9.1: Cost by basis and class, 2026

Basis	Cost class	bn UGX	m USD
gap	capital	157.5	42.6
gap	recurrent	1,105.2	298.7
requirement	capital	157.5	42.6
requirement	recurrent	1,808.7	488.8

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_cost_basis.csv).

The **requirement** is **1,966 bn UGX (531 m USD)**: 1,809 bn of recurrent cost and 158 bn of capital. The **gap** is 1,105 bn of recurrent cost and 158 bn of capital. The gap basis is smaller than the requirement because staff already in post are not re-costed. The staff requirement is 827 bn UGX, but the staff gap costs only 123 bn.

The composition of the gap needs a careful reading. Only for staff does the engine know what is already available. For every other resource no stock or availability data exists: there is no LMIS for commodities and no asset register for equipment and buildings. Availability is set to zero and flagged, never assumed to be met. The recurrent gap of 1,105 bn UGX therefore consists of 123 bn for missing staff, 858 bn for the full commodity requirement, and 124 bn for the full requirement of utilities, supervision, transport and other running costs. The capital gap equals the capital requirement (158 bn UGX in both bases). Only the 123 bn for staff is an increment in the strict sense; the rest is an upper bound on the increment, which will fall as stock and availability data are added.

9.2.3 By resource class

Table 9.2 and Figure 9.2 break the requirement down by resource class over the plan horizon.

Table 9.2: Requirement by resource class, 2026-2030 (bn UGX)

Resource class	2026	2027	2028	2029	2030	Share 2026
Staff	826.8	950.2	1,082.0	1,222.8	1,373.1	42.1%
Medicine	545.6	596.5	650.4	707.4	767.6	27.8%
Diagnostic	137.0	152.8	169.6	187.4	206.4	7.0%
Infrastructure	101.8	116.0	131.0	147.1	164.2	5.2%
Consumable	94.7	108.1	122.4	137.6	153.9	4.8%
Vaccine	80.4	90.7	101.6	113.0	125.0	4.1%
Utility	75.4	86.0	97.2	109.1	121.8	3.8%
Equipment	55.7	63.4	71.5	80.2	89.4	2.8%
Supervision	18.2	20.4	22.7	25.1	27.6	0.9%
Other	18.1	21.9	26.0	30.4	35.3	0.9%
Transport	12.4	14.2	16.1	18.1	20.2	0.6%

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_req_resource_class.csv).

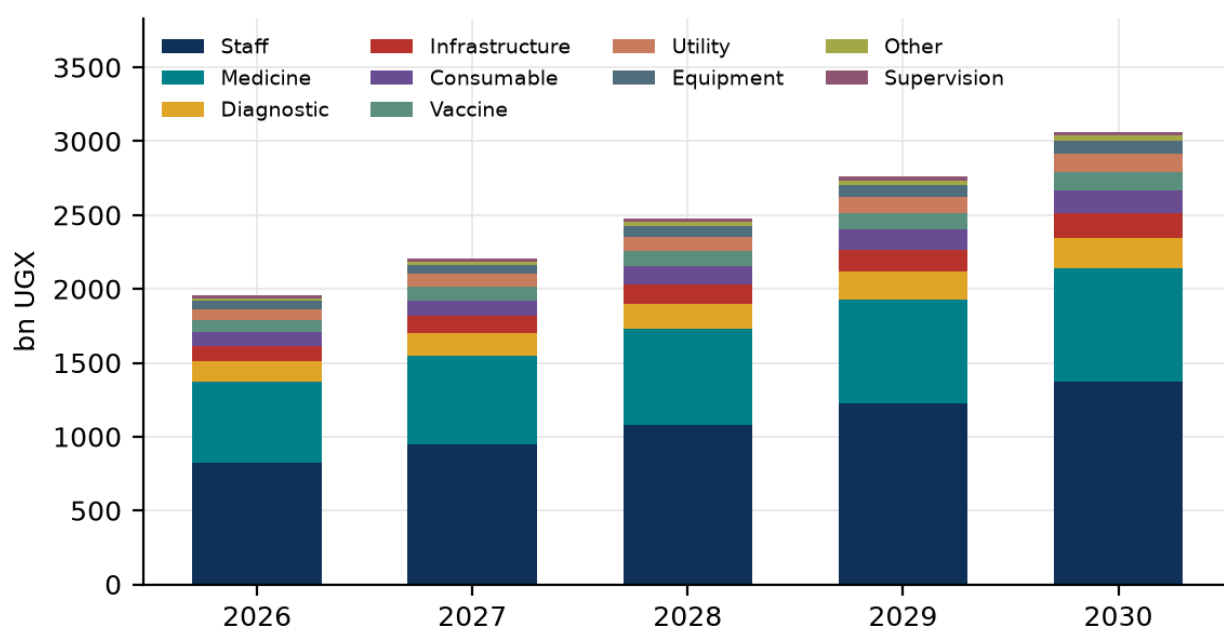


Figure 9.2: Requirement by resource class, 2026-2030

Source: HPRAS database, run uga-unconstrained-2026

Staff is the largest class, at 827 bn UGX (42.1%) in 2026. Medicines follow at 546 bn (27.8%), then diagnostics at 137 bn (7.0%). Infrastructure (102 bn), consumables (95 bn), vaccines (80 bn), utilities (75 bn) and equipment (56 bn) each account for between 2.8% and 5.2%, and supervision, transport and other costs together for under 3%. Over the horizon the staff requirement grows fastest, to 1,373 bn UGX in 2030, against 768 bn for medicines. The total requirement reaches 3,084 bn UGX in 2030, 56.9% above 2026. The engine attributes this growth to population and to the rising coverage targets. Staff grows faster than medicines because some of the fastest-growing services are staff-intensive: between 2026 and 2030, inpatient bed-days double and hypertension management more than doubles.

9.2.4 Economic classification

Every resource class maps to a Government Finance Statistics (GFS) economic code, so the requirement can be presented in the national chart of accounts without re-derivation (Table 9.3). Staff maps to code 21, Compensation of employees. Medicines, vaccines, diagnostics, consumables, utilities, transport, supervision and other costs map to code 22, Use of goods and services. Equipment and infrastructure map to code 31, Acquisition of non-financial assets.

Table 9.3: Requirement by GFS economic classification, 2026

GFS code	Economic class	bn UGX	Share
22	Use of goods and services	981.9	49.9%
21	Compensation of employees	826.8	42.1%
31	Acquisition of non-financial assets	157.5	8.0%

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_economic.csv).

Use of goods and services is the largest class at 982 bn UGX (49.9%), then compensation of employees at 827 bn (42.1%) and non-financial assets at 158 bn (8.0%). The plan log confirms that the programme, economic and administrative views of the requirement reconcile to within a fraction of a shilling. This is the check that a costing presented in three budget formats has not gained or lost money between them.

9.2.5 Programme view

Table 9.4 presents the same requirement by budget programme.

Table 9.4: Requirement by budget programme, 2026

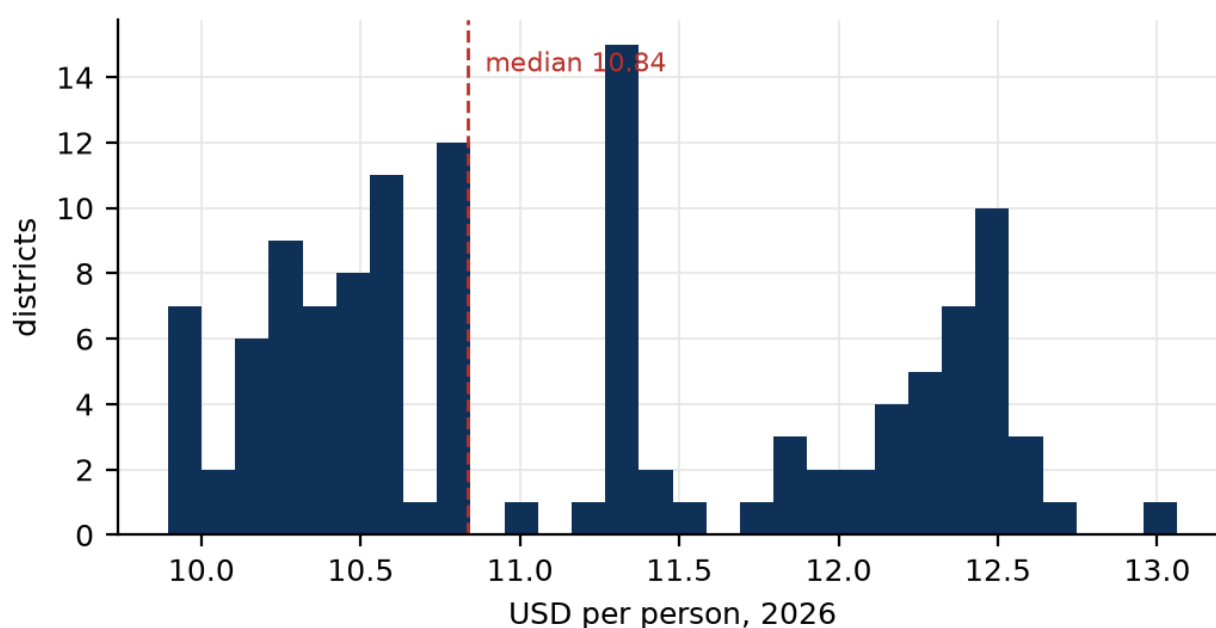
Programme	Requirement 2026 (bn UGX)	Share
Communicable disease control	737.7	37.5%
Hospital and referral services	405.1	20.6%
Reproductive, maternal, newborn and child health	383.9	19.5%
Primary healthcare services	228.3	11.6%
Immunisation	109.4	5.6%
Non-communicable disease and mental health	82.0	4.2%
Nutrition	19.8	1.0%

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_programme.csv).

Communicable disease control is the largest programme at 738 bn UGX (37.5%), driven by ART (472 bn UGX, 24.0% of the whole requirement) and malaria (162 bn). Hospital and referral services (405 bn, 20.6%) and reproductive, maternal, newborn and child health (384 bn, 19.5%) follow. Primary healthcare services, which here is outpatient consultation alone, account for 228 bn (11.6%). Immunisation (109 bn), non-communicable disease and mental health (82 bn) and nutrition (20 bn) complete the total. The dominance of ART is a planning fact in its own right. Nearly a quarter of the cost of the modelled services is one lifelong treatment, largely financed from external sources: Chapter 13 compares the Global Fund's financing with the ARV line.

9.3 The requirement per person

Figure 9.3 shows the distribution of the requirement per person across districts, and Figure 9.4 maps it.

**Figure 9.3:** Distribution of the per-person requirement across districts, 2026

Source: HPRAS database, run uga-unconstrained-2026

Nationally the requirement is **41,447 UGX (11.20 USD) per person** in 2026. The distribution is narrow: the highest district, Dokolo, requires 48,334 UGX per person and the lowest, a group of West Nile districts (Arua, Yumbe, Adjumani, Koboko and Moyo), 36,611 UGX. The ratio of highest to lowest is only 1.3. That narrowness is intended. The plan log attributes the spread to two drivers. The first is the DHS sub-regional fever index, which scales malaria need. The second is the sub-regional age structure. A third element compresses it: every district's outpatient requirement is lifted to the national 75th-percentile floor, so the largest single service varies little.

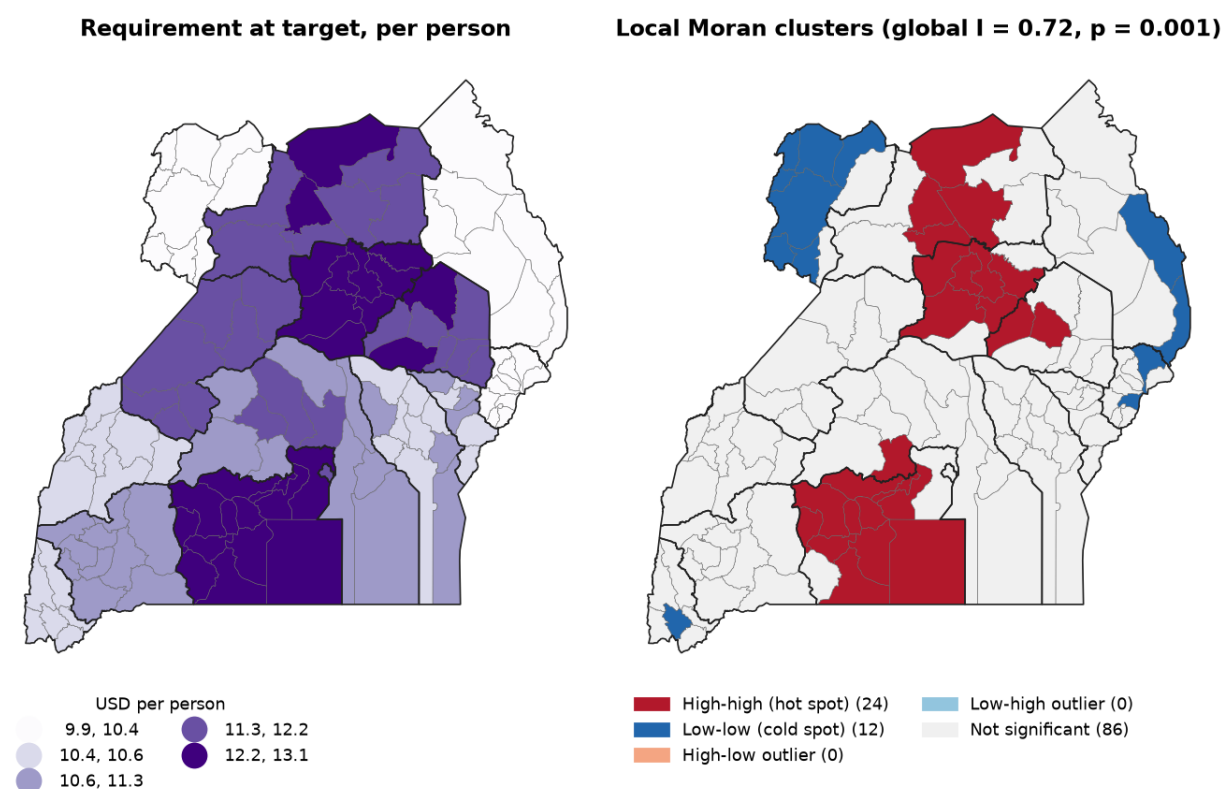


Figure 9.4: HM-06 - Requirement at target, per person (USD per person), by district, 2026; right: local Moran (LISA) clusters, 999 permutations

Source: HPRAS database, run uga-unconstrained-2026; quality tier derived. Boundaries (c) OpenStreetMap contributors (ODbL).

The map is strongly clustered (Moran's $I = 0.72$, $p = 0.001$). The hot spot of 24 districts covers Lango and Acholi (Dokolo, Lira, Apac, Oyam, Kole, Alebtong, Gulu, Omoro, Pader and Lamwo), extends into Teso (Soroti and Kaberamaido), and forms a second block from Masaka to Mpigi (Masaka, Kalungu, Lwengo, Bukomansimbi, Sembabule, Gomba, Mityana, Butambala, Mpigi, Lyantonde, Kyotera and Kalangala). The cold spot of 12 districts covers West Nile (Arua, Koboko, Moyo, Yumbe, Zombo, Maracha and Nebbi) and parts of Karamoja and the Elgon and Kigezi highlands (Moroto, Amudat, Bududa, Kween and Rubanda). The clusters match the need maps of Chapter 5. The Lango and Acholi block coincides with hot spots of both malaria and HIV need, and the Masaka-Mpigi block with a hot spot of HIV need. West Nile and Karamoja are cold spots of HIV need. The requirement per person follows need, as a needs-based costing should.

Figure 9.5 maps the staff share of each district's requirement. It varies only between 39.7% and 45.3%, but it is strongly patterned (Moran's $I = 0.68$, $p = 0.001$), and its pattern is the mirror image of the per-person map. The staff share is lowest (39.7%) across Lango (Oyam, Alebtong, Amolatar, Apac, Lira and Otuke) and in a cold spot running from Acholi to the Masaka-Mpigi belt. It is highest (45.3%) in Karamoja (Abim, Kaabong, Moroto, Nakapiripirit, Napak and Kotido), with a hot spot across West Nile and eastern Teso. Where commodity-heavy services such as ART and malaria treatment make up a large share of need, medicines dilute the staff share. Where they do not, staff dominate. This matters for budget structure: a district allocation formula built on the national average cost mix would over-fund wages in Lango and under-fund them in Karamoja.

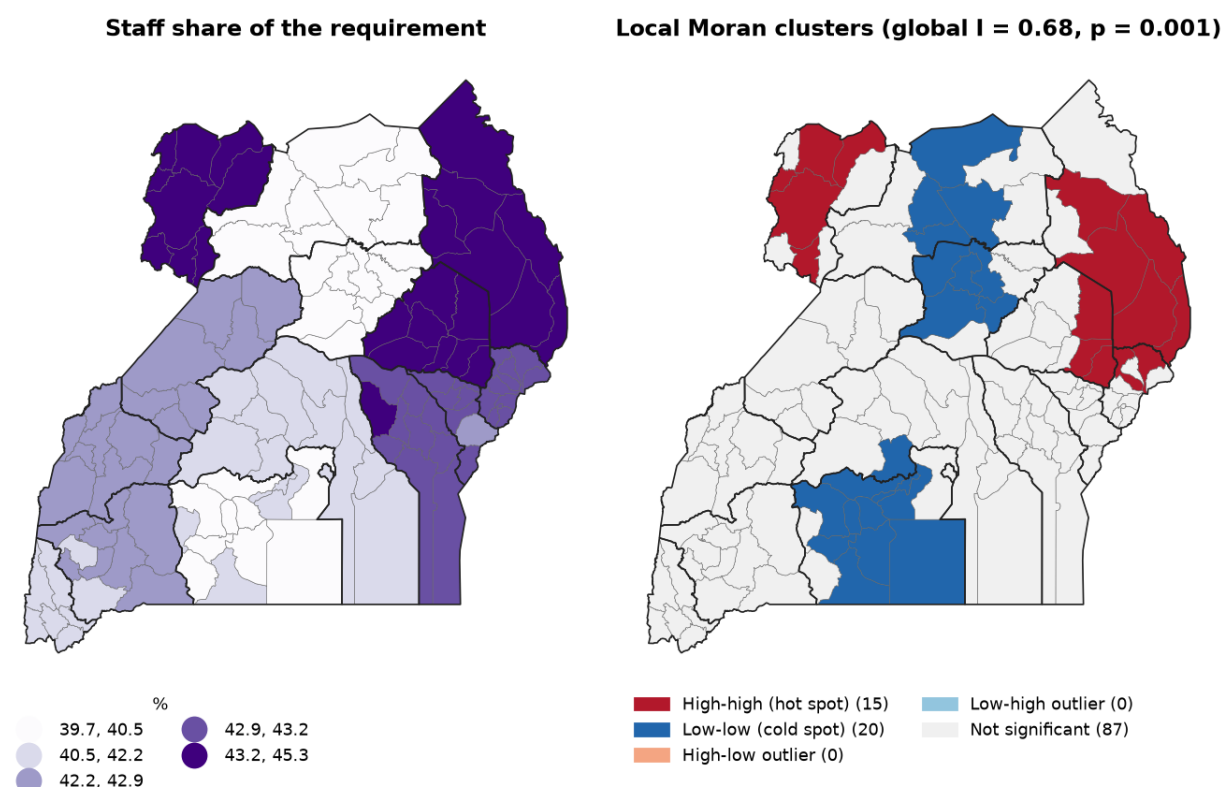


Figure 9.5: HM-06 - Staff share of the requirement (%), by district, 2026; right: local Moran (LISA) clusters, 999 permutations

Source: HPRAS database, run uga-unconstrained-2026; quality tier derived. Boundaries (c) OpenStreetMap contributors (ODbL).

9.4 Cross-checks

Cross-checks are applied last and never used to adjust the result. A failed check is a prompt to examine the norms, not to override the costing. The plan log records five checks against the engine manual's expected ranges:

Table 9.5: Cross-checks on the 2026 requirement (plan log)

Check	Engine	Expected range	Result
Wage bill share of recurrent	45.7%	45.0–70.0%	within range
Primary health care share of total	79.4%	35.0–60.0%	above
HC II–IV share, by facility level	70.0%	35.0–60.0%	above
Health as % of government expenditure	2.7%	0.0–20.0%	within range
Per-capita cost	11.2 USD	5.0–80.0 USD	within range

The two primary-care checks sit above their ranges, and Table 9.5 shows why this is expected rather than an error. The 28 modelled services are mostly primary-care services. The ranges describe whole-sector budgets, which include hospitals' non-modelled work, specialised care, administration and policy functions. The high primary-care share describes the scope of the catalogue, not a misallocation.

9.4.1 The UCSN cross-check on staff cost

The engine also compares its coefficients with the aggregates of the vendored snapshot from UnitCostModelling (UCSN), the system that owns unit cost estimation for Uganda. The comparison is reported and never applied: the norms are not rescaled to match. Three workforce and infrastructure densities agree closely. Nurses and midwives per 1,000 population are 1.600 in the engine against 1.529 in UCSN (+4.7%). Physicians per 1,000 are 0.137 against 0.143 (–4.0%). Hospital beds per 1,000 are 0.466 against 0.450 (+3.5%). All three are within the UCSN range.

The medical officer's annual cost is not. The engine's 48.6 million UGX per FTE-year is **25.1% below** the UCSN figure of 64.9 million UGX, and outside the UCSN range. The direction of the difference is the problem. UCSN reports gross salary, while the engine's figure is meant to be the full employment cost, which should not sit below gross salary. Either the basic salary used for the U4 scale (3,000,000 UGX a month, from the 2022 salary structure) is out of date, or the allowance multiplier of 1.35 understates allowances and employer contributions, or both. The 2025/26 salary structure is registered as a source but not yet used for prices. Raising the medical officer's cost to the UCSN figure would raise it by about a third. Because the same salary-scale method prices every cadre, the finding probably applies more widely.

This is an **issue for the norm owner**, not a correction this report makes. The engine's rule is that a disagreement with UCSN goes to the owner of the norm. The Ministry of Public Service salary structure and the actual allowances paid should be reviewed together, and the price vintage reissued. Until then, the staff cost, and with it 42.1% of the requirement, should be read as a lower bound.

9.5 Data quality and limitations

- **Staff prices are normed but likely low.** The salary scale is an official source (tier *normed*), but it is the 2022 structure, and the allowance multiplier is assumed. The UCSN cross-check suggests the result understates cost.
- **Many commodity prices are assumed.** International reference prices (Global Fund, UNICEF Supply Division, Stop TB Partnership) back the main medicines, vaccines and diagnostics, and are tier *normed*. Many baskets, consumables and allocations are AICTEM planning assumptions (tier *assumed*). The price list in Annex B gives the tier of every price.
- **Capital is an annualised allocation, not a capital budget.** Equipment and space are priced per service unit, with assumed prices, and no all-in capital standard per asset type has been loaded yet.
- **The gap basis is an upper bound except for staff.** Without LMIS or asset data, the commodity, running-cost and capital gaps equal the full requirement.
- **No geographic price variation.** Every price is national. Hardship and remote-area differentials in staff cost, and transport-driven differences in commodity cost, are not yet represented.
- **Salary drift is applied only in the MTEF.** The unit costs are in constant 2026 prices; the 2.5% a year increment drift enters in HM-10.

9.6 Implications for planning

Present the requirement and the increment together, and never interchange them. The modelled services require 1,966 bn UGX at target in 2026. The increment the engine can currently measure with confidence is 123 bn UGX of additional staff. The larger gap figure of 1,105 bn UGX recurrent is an upper bound until commodity and asset availability data are loaded.

Resolve the staff price before the plan is costed for the budget call. The UCSN cross-check places the medical officer's cost 25.1% below gross salary. Since staff are 42.1% of the requirement, updating the salary structure and the allowance multiplier is the single change most likely to move the headline figure. It should be done by the norm owner, with the Ministry of Public Service, before the MTEF submission.

Use the unit cost catalogue as a public good. A published, district-traceable cost of an antenatal visit, a delivery or a patient-year of ART is useful beyond this plan: for results-based financing tariffs, PNFP subventions and UCSN updates. The catalogue should be reviewed clinically, service by service, as the norm version's own status requires.

Build district allocations on district cost structures. The staff share of cost ranges from about 40% in Lango to about 45% in Karamoja. Allocation formulas that split wage and non-wage grants on the national average will misalign with need in both places.

CHAPTER 10

10 Investment and workforce plan (HM-07)

Chapter 8 showed where capacity falls short and Chapter 9 what the shortfall costs. This chapter turns those findings into the two things a ministry can commission: a **capital programme**, meaning what to build, where and when, and a **workforce plan**, meaning how many people of each cadre must be recruited and trained, and by when. It answers four questions:

- How much capital would close the facility gap, and what recurrent obligation would that capital create?
- How should the capital be phased over the medium term?
- Which districts come first, and what does physical access say about the kind of investment each needs?
- How many health workers must be recruited to 2030, and is that feasible?

Two rules from the Master Command govern the chapter. First, **no capital figure appears without its induced recurrent cost beside it**. A health centre is not a one-off expense but an annual bill for as long as it operates, and governments that build with donor capital and cannot staff or maintain the result are the commonest failure of health investment. Second, **access is shown beside the facility gap and never folded into it**. The facility gap ranks the sites, and access columns sit next to it so the reader can see which sites also have people beyond reach.

10.1 What HM-07 does in this run

The engine manual describes a full investment module. It would net committed projects out of the gap, apply a decision rule that prefers rehabilitation to upgrading and upgrading to construction, site new facilities with a maximal-coverage location model, sequence works against construction throughput and staffing readiness, and test recruitment against the training pipeline. This run implements the first layer of that design, in `investment_programme` in `src/Exports.jl` and `recruitment_plan` in `src/Allocation.jl`:

- districts ranked by facility gap, with capital to close, its induced recurrent cost, and physical access in separate columns;
- a capital phasing profile with the induced recurrent cost it creates year by year;
- a recruitment plan by cadre and year, combining the workload gap with attrition.

The committed project pipeline, the rehabilitate/upgrade/construct classification, siting within districts and the training-institution capacity are not yet loaded. The results below should therefore be read as the **scale and geography** of the investment need, not as a list of buildable projects.

10.2 Capital to close the facility gap

10.2.1 The capital figure and what it measures

The gap matrix of Chapter 8 records a capital cost to close the gap in each district. Nationally it is **158 bn UGX (43 m USD)** in 2026.

This figure needs a careful reading. As Chapter 9 explained, capital enters the engine as annualised allocations for equipment and facility space per unit of service, and there is no asset register to say what equipment and space already exist. The capital gap therefore equals the **capital requirement of the full service volume**, not the cost of building the facility-equivalents of Gap 4. Two consequences follow. First, capital to close is almost flat per person: it ranges only from 0.79 to 1.07 USD per person across districts. Second, it scales with population and service

volume, not with the facility gap. Wakiso, with a facility gap of 6.7 facility-equivalents, carries 10.18 bn UGX of capital, while Serere, with the largest facility gap in the country (9.9), carries 1.58 bn UGX.

The facility gap in facility-equivalents is the physical indicator of where building is needed. The capital figure is the budget-scale indicator of what the capital component of the modelled services costs. They are not yet linked through a capital standard per facility type, as the engine manual intends (docs/08_HM06_COSTING.md, §6.4). Until they are, the capital figure should be used for the size of the development budget line and the facility gap for the choice of sites.

10.2.2 Induced recurrent cost

Every unit of capital commits a recurrent obligation (staffing, maintenance, utilities and consumables) from the year it comes into use. The engine applies a single share:

$$I = \phi \times K \quad (10.1)$$

where:

- K is the capital cost, in UGX;
- $\phi = 0.15$ is the induced recurrent share, the annual recurrent obligation created per unit of capital, a fiscal parameter of the norm version;
- I is the induced recurrent cost, in UGX per year, which continues for the life of the asset.

The share of 0.15 is the engine's planning parameter. The worked example in the engine documentation illustrates how a figure of this order arises. Eleven new or upgraded facilities with six minimum-staffing posts each, plus maintenance at 3% of capital and utilities, give an annual obligation of about 15% of their capital cost, in perpetuity.

Applied to the 158 bn UGX of capital, the induced recurrent cost is **24 bn UGX a year** once the programme is complete. That is 15% of the capital cost, every year, for as long as the facilities operate. A ministry that approves the capital without budgeting the recurrent consequence will commission facilities it cannot run.

10.2.3 Phasing

Capital is spent over a build period, not in one year. The engine applies a three-year profile of 20%, 50% and 30%, and accumulates the induced recurrent cost as the capital is spent:

$$K_t = \pi_t \times K \quad (10.2)$$

$$I_t = \phi \sum_{\tau \leq t} \pi_{\tau} K \quad (10.3)$$

where π_t is the share of the capital spent in year t of the programme (0.20, 0.50, 0.30). Applied to 158 bn UGX, this gives the following profile.

Table 10.1: Capital phasing and induced recurrent cost, bn UGX (capital to close 158 bn; $\phi = 0.15$; phasing 20/50/30)

Year	Capital	Induced recurrent in the year
2026	31.5	4.7
2027	78.8	16.5
2028	47.3	23.6
2029	0	23.6
2030	0	23.6

Table 10.1 shows the essential asymmetry. The capital falls to zero after three years, while the induced recurrent cost rises to 23.6 bn UGX a year and stays there. Over the five years of the plan the capital totals 158 bn UGX and the induced recurrent 92 bn, and the recurrent line continues beyond the plan period. The engine starts the induced cost in the year the capital is spent. This is conservative: the manual would start it the year after commissioning, which would shift each year's recurrent figure one year later.

10.2.4 How this relates to the MTEF

Chapter 13 presents a different induced recurrent figure. The MTEF in the plan log shows a steady-state recurrent obligation of 10 bn UGX a year, rising from zero in 2026 to 10 bn in 2030. The difference is one of method, and the plan log says so. The MTEF derives its induced recurrent from the **year-on-year growth** of the annualised capital line in the requirement, which rises from 158 bn UGX in 2026 to 254 bn in 2030 as service volumes grow. The investment programme applies the share to the **whole** capital to close. The plan log notes that a real induced recurrent figure needs HM-07's investment programme, meaning a list of what is actually built. Until the capital standard links the facility gap to real assets, the report shows both figures, and neither should be read as the obligation of a specific building programme.

10.3 Where to invest: sites ranked by facility gap, with access beside

The investment programme ranks districts by facility gap and places physical access in separate columns beside it (Table 10.2). The workbook version ranks by facility gap per 100,000 people; the table here lists the twenty districts with the largest facility gap in facility-equivalents. Capital and induced recurrent cost always appear together.

Table 10.2: Investment sites: the 20 districts with the largest facility gap, with physical access beside it

District	Facility gap (eq.)	Capital (bn UGX)	+ induced recurrent bn/yr	60 min drive	60 min walk	People beyond 60 min walk
Serere	9.9	1.58	0.24	98%	79%	74,750
Kole	7.9	1.18	0.18	100%	72%	81,801
Kakumiro	7.8	1.57	0.24	100%	61%	161,568
Alebtong	7.3	1.12	0.17	100%	76%	63,982
Wakiso	6.7	10.18	1.53	100%	99%	23,823
Buyende	6.6	1.51	0.23	97%	60%	167,413
Namisindwa	6.0	0.94	0.14	100%	100%	715
Kaliro	5.8	1.08	0.16	100%	88%	36,301
Dokolo	5.8	0.97	0.15	100%	68%	70,043
Kagadi	5.7	1.64	0.25	100%	82%	86,360
Budaka	5.7	0.98	0.15	100%	100%	0
Kibuku	5.6	0.93	0.14	100%	99%	1,519
Yumbe	4.7	2.24	0.34	100%	85%	100,906
Kayunga	4.6	1.61	0.24	100%	89%	43,882
Manafwa	4.3	0.56	0.08	100%	100%	868
Mubende	4.2	3.17	0.48	99%	80%	179,170
Kumi	4.1	1.22	0.18	99%	86%	43,150
Kyankwanzi	4.0	1.02	0.15	97%	63%	106,269
Pallisa	3.8	1.17	0.18	100%	99%	4,055
Kyenjojo	3.8	1.80	0.27	100%	68%	171,321

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_invest_sites.csv).

Serere heads the list with 9.9 facility-equivalents, followed by Kole (7.9), Kakumiro (7.8), Alebtong (7.3), Wakiso (6.7) and Buyende (6.6). Most of the top twenty are in Teso, Bukedi, Busoga and Lango, matching the facility-gap hot spot of Chapter 8. The access columns divide these districts into two groups that call for different kinds of investment:

- **Facility gap with good access.** In Namisindwa, Budaka, Kibuku, Manafwa and Pallisa, 99–100% of people are within an hour's walk of a facility, and hardly anyone lives beyond it (none in Budaka, 715 people in Namisindwa). The facilities are close to people; they are too small for the volume required. The indicated response is to expand or upgrade existing sites (more rooms, beds or an HC III to HC IV upgrade), not to build new ones.
- **Facility gap with poor access.** In Kakumiro (61% within an hour's walk, 161,568 people beyond), Buyende (60%, 167,413), Kyankwanzi (63%, 106,269), Kyenjojo (68%, 171,321) and Mubende (80%, 179,170), large numbers of people are beyond an hour's walk as well as short of capacity. Here the case for **new sites**, placed where the unreached populations live, is strongest. Dokolo (68%) and Kileleshya (72%) in Lango sit between the two groups.

This is the reading the manual's decision rule would formalise: construct where access falls below a threshold, otherwise upgrade, rehabilitate or expand. Because the rule is not yet encoded, the report makes the distinction visible and leaves the choice to the Ministry. The ranking remains the facility gap. A planner who prefers to rank by people beyond an hour's walk would start instead with Hoima, Mubende, Kiruhura, Kyenjojo and Buyende (Chapter 7). Several of those districts appear on both lists, and where they do the case for investment is strongest on both criteria.

10.3.1 The HM-07 maps

Figure 10.1 maps capital to close per person, with the induced recurrent cost carried as the upper bound of the layer. It is strongly clustered (Moran's $I = 0.73$, $p = 0.001$). The hot spot of 19 districts covers Teso and Lango (Serere, Soroti, Amuria, Katakwi, Ngora, Kumi, Kaberamaido, Dokolo, Lira, Apac, Alebtong, Otuke, Kileleshya, Amolatar and Oyam) with Omoro, Pader, Pallisa and Napak. The cold spot of 19 districts covers the south-west and the Rwenzori (Kabale, Kisoro, Rukiga, Rubanda, Kanungu, Rukungiri, Ntungamo, Mbarara, Sheema, Bushenyi, Ibanda, Buhweju, Mitooma, Rubirizi, Kasese, Kabarole, Bunyangabu, Kamwenge and Bundibugyo). The per-person range is narrow, from 0.79 USD in the Kigezi districts to 1.07 USD in Serere. Because capital is an allocation per unit of service, this map follows service volume per person, and the pattern closely matches the malaria-need clusters of Chapter 5: high in Teso and Lango, low in the south-west.

Capital to close the gap (with induced recurrent as range high) Moran clusters (global $I = 0.73$, $p = 0.001$)

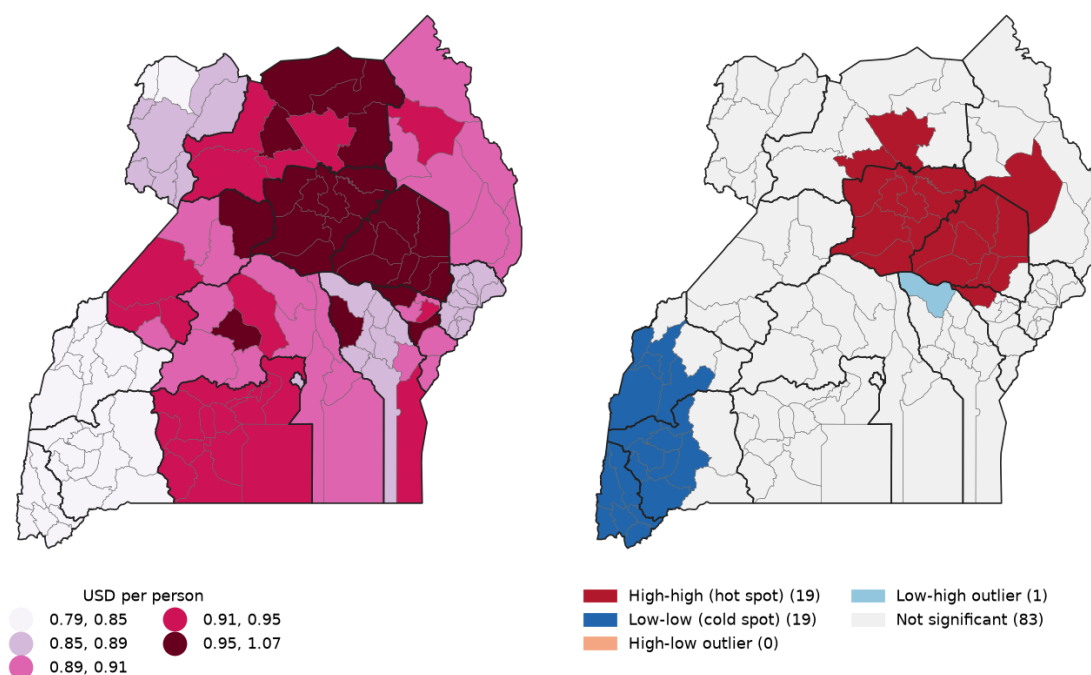


Figure 10.1: HM-07 - Capital to close the gap (with induced recurrent as range high) (USD per person), by district, 2026; right: local Moran (LISA) clusters, 999 permutations

Source: HPRAS database, run uga-unconstrained-2026; quality tier measured. Boundaries (c) OpenStreetMap contributors (ODbL).

Figure 10.2 maps the recurrent cost to close the gap per person. It ranges from 4.70 USD in Moyo to 8.72 USD in Gomba (Moran's $I = 0.53$, $p = 0.001$). The hot spot combines Lango and Acholi (Lira, Oyam, Apac, Alebtong, Dokolo, Gulu, Omoro and Pader) with a central belt (Mubende, Gomba, Sembabule, Bukomansimbi, Lwengo, Masaka, Kalungu, Kyotera, Lyantonde and Butambala). The cold spot covers West Nile (Moyo, Maracha, Koboko, Yumbe and Arua) and Karamoja (Moroto, Nakapiripirit and Amudat), with Kween. The recurrent gap is dominated by commodities, so it follows the commodity map of Chapter 8, shaped by ART and malaria need, with the workforce gap adding to it in the central belt.

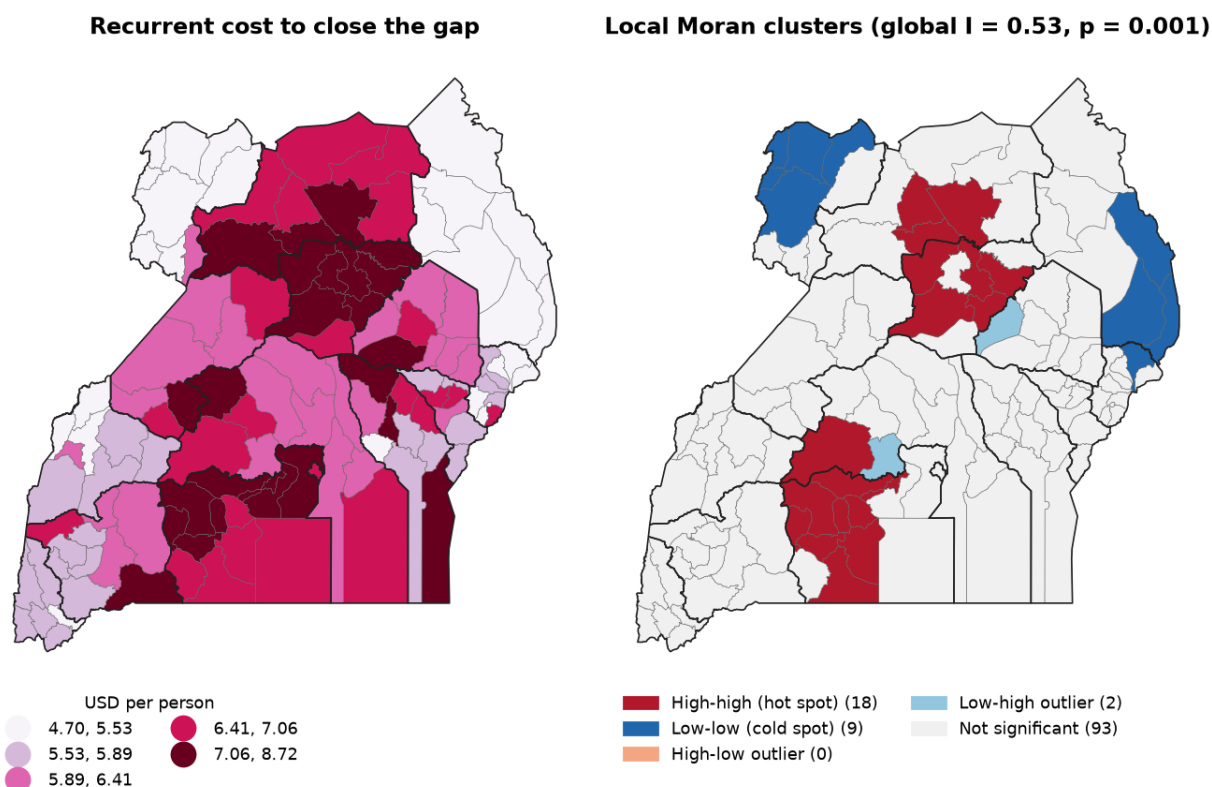


Figure 10.2: HM-07 - Recurrent cost to close the gap (USD per person), by district, 2026; right: local Moran (LISA) clusters, 999 permutations

Source: HPRAS database, run uga-unconstrained-2026; quality tier measured. Boundaries (c) OpenStreetMap contributors (ODbL).

The two maps do not coincide. The capital need per person is highest in Teso; the recurrent need per person is highest in Lango, Acholi and the central belt. A plan that funded capital in Teso without the recurrent budget to use it, or recurrent budgets in the central belt without the facilities to spend them in, would leave gaps open on the other dimension.

10.4 The workforce plan

10.4.1 Recruitment need

Buildings without staff are the classic failure of health investment. The recruitment plan estimates, cadre by cadre and year by year, how many health workers must be recruited:

$$N_{c,t} = \max(0, W_{c,t} - F_c) + \delta_c F_c (t - t_0 + 1) \quad (10.4)$$

where:

- $W_{\{c,t\}}$ is the WISN workload requirement of cadre c in year t for the modelled services (HM-03), in FTE;

- $F_{c,t}$ is the FTE of cadre c in post (Chapter 7);
- $\delta_c = 0.06$ is the annual attrition rate, from the WISN standards of the norm version;
- $t_0 = 2026$ is the first year of the plan;
- $N_{\{c,t\}}$ is the cumulative recruitment need from 2026 to year t .

The first term is the **real gap**: the workload of the modelled services in excess of the whole establishment. The second is **attrition**: the staff who must be replaced simply to stand still. Without recruitment the workforce declines:

$$F_{c,t+1} = F_{c,t} \times (1 - \delta_c) + R_{c,t} \quad (10.5)$$

where $R_{\{c,t\}}$ is recruitment in year t . A plan that adds no staff does not hold coverage constant; it loses ground.

10.4.2 The caution that governs the reading

The WISN requirement covers **the modelled services only**. The workforce in post is the **whole establishment**, which also delivers everything outside the catalogue. The plan log is explicit on the point: a requirement below the establishment is not a surplus. It is the part of the workforce the modelled services do not account for. Only where the modelled services alone already exceed the establishment is there a real gap, and only that part enters the first term of Equation (10.4), above. Negative differences are set to zero, never counted as spare staff.

10.4.3 Results

Table 10.3 gives the plan for 2030 by cadre, and Table 10.4 and Figure 10.3 give the national totals by year.

Table 10.3: Recruitment plan, 2030

Cadre	WISN required 2030	In post	Real gap	Attrition loss	Recruit in 2030
Registered nurse	13,851	25,311	0	7,593	7,593
Support staff	5,253	23,811	0	7,143	7,143
Enrolled nurse	9,541	21,115	0	6,334	6,334
Enrolled midwife	4,142	17,963	0	5,389	5,389
Clinical officer	5,921	1,728	4,194	518	4,712
Registered midwife	5,708	11,517	0	3,455	3,455
Village health team member	2,076	0	2,076	0	2,076
Medical officer	2,371	5,893	0	1,768	1,768
Health records officer	2,365	3,892	0	1,168	1,168
Pharmacy technician	1,183	183	1,000	55	1,055
Laboratory technologist	207	2,946	0	884	884
Anaesthetic officer	223	2,299	0	690	690
Laboratory technician	296	1,361	0	408	408
Specialist / consultant	229	628	0	188	188
Nutritionist	43	0	43	0	43

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_recruitment.csv).

The real gap is concentrated in four cadres. By 2030 the modelled services need 5,921 FTE of clinical officers against 1,728 in post, a real gap of 4,194 FTE. The plan log puts the requirement at 343% of the establishment. Pharmacy technicians show a real gap of 1,000 FTE (1,183 required against 183 in post, 645% of the establishment). Village health team members show 2,076 FTE and nutritionists 43 FTE; neither cadre has a facility establishment, so the whole requirement appears as a gap. In total the real gap reaches **7,312 FTE by 2030**, and the plan log notes that it lies in cadres already over-committed.

The two facility cadres share a cause. The minimum staffing norms establish clinical officers only at HC IIIs and HC IVs, and pharmacy technicians only at HC IVs (Chapter 7). The service norms, by contrast, assign them time at levels where the establishment provides no post: clinical-officer time at general and referral hospitals, and

pharmacy-technician time at HC IIIs and at hospitals. The gap is therefore partly a real shortage and partly an inconsistency between two sets of norms. Either the establishment should be raised, or the workload should be assigned to cadres the establishment does provide, such as medical officers and nurses. Both are decisions for the Ministry. Substitution rules in the cadre catalogue would allow part of the clinical-officer workload to fall to medical officers, but, as Chapter 8 noted, they are not yet applied.

Attrition dominates the total. At 6% a year, replacing leavers requires 7,119 FTE of recruitment in 2026 alone and **35,594 FTE cumulatively by 2030**, about 30% of the workforce in post. The largest attrition losses are among registered nurses (7,593 by 2030), support staff (7,143), enrolled nurses (6,334), enrolled midwives (5,389) and registered midwives (3,455). None of these cadres has a real workload gap for the modelled services, but all must still be replaced. Attrition therefore dwarfs the workload gap: of the 42,906 FTE of cumulative recruitment need by 2030, 35,594 FTE (83%) is replacement.

Table 10.4: Recruitment need by year

Year	Real gap FTE	Attrition FTE	Recruitment FTE
2026	4,024	7,119	11,143
2027	4,783	14,238	19,021
2028	5,583	21,356	26,940
2029	6,425	28,475	34,900
2030	7,312	35,594	42,906

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_recruitment_years.csv).

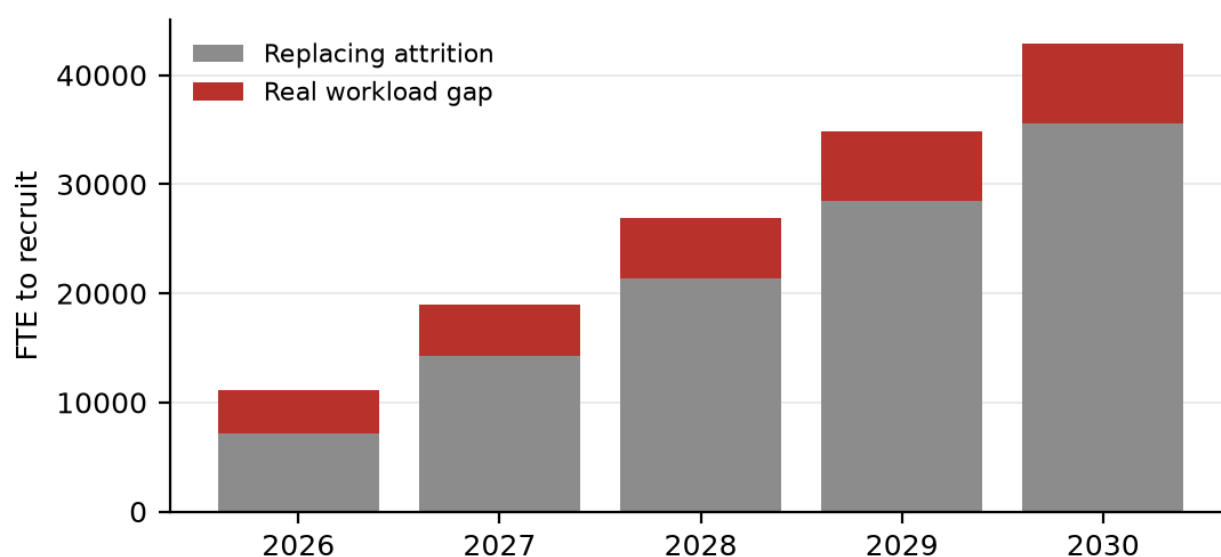


Figure 10.3: Recruitment need by year: attrition replacement and the real workload gap

Source: HPRAS database, run uga-unconstrained-2026

The yearly figures in Table 10.4 are cumulative from 2026. Recruitment need rises from 11,143 FTE in 2026 to 42,906 FTE by 2030, and the rows must not be added together. The annual recruitment the plan implies is about 7,100 FTE of replacement each year, plus the growth in the real gap: from 4,024 FTE in 2026 to 7,312 FTE in 2030.

10.4.4 Training pipeline implications

The recruitment plan says how many staff are needed. Whether they can be hired depends on how many graduate, and the engine does not yet hold training-institution data (intake, completion and absorption by cadre). Feasibility against the pipeline therefore cannot yet be tested. Principle P9 is plain that a plan requiring more graduates than the country produces is arithmetic fiction. That test must be run before the workforce plan is adopted.

The training durations in the cadre catalogue set the timetable. A clinical officer takes three years to train and a pharmacy technician two. A clinical-officer gap that is to be closed by 2030 must therefore be met from intakes admitted by 2027 at the latest, and from earlier intakes for any part of it wanted sooner. Registered nurses and midwives also take three years and medical officers five, so the replacement of 35,594 leavers by 2030 draws on students who are already in training or will enter in the next two years. Village health teams, at 0.2 years of training, can be expanded quickly, but they are community-based and cannot fill a facility gap.

The recruitment need also has a fiscal side, and it links back to the capital programme. Every facility-equivalent built creates posts under the minimum staffing norms. Those posts are part of the induced recurrent cost, and they add to the recruitment need above. The two plans have to be sequenced together: no facility should be commissioned in a year when its staff cannot be in post.

10.5 Data quality and limitations

- **Capital to close is an annualised allocation of the full requirement**, not a costed list of facilities. It is priced from assumed allocations, not an all-in capital standard. The facility gap and the capital figure are not yet linked.
- **The induced recurrent share is a single parameter** (0.15). The manual's asset-by-asset calculation from minimum staffing, maintenance and utilities is not yet implemented.
- **No committed pipeline is netted**. Works already under construction or contracted are not subtracted from the gap, so the programme may double-count capacity that is on its way.
- **No siting or sequencing model**. Sites are districts, not locations within them, and the phasing does not test construction throughput or staffing readiness.
- **The workforce in post is derived** (establishment $\times$ fill rate), and the WISN requirement covers the modelled services only. The real gap is therefore a lower bound on the true shortage in the affected cadres, and silent on cadres the catalogue does not use.
- **Attrition is a single rate** of 6% for every cadre, and the training pipeline is not modelled.

10.6 Implications for planning

Budget the capital programme and its recurrent consequence together. Closing the gap as measured here needs 158 bn UGX of capital over three years. It then commits 24 bn UGX a year of recurrent cost, rising to that level by 2028 and continuing indefinitely. The development budget and the recurrent budget must be approved together, and the MTEF outer years must carry the recurrent line.

Upgrade where access is good; build where it is not. In Teso and Bukedi districts such as Namisindwa, Budaka, Kibuku and Pallisa, people already live close to facilities that are too small. Expansion and upgrading are the indicated response. In Kakumiro, Buyende, Kyankwanzi, Kyenjojo and Mubende, a facility gap coincides with large populations beyond an hour's walk, and new sites are indicated. Encoding the manual's decision rule and siting model would turn this reading into a project list.

Plan recruitment around attrition, not only the gap. Replacing leavers accounts for 83% of the recruitment need to 2030. A workforce plan that financed only the workload gap would see the establishment shrink by about 6% a year. The wage bill and the training budget should be set against the full recruitment need.

Resolve the clinical-officer and pharmacy-technician norms before scaling training. The real gaps in these two cadres arise partly from a mismatch between the minimum staffing establishment and the WISN workload norms. The Ministry should decide whether to raise the establishment or to redistribute the workload, and set training intakes accordingly. With a three-year training cycle for clinical officers, that decision needs to be taken in time for the 2027 intake.

Load the training pipeline and the committed project list next. These two datasets would make the workforce plan testable for feasibility and remove double-counting from the capital programme. Together with an all-in capital standard, they would turn this chapter from a statement of scale into a buildable, staffable programme.

CHAPTER 11

11 Resource allocation: what the money available can buy

Chapters 4 to 10 set out what Uganda's population requires. This chapter turns to the money that actually exists. It asks one question: **given a fixed increase in the health budget, how could it be shared across services and districts, and what would each way of sharing it buy?** This is HM-08, the allocation module. It is where the plan meets the budget, and it is the part of the analysis that a Ministry of Finance or a development partner is most likely to act on.

The chapter answers the question in two ways, as the engine documentation requires (docs/10_HM08_ALLOCATION.md). The first is six **rule-based scenarios**, labelled A to F. Each is a single rule that can be stated to a minister in one sentence: follow current spending, fund the basic package, favour primary care, favour hospitals, favour the worst-served districts, or follow the burden of disease. The second is an **optimiser**, a linear programme that finds the allocation that maximises lives saved on its stated objective. Both are judged by the same code and on the same terms. The report does not pick a winner among them. The scenarios value different things, and the choice between geographic equity and aggregate health gain is a political one. The job of the analysis is to make that choice visible.

11.1 The envelope

11.1.1 What is being allocated

The engine distinguishes three quantities for 2026 (FY2025/26), all taken from the plan run log.

- **The baseline** is the cost of what the health system delivers today: 1,503 bn UGX (406 m USD). It is computed, not assumed. For each district and service, the engine prices the volume actually delivered, which is capacity capped at the requirement, at the district's unit cost. Capacity above the requirement is treated as idle, not as spending.
- **The requirement** is the cost of the 28 modelled services at their target coverage: 1,966 bn UGX (531 m USD), from Chapter 9.
- **The financing gap** is the difference between the two: 463 bn UGX (125 m USD). It is the cost of the service shortfall, the units required but not delivered, priced at unit cost.

$$B_0 = \sum_{d,s} c_{d,s} \min(Q_{d,s}, R_{d,s}) \quad (11.1)$$

$$G = C^{\text{req}} - B_0 = \sum_{d,s} c_{d,s} S_{d,s}, \quad S_{d,s} = \max(R_{d,s} - Q_{d,s}, 0) \quad (11.2)$$

where:

- d is a district and s a service;
- c is the unit cost of service s in district d : the national unit cost at each facility level, weighted by the district's normative level mix;
- Q is the capacity in service units (Chapter 7) and R the required units (Chapter 6);

- S is the shortfall in units;
- C^{req} is the full requirement and B_0 the baseline.

11.1.2 The incremental envelope: 413 bn UGX

The money the scenarios share out is the **incremental envelope**. Its size is observed, not assumed. The function `observed_increment` in `src/Budget.jl` takes the approved health budgets for FY2025/26 and FY2026/27 (Chapter 13) and computes the increase in the five institutions that deliver the modelled services: local-government primary health care, KCCA health, National Medical Stores and the regional and national referral hospitals. That increase is **413 bn UGX (112 m USD)**. From the institutional budget table in Chapter 13, it is made up of +60 bn for local-government PHC, +10 bn for KCCA, +145 bn for NMS, +130 bn for the regional referral hospitals and +68 bn for the national referral hospitals. The whole health budget grows by 657 bn between the two years. The difference, 244 bn, goes mainly to the specialised institutes and to agencies and commissions, which fund almost none of the modelled services.

The envelope is about 89% of the financing gap. In round terms, the approved increase for FY2026/27 would close most of the gap in the modelled services, but only if every shilling reached a service shortfall. The rest of this chapter shows that most rules do not manage that.

Table 11.1: The allocation envelope

Year	Class	Financing	bn UGX	Earmark	Source
2026	recurrent	GoU	268.6		user-specified incremental envelope
2026	recurrent	donor_earmarked	144.6	P1.3	donor funds tied to communicable disease programmes

Source: HPRAS database, run `uga-unconstrained-2026` (`report/build/data/t_envelope.csv`).

Table 11.1 shows how the envelope is split into financing pools. All of it is recurrent: 268.6 bn is government (GoU) money and 144.6 bn is donor money earmarked to communicable disease control (programme P1.3). **The earmarked share is an assumption, not an observation.** It is the code default of 35% in `budget_envelope` (`src/Allocation.jl`), and its quality tier is *assumed*. No capital is allocated. The envelope is recurrent by construction, so the allocations in this chapter create no new assets and no induced recurrent cost. The recurrent obligation created by capital is treated in Chapters 10 and 13.

The envelope is set against the baseline, not in place of it. The documentation insists on reporting both. A plan that spends only new money is a very different political proposition from one that reallocates what districts already receive. Every scenario here spends new money only. The 1,503 bn baseline is left where it is.

11.2 Six allocation rules

11.2.1 The common mechanics

Every rule-based scenario works the same way. A rule assigns a non-negative weight to each district-service cell that has a shortfall. The weights are normalised to sum to one, and each cell is offered its share of the envelope. The offer is then cut back by two caps, applied in descending order of weight.

$$\hat{w}_{d,s} = \frac{w_{d,s}}{\sum_{d',s'} w_{d',s'}} \quad (11.3)$$

$$a_{d,s} = \min(M \hat{w}_{d,s}, c_{d,s} S_{d,s}, K_d - A_d) \quad (11.4)$$

$$K_d = \mu \phi_d \sum_s c_{d,s} Q_{d,s} \quad (11.5)$$

where:

- M is the incremental envelope, 413 bn UGX;
- a is the money allocated to the cell and $\hat{w}$ its normalised weight;
- $c \times S$ is the **need ceiling**: no cell is funded beyond the cost of its shortfall;
- K is the district's **absorption ceiling** on new money, and A is what the district has already received from cells with higher weight;
- $\mu = 1.5$ is the absorption multiple and ϕ is the district's establishment fill rate, the share of approved posts that are filled.

The fill rate stands in for absorptive capacity because no district-level budget execution data is held. The code states the reasoning: a district that cannot fill three posts in ten will not spend a tripled budget. Across the 122 districts the fill rate runs from 0.39 to 1.00.

The money bought by a cell becomes service units at the district unit cost. Coverage rises by those units over the requirement. That coverage change is what Chapter 12 turns into deaths averted.

$$u_{d,s} = \frac{a_{d,s}}{c_{d,s}}, \quad \Delta c_{d,s} = \frac{u_{d,s}}{R_{d,s}} \quad (11.6)$$

Two features of the mechanics matter for reading the results. First, the rule is a **single pass**: money a cell cannot use because of a cap is not offered again to other cells. It is reported as unspent. Second, **coverage floors do not drive the rule-based allocations**. The coverage target set gives a minimum coverage, or floor, for each of the 28 services, for example 60% for outpatient consultations, 90% for DPT3 and BCG, and 85% for ART. The rules report how many districts meet every floor after allocation, but none of them is steered by the floors. Only the optimiser treats floors as constraints.

11.2.2 The six rules

Each rule is one weight. The engine's formulas (`scenario_weights` in `src/Allocation.jl`) are as follows.

$$w_{d,s}^A = Q_{d,s}, \quad w_{d,s}^B = S_{d,s} \delta_s^{\text{basic}} \quad (11.7)$$

$$w_{d,s}^C = S_{d,s} [\pi \delta_s^{\text{PHC}} + (1 - \pi)(1 - \delta_s^{\text{PHC}})] \quad (11.8)$$

$$w_{d,s}^D = S_{d,s} [\pi \delta_s^{\text{hosp}} + (1 - \pi)(1 - \delta_s^{\text{hosp}})] \quad (11.9)$$

$$w_{d,s}^E = P_d \left(\frac{S_{d,s}}{R_{d,s}} \right)^\gamma \quad (11.10)$$

$$w_{d,s}^F = S_{d,s} \frac{H_d}{\max(\kappa_d, 0.2)} \quad (11.11)$$

where:

- δ^{basic} is 1 if the service is in the basic package and 0 otherwise (27 of the 28 services are);
- δ^{PHC} is 1 for community and primary-tier services (21 of the 28) and δ^{hosp} is 1 for secondary and tertiary services (the other 7);
- $\pi = 0.70$ is the tier share;
- P is the district population and $\gamma = 1.5$ the equity exponent;
- H is the number of facility deaths the district recorded in HMIS form 108 in the latest year, and κ is its reporting completeness.

In words, the six rules are:

- **A, current trajectory.** Money follows what is already delivered. It is the do-nothing counterfactual, and the other scenarios are best read as differences from it.
- **B, universal basic services.** Money follows the shortfall in basic-package services.
- **C, primary healthcare emphasis.** Money follows the shortfall, with primary-tier cells weighted 0.70 and hospital cells 0.30.
- **D, hospital expansion.** This is the mirror image of C: hospital cells are weighted 0.70.
- **E, geographic equity.** Money follows population times the proportional coverage deficit raised to the power γ . With γ above 1, the rule concentrates on the worst-served cells. With $\gamma = 0$ it becomes a per-capita allocation, and with $\gamma = 1$ it is proportional to the deficit. The interface lets the user move γ and see the allocation shift.
- **F, disease burden.** Money follows the shortfall, scaled by facility deaths corrected for reporting completeness. The code is explicit that this is a ranking signal of *imputed* quality, not an estimate of burden. Facility deaths are not population deaths. They carry both reporting bias, which the completeness correction partly removes, and care-seeking bias, which it does not.

11.3 The optimiser

11.3.1 The linear programme

The optimiser (`src/Optimise.jl`) asks a different question: what is the most this money can buy, under an explicit objective? The run uses the objective `max_lives`. The decision variable x is the number of extra service units funded in each cell i , where i indexes the district-service cells with a positive shortfall and a positive unit cost. There are 1,854 such cells in the solution with non-zero funding.

$$\max_{x, \sigma} \sum_i v_i x_i - \Pi \sum_i \sigma_i \quad (11.12)$$

$$\sum_i c_i x_i \leq M \quad (11.13)$$

$$0 \leq x_i \leq S_i \quad (11.14)$$

$$\sum_{i \in d} c_i x_i \leq K_d \quad \text{for every district } d \quad (11.15)$$

$$Q_i + x_i + \sigma_i \geq f_s R_i, \quad \sigma_i \geq 0 \quad (11.16)$$

$$v_i = \frac{1}{R_i} \sum_j \beta_{d,j} \text{AF}_{s,j} E_{s,j} \quad (11.17)$$

where:

- v is the number of deaths averted per extra unit of service s in district d ;
- β is the baseline number of deaths from outcome j in the district: the national rate times the district's births or population (Chapter 12);
- AF and E are the affected fraction and the efficacy of service s against outcome j (the effectiveness table in Chapter 12);
- f is the coverage floor of the service, and σ the floor shortfall of the cell;
- $\Pi = 10^6$ is the penalty on each unit of floor shortfall;
- K is the same absorption ceiling as in Equation (11.5).

Equation (11.13) is the envelope, Equation (11.14) the need ceiling, Equation (11.15) the absorption cap and Equation (11.16) the floors. The model is linear in x , so it solves as a linear programme. The HiGHS solver finished in 6.7 seconds, with all 413 bn UGX allocated across 1,854 district-services.

Two features of the formulation shape its answer.

- **The floors are soft but heavy.** The documentation requires soft floors so that the model always solves and the pressure shows up as slack, not as a solver error. At a penalty of 10^6 per unit, however, any reachable floor is met before any life-saving is considered. In practice the objective is lexicographic: first lift every reachable cell to its floor, then maximise deaths averted with the money that remains. The run reported no floor that the envelope could not reach.
- **The objective is linear.** Each extra unit averts a fixed number of deaths, so effects that overlap within an outcome are added, not compounded. HM-09 uses the exact multiplicative form. The difference between the two, measured on the optimiser's own allocation, is 5.9%, inside the 10% tolerance the documentation sets. The per-unit values also use the national death rates on district denominators, without the district mortality index that HM-09 applies (Chapter 12). This is a small inconsistency. It should be removed when the objective is next revised.

11.3.2 Earmarks

The documentation is emphatic that earmarked donor money must be allocated as a separate pool: a plan that treats it as fungible cannot be executed. In the notation above, the donor pool M^D can be spent only on the communicable disease programme, which implies the following constraint.

$$\sum_{i \notin P1.3} c_i x_i \leq M - M^D \quad (11.18)$$

Neither the rule-based scenarios nor the optimiser imposes this constraint in the current code. The envelope table records the earmark (Table 11.1), but the allocation functions do not read it. The consequences are large, not academic. The cost of the whole communicable-disease shortfall (ART, HIV testing, PMTCT, malaria and TB) is only 56.3 bn UGX, computed from the database as in Equation (11.2). This is because capacity for these services already roughly matches the requirement: the capacity ratio is 1.02 for ART and 1.01 for malaria (Chapter 7). The OPT allocation spends 55.8 bn on communicable disease and 357.4 bn on everything else. That is more than the 268.6 bn of flexible GoU money. If the earmark were enforced, at most $268.6 + 56.3 = 324.9$ bn of the envelope could be spent on the modelled shortfalls, and the remaining donor money would have no modelled gap to fund.

This finding should be read carefully. It does not mean that donor money for communicable disease is wasted. HIV, TB and malaria programmes fund a great deal outside the 28 modelled services: commodities for the existing caseload, nets, diagnostics and programme costs (Chapter 13). It does mean that, **within the modelled services, the 2026 gap lies almost entirely outside the programmes that donors earmark.** The 35% earmark share is also an assumption. Both points need resolving before the allocation results are used in a budget negotiation.

11.3.3 The gate

A rule-based scenario is only a benchmark if the optimiser has to beat it. The engine asserts this as a gate (check V9 in the documentation). On deaths averted, measured by HM-09 in the multiplicative form, **the optimiser must match or exceed every rule-based scenario on its own objective.** It does: 20,053 deaths averted against 15,010 for scenario E. The gate passed. If it failed, the model would be mis-specified, and the run would say so.

11.4 What each allocation buys

11.4.1 The comparison

Table 11.2 and Figure 11.1 set the seven allocations side by side. Each spends from the same 413 bn UGX envelope.

Table 11.2: What each allocation of the 413 bn UGX envelope buys, 2026 (no scenario is recommended)

Scenario	Coverage gain (pp)	Districts above floor	FTE added	Spent (bn UGX)	Unspent (bn UGX)	Equity ratio	Deaths averted (range)
A Current trajectory	11.99	40	7,764	207.9	205.2	2.47	9,150 (6,133-11,975)
B Universal basic services	13.20	45	9,729	270.3	142.8	2.32	10,503 (6,889-13,928)
C Primary healthcare emphasis	13.53	45	9,777	265.5	147.6	2.33	10,024 (6,596-13,267)
D Hospital expansion	15.06	45	9,826	289.2	124.0	2.17	11,470 (7,484-15,256)
E Geographic equity	23.41	37	5,429	229.2	184.0	1.75	15,010 (10,321-19,293)
F Disease burden	5.55	35	5,327	132.7	280.4	3.26	5,558 (3,758-7,222)
OPT Optimised (max lives)	22.44	119	9,534	413.2	0.0	1.75	20,053 (13,381-26,299)

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_scenarios.csv).

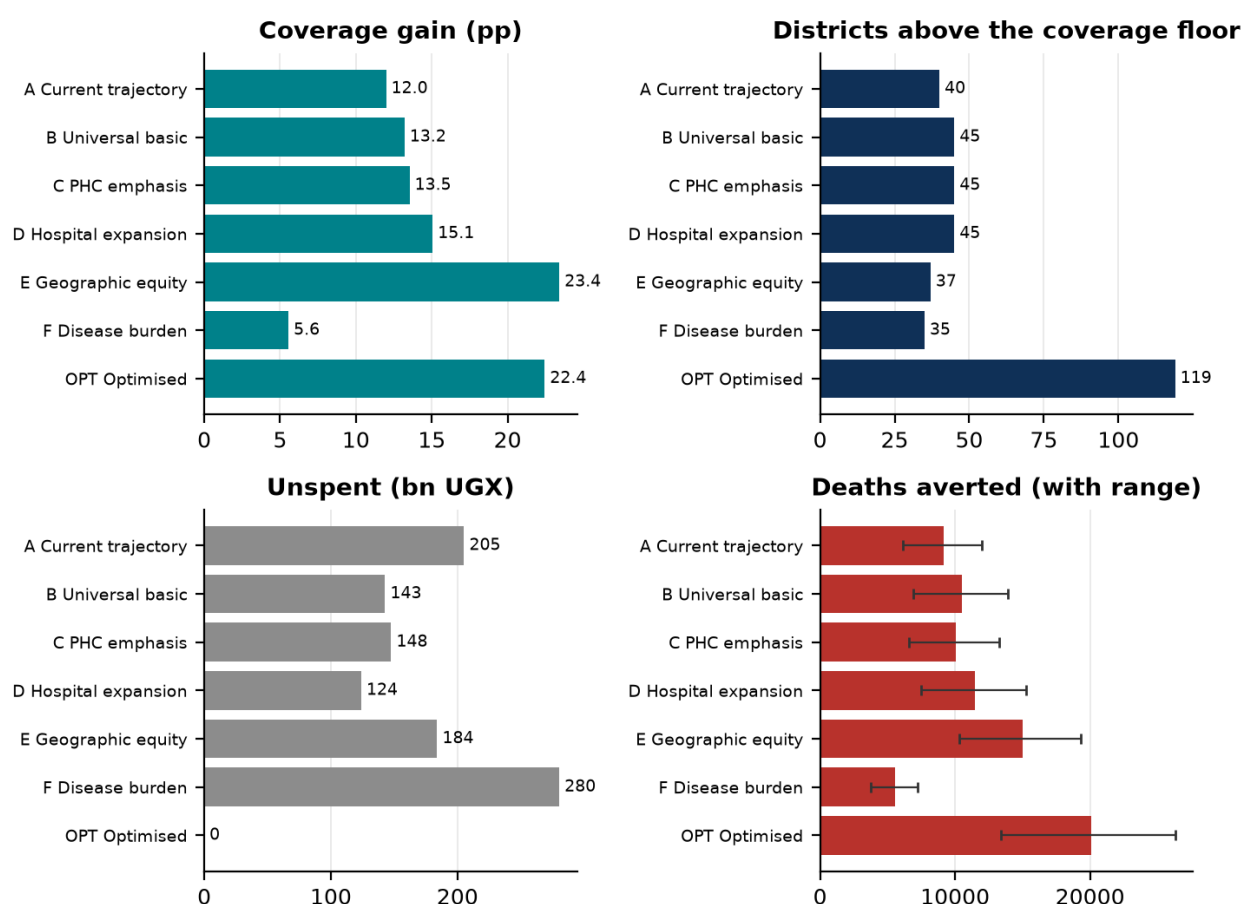


Figure 11.1: What each allocation of the same 413 bn UGX buys, 2026. No scenario is marked best: they differ in what they value

Source: HPRAS database, run uga-unconstrained-2026

The metrics are defined in `record_scenario!` (src/Allocation.jl).

- **Coverage gain** is the mean increase in coverage, in percentage points, over every district-service cell.
- **Districts above floor** counts the districts in which every service meets its floor after the allocation.
- **FTE added** converts funded units to full-time equivalents at the plan's national average workload per unit. It is an order of magnitude, not a recruitment plan.

- **Equity ratio** is the mean coverage of the district at the 90th percentile divided by that at the 10th. Lower is more equal.

Population reached is 47.4 million in every scenario, because every scenario puts some money into every district. It does not discriminate between them and is left out of the table.

The rows read as follows.

- **Scenario E (geographic equity)** raises coverage most among the rules: +23.4 percentage points. It also compresses the spread between districts most, with an equity ratio of 1.75. It averts 15,010 deaths (range 10,321–19,293), more than any other rule. Yet it brings only 37 districts above every floor, because it concentrates on the largest proportional deficits and leaves other services below their floor elsewhere.
- **Scenario D (hospital expansion)** spends the most of any rule (289 bn) and averts 11,470 deaths (range 7,484–15,256). Hospital services such as sick newborn care and paediatric admission act directly on neonatal and under-five mortality.
- **Scenarios B and C** are almost identical. Of the 28 services, 27 are in the basic package and 21 are primary tier, and the shortfall weight dominates. Each lifts 45 districts above every floor and averts about 10,000 deaths: 10,503 (range 6,889–13,928) for B and 10,024 (range 6,596–13,267) for C.
- **Scenario A (current trajectory)** averts 9,150 deaths (range 6,133–11,975). This is what the increase would buy if it followed existing delivery.
- **Scenario F (disease burden)** raises coverage least (+5.6 points), leaves the widest spread between districts (equity ratio 3.26) and averts 5,558 deaths (range 3,758–7,222). The HMIS facility-death signal pulls money towards districts with large hospitals, where deaths are recorded, and away from the shortfalls.
- **The OPT allocation** maximises lives saved on its stated objective. It spends the whole envelope, brings 119 of 122 districts above every floor, raises coverage by 22.4 points with an equity ratio of 1.75, and averts 20,053 deaths (range 13,381–26,299) and 1,080,380 DALYs.

The run log summarises the trade-off in the engine's own words. Scenario E gives the most coverage among the rules, B the most districts above the floor, and D the least unspent money. No scenario is marked best.

11.4.2 Deaths averted per shilling spent

Much of the gap between the scenarios comes from how much money each one manages to spend, not from what it values. Dividing deaths averted by money spent, both from Table 11.2, gives the following, per bn UGX actually spent:

- E: 65.5;
- OPT: 48.5;
- A: 44.0;
- F: 41.9;
- D: 39.7;
- B: 38.9;
- C: 37.8.

On this measure, scenario E averts more deaths per shilling than the OPT allocation. There is no contradiction. The optimiser is required to meet floors first, and floors oblige it to buy low-value units, such as outpatient consultations and immunisation doses in districts already near their target, before it can pursue lives. Its lead in total deaths averted comes from spending all 413 bn while meeting floors in 119 districts. A reader who values lives per shilling above floors would weigh E and OPT differently from one who values the floors. That is precisely the political choice the report leaves open.

11.4.3 Money left unspent, and why

Every rule-based scenario leaves money unspent: between 124 bn (D) and 280 bn (F), a third to two-thirds of the envelope. The engine records the reason for every scenario as **"no remaining gap to fund"**. The absorption ceiling binds in none of them. It is the need ceiling that does the work, for a reason visible in the weight equations. The weights are measured in **service units**, while the need ceiling is measured in **money**.

High-volume, low-cost services therefore attract a larger share of the envelope than their shortfall costs to close. Outpatient consultations are the clearest case: 19.3 million are required in 2026 at a capacity ratio of 0.46. These cells hit the need ceiling at once, and the excess is not passed on. In scenario B, for example, primary care receives 125.6 bn (Table 11.4), which is the entire cost of the outpatient shortfall. The rest of the money offered to those cells lapses. Scenario E, whose weights are proportional deficits, not units, brings 1,210 of its 2,105 funded cells to their full requirement. Scenario F brings only 240 cells to full requirement, but its facility-death weight sends much of the envelope to a few districts, where it is capped.

The unspent money is therefore **a property of the rules, not of Uganda's capacity to absorb**. Two lessons follow.

- **A rule should recycle what it cannot place.** The allocation should iterate until the envelope is spent or no cell can take more. This is the next refinement the module needs. Until then, the rule-based totals understate what each rule could buy, and comparisons of total deaths averted mix what the rule values with how much it spends.
- **The optimiser is not held back by this at all.** It spends every shilling. The absorption ceiling binds in five districts: Budaka, Kakumiro, Luuka, Namisindwa and Serere. In each, the shortfall costs more than 1.5 times the fill rate times what the district delivers today. These are the districts where the documentation's advice applies: invest in implementation capacity before sending more money. About 50 bn UGX of the financing gap (463 bn less the 413 bn allocated) remains unfunded under OPT. Comparing Table 11.4 with Table 11.3, most of it is outpatient consultations (about 19 bn) and RMNCAH services (about 17 bn).

11.5 Where the money goes: service categories

Table 11.4 and Figure 11.2 show how each scenario spends the envelope by service category. The underlying cost of the shortfall, computed from the database as in Equation (11.2), is shown in Table 11.3.

Table 11.3: Cost of the 2026 service shortfall by category (bn UGX; computed from the HPRAS database)

Category	bn UGX
Primary care (outpatient consultations)	125.6
RMNCAH	105.2
Hospital	75.7
NCD	61.6
Communicable	56.3
Immunisation	31.5
Nutrition	7.2

Together these make up the 463 bn financing gap.

Table 11.4: Allocation by service category and scenario, 2026 (bn UGX)

Category	A	B	C	D	E	F	OPT
Communicable	38.8	39.6	39.6	39.6	23.1	18.9	55.8
Hospital	5.2	12.9	5.6	28.4	30.4	1.9	71.3
Immunisation	28.5	27.7	31.0	30.8	31.1	18.9	27.7
NCD	5.6	15.8	16.0	15.1	54.8	10.3	56.4
Nutrition	0.6	0.6	0.5	0.7	6.8	0.6	7.2

Category	A	B	C	D	E	F	OPT
Primary care	83.8	125.6	125.6	125.6	27.7	63.5	106.8
RMNCAH	45.5	48.1	47.1	49.0	55.4	18.6	87.9

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_alloc_category.csv).

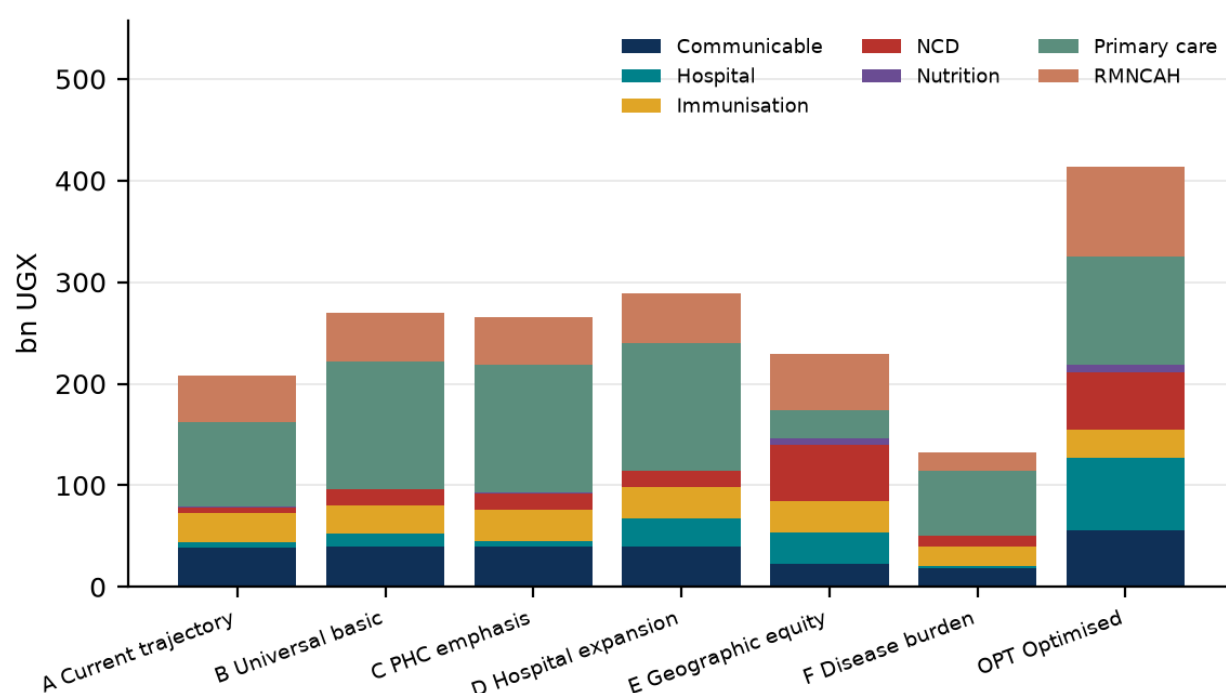


Figure 11.2: How each scenario spends the envelope, by service category, 2026

Source: HPRAS database, run uga-unconstrained-2026

The rules differ sharply in what they buy.

- **B, C and D** all place 125.6 bn in primary care, the whole outpatient shortfall, and about 40 bn in communicable disease. D moves 28.4 bn to hospital services, compared with 5.6 bn under C.
- **E** is the only rule that funds non-communicable disease at scale: 54.8 bn, against 5.6 bn under A. Hypertension management and severe mental disorders have the lowest capacity ratios in the catalogue, 0.20 and 0.18 (Chapter 7). This gives them the largest proportional deficits, which the γ exponent amplifies. E also spends 30.4 bn on hospital services, but only 27.7 bn on primary care.
- **The OPT allocation** funds almost every category close to its full shortfall: nutrition 7.2 of 7.2 bn, hospital services 71.3 of 75.7, NCD 56.4 of 61.6, communicable disease 55.8 of 56.3, and RMNCAH 87.9 of 105.2. It leaves the largest residual in primary care, 106.8 of 125.6 bn. Outpatient consultations avert few deaths per unit in the effectiveness table: an affected fraction of 0.15 and an efficacy of 0.12 against under-five deaths. Once their floors are met, the optimiser has little reason to buy more of them.

The category mix explains much of the outcome ranking in Chapter 12. Money for sick newborn care, paediatric admission, deliveries and hypertension buys deaths averted. Money for outpatient consultations buys contacts and floors.

11.6 Where the money goes: districts

11.6.1 The distribution across districts

Figure 11.3 shows the allocation per person across the 122 districts under each scenario. Spread over 47.4 million people, the 413 bn envelope is about 2.35 USD per person. The scenarios spread it very differently.

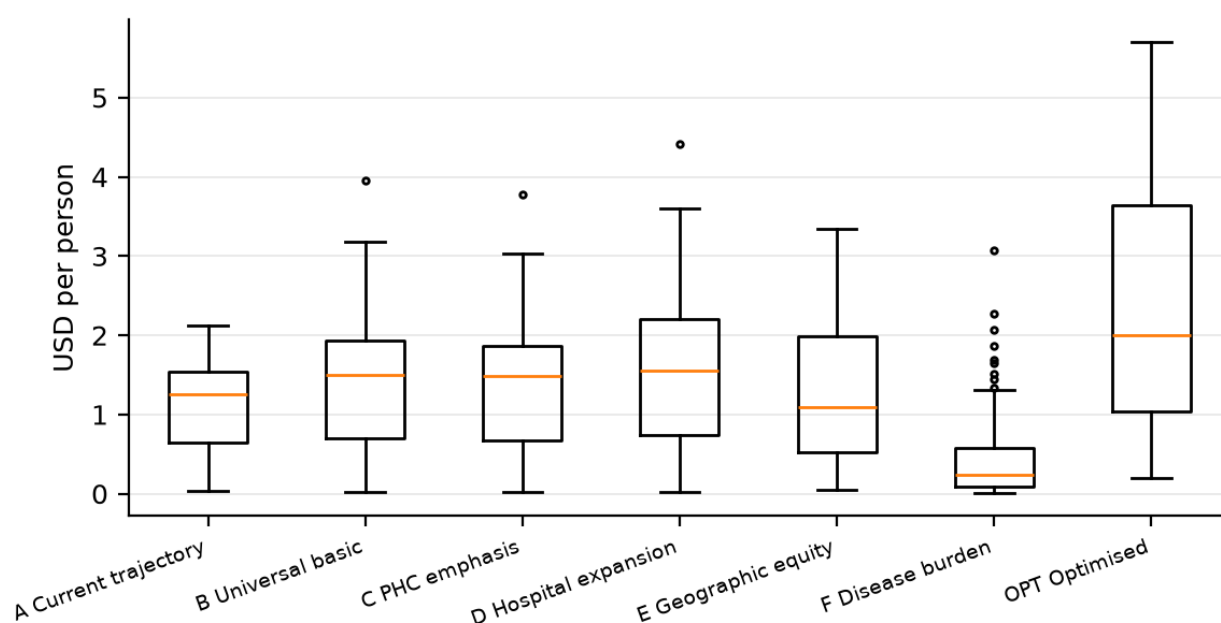


Figure 11.3: Distribution of the allocation per person across districts, by scenario, 2026

Source: HPRAS database, run uga-unconstrained-2026

- **The OPT allocation** has the highest median, 2.00 USD per person, because it spends the whole envelope. It also has the widest spread, from 0.20 USD in Moyo to 5.70 USD in Alebtong.
- **Scenarios A to D** have medians between 1.25 and 1.55 USD, with maxima of 2.1 to 4.4 USD.
- **Scenario E** has a lower median, 1.09 USD, but its upper quartile reaches the high-deficit districts.
- **Scenario F** is the outlier. Its median is 0.24 USD, and a handful of districts with large hospitals stand far above the rest: Kampala 3.08, Wakiso 2.27, Soroti 2.07 and Lira 1.87 USD per person.

11.6.2 The seven allocation maps

Each map shows the allocation per person (left) and the local Moran (LISA) clusters (right). The clusters mark hot spots, where high-allocation districts neighbour each other (HH), and cold spots, where low-allocation districts neighbour each other (LL). The statistics come from `raw_gis_layers.csv` and the GIS layer tables.

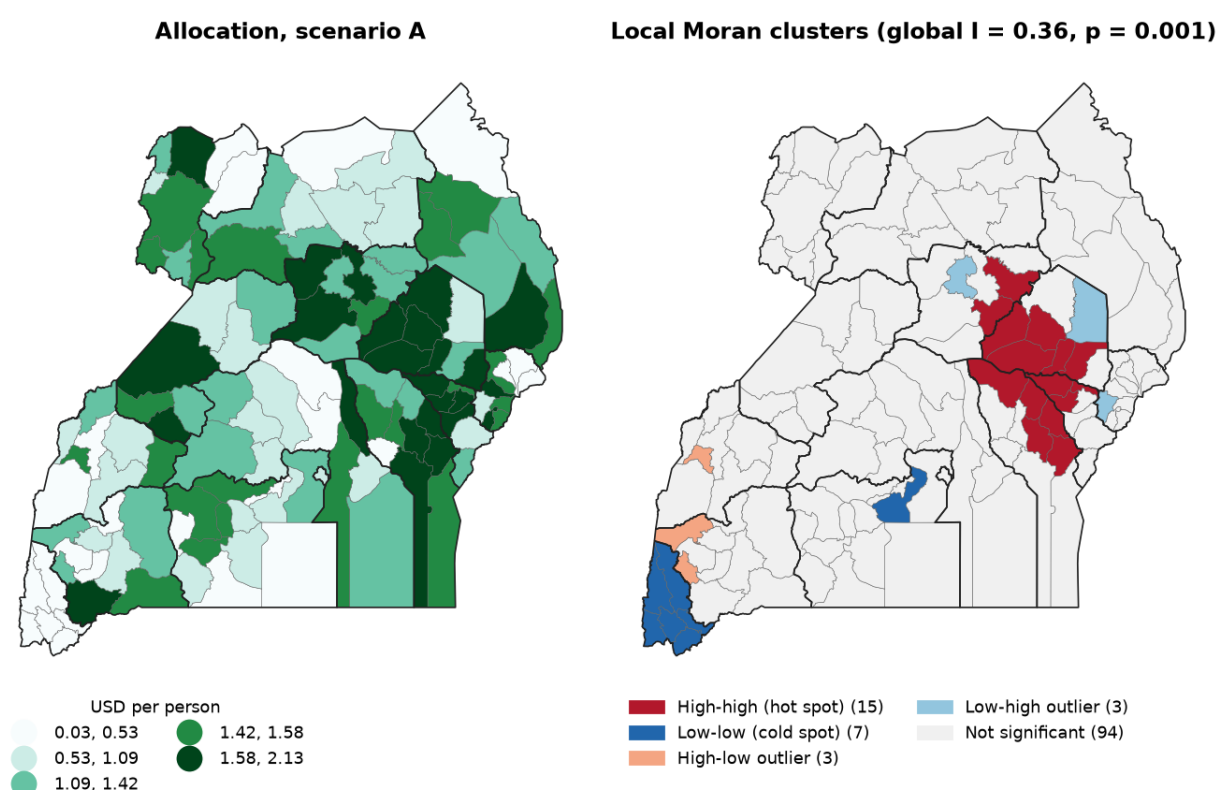


Figure 11.4: HM-08 - Allocation, scenario A (USD per person), by district, 2026; right: local Moran (LISA) clusters, 999 permutations

Source: HPRAS database, run uga-unconstrained-2026; quality tier derived. Boundaries (c) OpenStreetMap contributors (ODbL).

Scenario A (Figure 11.4; Moran's I = 0.36, 15 hot and 7 cold districts). Money follows existing delivery into the shortfall cells. The hot spot is a continuous band across Teso, Bukedi, Busoga and southern Lango: Pallisa, Kaberamaido, Soroti, Serere, Kibuku, Iganga, Bugiri, Namutumba, Ngora, Dokolo and neighbours. These districts combine a high malaria need index with large service shortfalls. The cold spot is Kigezi (Kisoro, Rubanda, Rukiga, Kanungu, Kabale, Rukungiri) with Mpigi. Kigezi carries the floor value of the malaria index and small shortfalls. Kabale and Rukungiri receive 0.03 USD per person.

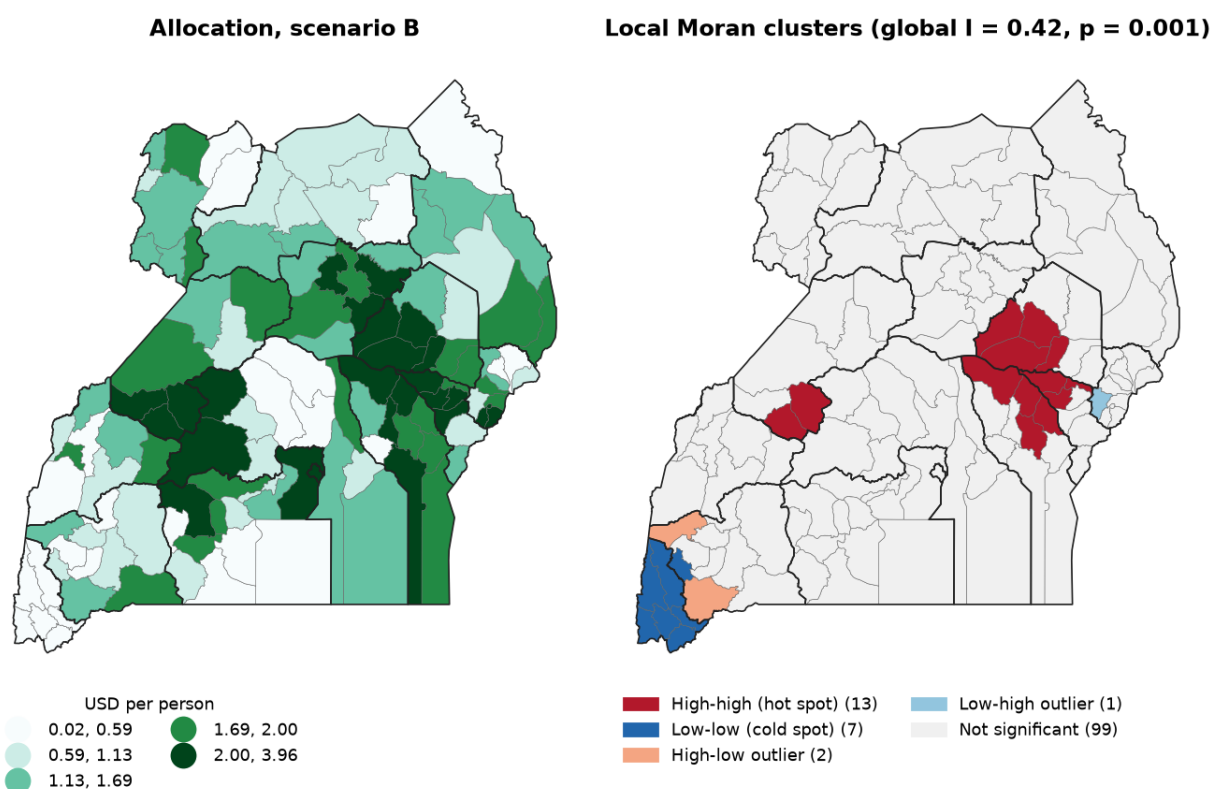


Figure 11.5: HM-08 - Allocation, scenario B (USD per person), by district, 2026; right: local Moran (LISA) clusters, 999 permutations

Source: HPRAS database, run uga-unconstrained-2026; quality tier derived. Boundaries (c) OpenStreetMap contributors (ODbL).

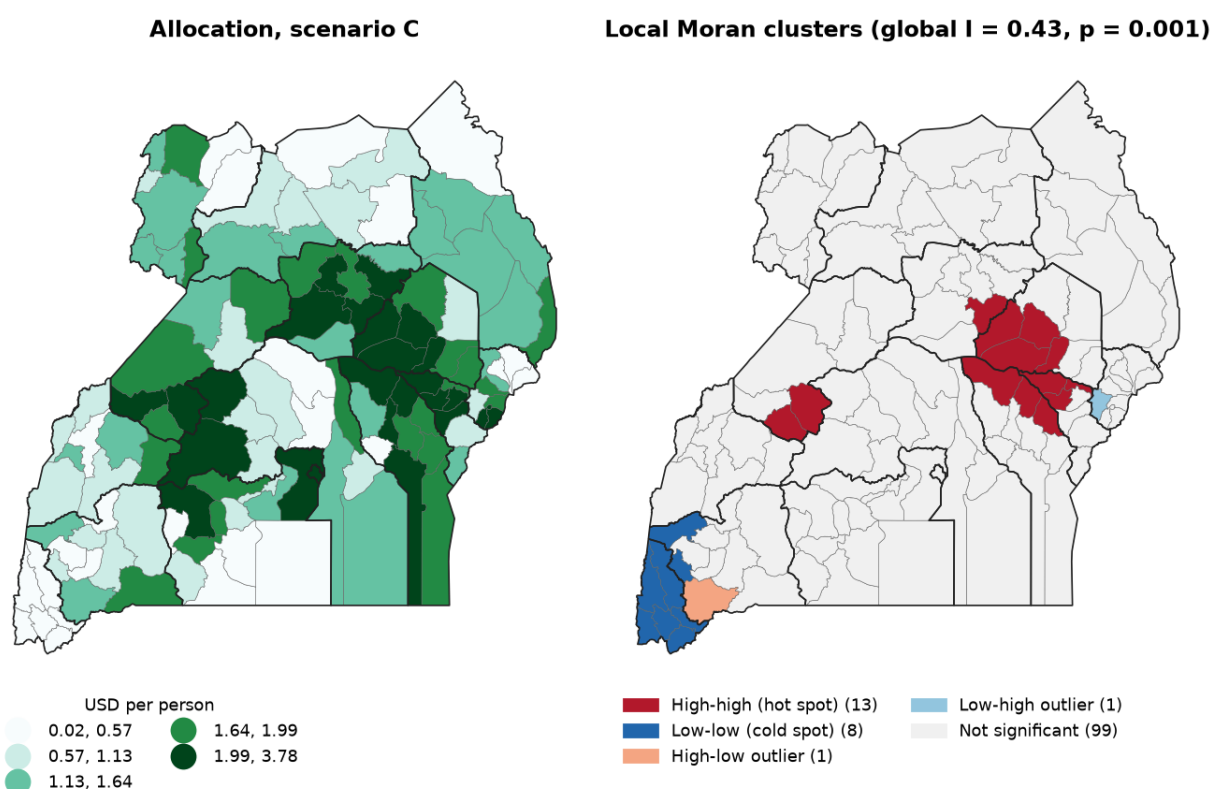


Figure 11.6: HM-08 - Allocation, scenario C (USD per person), by district, 2026; right: local Moran (LISA) clusters, 999 permutations

Source: HPRAS database, run uga-unconstrained-2026; quality tier derived. Boundaries (c) OpenStreetMap contributors (ODbL).

Scenarios B and C (Figure 11.5, Figure 11.6; $I = 0.42$ and 0.43 , 13 hot and 7–8 cold districts). The pattern is the same eastern band, extended west to Kakumiro and Kibaale in Bunyoro. Serere is the highest district in both, at

3.96 and 3.78 USD per person. It has one of the largest service gaps in the country (Chapter 8). Kigezi, with Mitooma and Rubirizi in Ankole, remains the cold spot. Kampala enters the top five under C, where primary-tier shortfalls carry the higher weight.

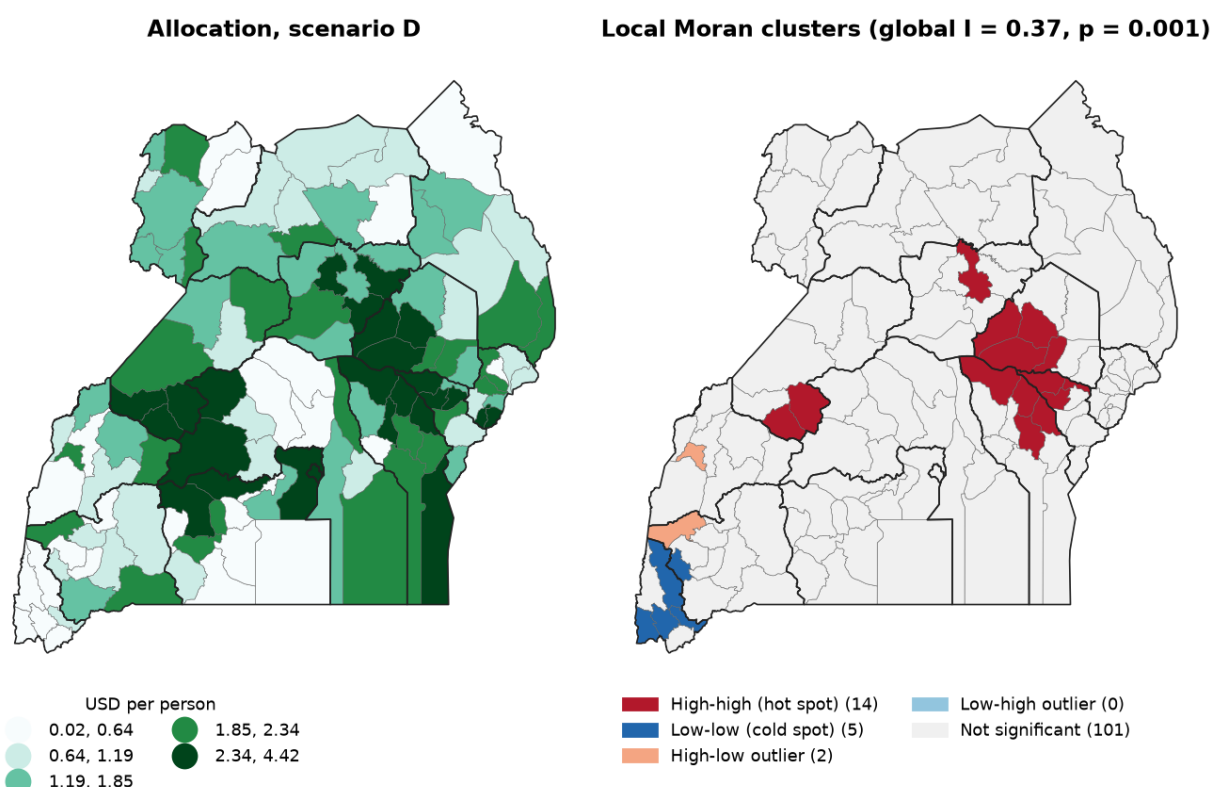


Figure 11.7: HM-08 - Allocation, scenario D (USD per person), by district, 2026; right: local Moran (LISA) clusters, 999 permutations

Source: HPRAS database, run uga-unconstrained-2026; quality tier derived. Boundaries (c) OpenStreetMap contributors (ODbL).

Scenario D (Figure 11.7; $I = 0.37$, 14 hot and 5 cold districts). The hot spot is essentially that of B and C, with Lira added. Serere reaches 4.42 USD per person and Budaka 3.60. Moving money towards hospital services does not move it towards different districts. It moves it towards different services in the same districts, because the hospital shortfalls sit where the primary shortfalls are.

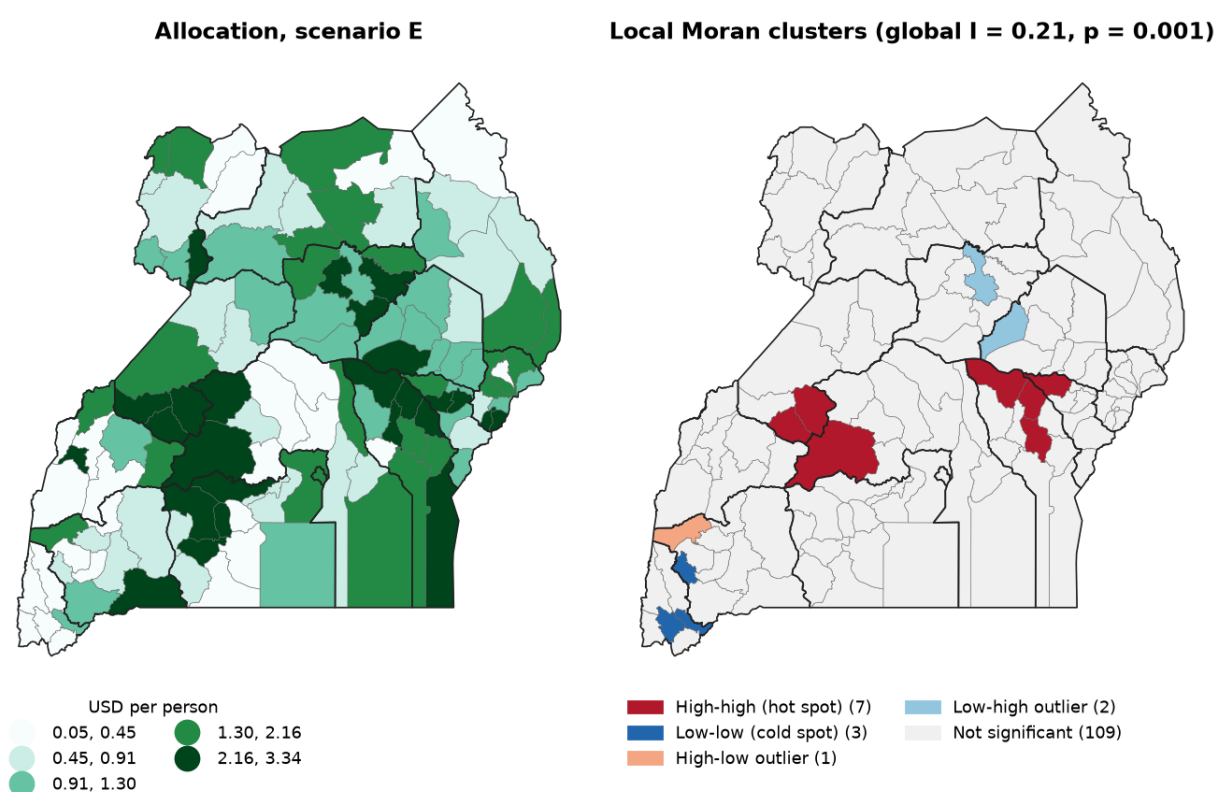


Figure 11.8: HM-08 - Allocation, scenario E (USD per person), by district, 2026; right: local Moran (LISA) clusters, 999 permutations

Source: HPRAS database, run uga-unconstrained-2026; quality tier derived. Boundaries (c) OpenStreetMap contributors (ODbL).

Scenario E (Figure 11.8; $I = 0.21$, 7 hot and 3 cold districts). Clustering weakens by half. The equity rule targets proportional deficits, which are scattered across services and districts, not tied to the eastern malaria belt. The remaining hot spot links Busoga and Bunyoro: Kakumiro, Buyende, Kaliro, Kibaale, Mubende, Pallisa and Iganga. Namisindwa (3.13) and Kole (2.99 USD per person) rise near the top. Kaberamaido and Lira are low-high outliers: districts that receive little while their neighbours receive much.

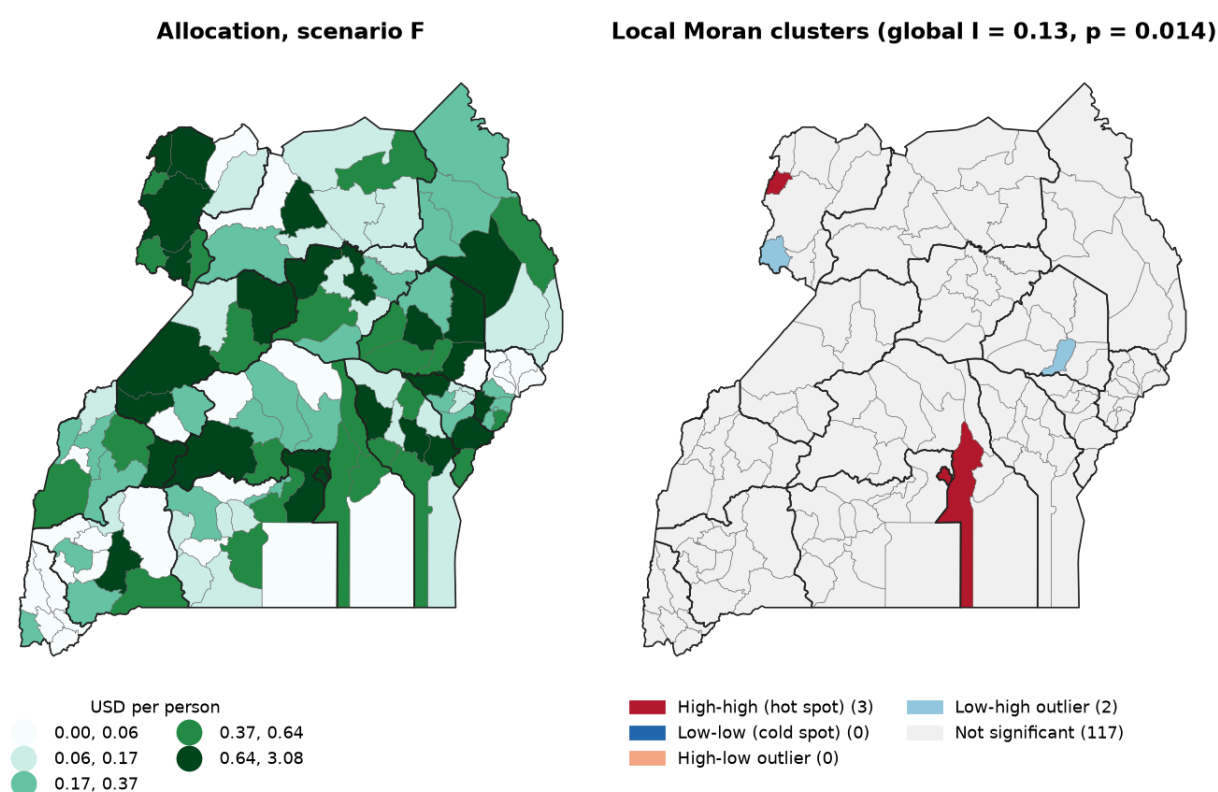


Figure 11.9: HM-08 - Allocation, scenario F (USD per person), by district, 2026; right: local Moran (LISA) clusters, 999 permutations

Source: HPRAS database, run uga-unconstrained-2026; quality tier derived. Boundaries (c) OpenStreetMap contributors (ODbL).

Scenario F (Figure 11.9; $I = 0.13$, $p = 0.014$, 3 hot and no cold districts). Clustering is weakest here, and only barely significant. The allocation follows recorded facility deaths. It picks out Kampala and Mukono, the metropolitan referral hub, with Maracha in West Nile, and it places Soroti, Lira and Hoima, the sites of regional referral hospitals, high above their neighbours. This is the care-seeking bias the code warns about, and the map makes it visible: deaths are recorded where hospitals are, not where people die.

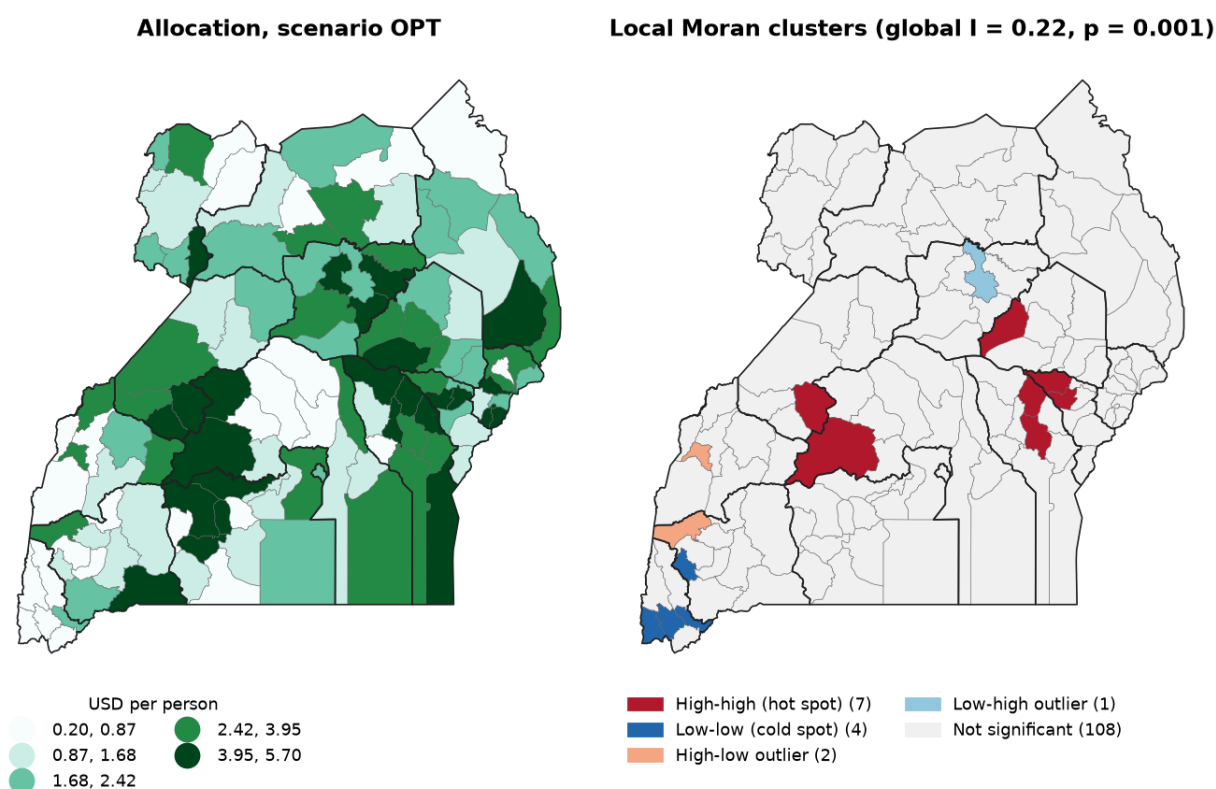


Figure 11.10: HM-08 - Allocation, scenario OPT (USD per person), by district, 2026; right: local Moran (LISA) clusters, 999 permutations

Source: HPRAS database, run uga-unconstrained-2026; quality tier derived. Boundaries (c) OpenStreetMap contributors (ODbL).

The OPT allocation (Figure 11.10; $I = 0.22$, 7 hot and 4 cold districts). The highest allocations are in Alebtong (5.70 USD per person), Serere (5.43), Budaka (5.14), Kaliro (5.09) and Buyende (5.03). The hot spot runs from Busoga and Bukedi into Bunyoro and Mubende. The cold spot is again Kigezi with Mitooma. Every district receives something, with a minimum of 0.20 USD per person, because the floors oblige the optimiser to reach every district before it concentrates.

11.6.3 What the maps have in common

Three regularities hold across all seven maps.

- **The eastern and east-central band is funded under every rule except F.** Teso, Bukedi, Busoga and southern Lango combine the highest malaria need index (Lango 2.00, Teso 1.80), large outpatient and delivery shortfalls, and fill rates high enough to absorb the money. Any rule driven by shortfall sends money there.
- **Kigezi is a cold spot under every rule except F.** Its malaria need index sits at the floor of 0.35, its shortfalls are small, and in several services its capacity exceeds the requirement. Moyo in West Nile is the lowest or near-lowest district in every scenario, for the same reason. These districts are not under-served by the allocation. They have little modelled gap to fill.
- **The choice of rule changes which services are bought more than which districts are funded.** Because the eastern hot spot persists across A, B, C, D and OPT, a district health officer in Serere or Pallisa can plan on a substantial increase under almost any rule. The rules differ on whether that increase buys outpatient contacts, hospital beds or hypertension care.

11.7 Data quality and limitations

The allocation inherits every quality flag from the chain behind it. The need rates for malaria and HIV, and the district mortality indices, are *imputed*: national totals apportioned by survey geography. Capacity is *measured* for all 122 districts. Four limitations are specific to this module.

1. **The earmark is assumed and not enforced.** The 35% donor share is a code default, and neither allocation method treats it as a separate pool. Enforcing it would limit the spendable envelope to about 325 bn UGX, as shown above.
2. **The rules make a single pass.** Unspent money is an artefact of the rules, not an absorption constraint. The rule-based totals understate what each rule could buy.
3. **The absorption ceiling rests on a proxy.** It uses the establishment fill rate, because budget execution is held only by institution, not by district (Chapter 13). The ceiling is loose. It binds only under OPT, and only in five districts.
4. **The optimiser is a one-year linear programme without workforce dynamics.** It does not model recruitment, training supply, construction or referral constraints (constraints 4–6 and 10–13 in the documentation). Floors dominate its objective through the penalty, and its per-unit values omit the district mortality index. The FTE figures in Table 11.2 are workload equivalents at the national average and do not add up to a recruitment plan. Chapter 10 treats recruitment.

The engine also cannot see allocations to services outside the 28 in the catalogue. The envelope is the approved increase for the whole of five institutions, so part of it will in practice fund activity the model does not represent.

11.8 Implications for planning

- **The approved FY2026/27 increase is large relative to the modelled gap.** At 413 bn UGX, the increase in the service-delivery institutions is 89% of the 463 bn financing gap in the modelled services. How it is shared matters more than its size. On the same money, deaths averted range from 5,558 (range 3,758–7,222) under a burden rule driven by facility deaths to 20,053 (range 13,381–26,299) under the allocation that maximises lives saved on its stated objective.
- **Allocation rules must recycle what they cannot place.** A formula that offers money to cells that cannot use it leaves a third or more of the envelope unallocated. Any formula the Ministry adopts for sharing an increase, whether across districts or programmes, should reallocate the residual. The rule-based results here should be re-run once the engine does so.
- **The earmark question comes before the allocation question.** Within the modelled services, the communicable-disease shortfall is only 56 bn UGX. Donor funds earmarked for HIV, TB and malaria at the assumed scale could not be absorbed by the modelled gap. The Ministry and partners should establish the actual earmarked share of the FY2026/27 increase and what it is tied to before any allocation result is used in negotiation.
- **Equity and aggregate health gain pull in different directions, and the report does not choose between them.** Scenario E buys the most coverage and the most deaths averted per shilling among the rules, and it narrows the gap between districts most. The OPT allocation averts the most deaths in total and meets the floors in 119 districts. Scenario B lifts the most districts above the floors among the rules. Which of these to favour is a political decision. The tables in this chapter state its price.
- **Five districts need implementation capacity before more money.** Budaka, Kakumiro, Luuka, Namisindwa and Serere hit the absorption ceiling under OPT. Support for staffing and financial management there would release health gains that money alone cannot buy.

CHAPTER 12

12 Health outcomes: deaths and DALYs averted

Chapter 11 showed what each allocation of the 413 bn UGX envelope buys in services and coverage. This chapter asks what that coverage is worth in health: **how many deaths, and how many years of life, would each allocation avert in 2026?** This is HM-09, the outcomes module. It closes the chain the concept note calls the most important extension of the system:

Money → Inputs → Services → Coverage → Health outcomes

The aim is not precision. Estimates of deaths averted carry wide uncertainty, and the report always shows them as a range. The aim is **consistency**. The same money always buys the same coverage, and the same coverage always implies the same outcome. That consistency is what lets seven allocations, built on different principles, be compared honestly on one scale. It also makes the optimiser's gate in Chapter 11 meaningful. The optimiser is tested on the outcomes computed here, not on its own objective.

For Uganda the question matters because the modelled services are dominated by maternal, newborn and child health, HIV, malaria and TB. These are the areas where the Lives Saved Tool evidence base is strongest, and where district differences in mortality are large. On the rates used here, a baseline of around 220,000 deaths a year across seven outcomes gives the planning problem its weight.

12.1 From money to deaths averted

12.1.1 The chain, made explicit

Each link in the chain is computed by a named module and rests on a documented coefficient.

- **Money to inputs, and inputs to services** (HM-06, HM-08). The money allocated to a district-service cell is divided by the district unit cost to give service units.
- **Services to coverage** (HM-08). The units funded, divided by the required units, give the change in coverage (Chapter 11).
- **Coverage to outcomes** (HM-09). The change in coverage is multiplied by the fraction of deaths the service can reach and by its efficacy.

A worked case from the run shows the whole chain in one cell. Under the OPT allocation, Serere district receives 1.26 bn UGX for malaria diagnosis and treatment. At the district unit cost, this buys 78,405 additional treatments. Capacity was 75,799 treatments against the requirement, so coverage of the requirement rises from 0.49 to 1.00, a change of 0.51. Serere has 400,846 people, and Teso's malaria mortality index is 1.80. Its baseline malaria deaths are therefore 217 a year. With an affected fraction of 0.90 and an efficacy of 0.60, the coverage change averts 59.6 malaria deaths. The range is 43.7 to 74.5, from the lower and upper bounds of the efficacy interval. Every number in that sentence can be traced to a table in this report or in the database.

12.1.2 Baseline deaths

Deaths averted are a fraction of baseline deaths, so the baseline sets the scale. The engine applies a national mortality rate for each of seven outcomes to each district's own denominator, which is either births or total population. It then scales the result by a district mortality index where the data support one.

$$D_{d,j}^0 = r_j N_{d,j} I_{d,j} \quad (12.1)$$

$$\frac{\sum_d W_d I_{d,j}}{\sum_d W_d} = 1 \quad (12.2)$$

where:

- D^0 is the baseline deaths from outcome j in district d in 2026;
- r is the national rate for outcome j (Table 12.1);
- N is the denominator: births for maternal, neonatal and under-five deaths, and total population for malaria, TB, HIV and cardiovascular disease;
- I is the district mortality index, set to 1 where no index exists;
- W is the weight used to normalise the index: total population for HIV and malaria, and under-fives for under-five mortality.

Equation (12.2) says that the index has a weighted mean of exactly 1. **National deaths are therefore unchanged by the index. Only their distribution across districts moves.**

Table 12.1: Baseline mortality parameters (HM-09)

Outcome	Rate	Per	YLL per death	Source	Year
Maternal	0.00189	births	42.1	Uganda DHS 2022 maternal mortality ratio	2022
Neonatal	0.02200	births	62.8	Uganda DHS 2022 neonatal mortality rate	2022
Under5	0.05200	births	61.5	Uganda DHS 2022 under-five mortality rate	2022
Malaria	0.00030	population	45.0	WHO World Malaria Report, Uganda	2024
Tb	0.00035	population	32.0	WHO Global TB Report, Uganda	2024
Hiv	0.00042	population	38.0	UNAIDS Uganda: 20,000 AIDS deaths in 2024	2024
Cvd	0.00050	population	18.0	WHO NCD country profile, Uganda: cardiovascular disease ~10% of ~250,000 deaths	2018

Source: HPRAS database, run `uga-unconstrained-2026 (report/build/data/t_mortality.csv)`.

Table 12.1 lists the rates and their sources.

- Maternal, neonatal and under-five mortality come from the published Uganda DHS 2022 report: 189 maternal deaths per 100,000 births, 22 neonatal deaths per 1,000 births and 52 under-five deaths per 1,000 births. These replace the DHS 2016 figures (336, 27 and 64), which `scripts/seed_data.py` notes overstated baseline deaths, and therefore deaths averted, by 20–45%.
- Malaria (30 per 100,000) and TB (35 per 100,000) are from the WHO World Malaria and Global TB Reports.
- HIV is the UNAIDS estimate of 20,000 AIDS deaths in 2024, divided by the population.
- Cardiovascular disease (50 per 100,000) is from the WHO NCD country profile.

Applied to the 2026 denominators (1.94 million births and 47.4 million people), the rates imply the following national baseline deaths, computed from the database with Equation (12.1):

- under-five: 100,784;
- neonatal: 42,726;
- cardiovascular disease: 23,720;
- HIV: 19,891;
- TB: 16,604;
- malaria: 14,232;
- maternal: 3,671.

Together these make 221,627. The outcomes overlap. Under-five deaths include neonatal deaths by definition, and malaria, HIV and TB deaths include some children. The seven totals should therefore not be added into a single count of deaths in Uganda. Each is the denominator for its own set of interventions.

12.1.3 The district mortality index

Three outcomes carry a district index (Table 12.2; Figure 12.1). The index exists because, without it, need and mortality would have different geographies. The need side of the model already follows UPHIA HIV prevalence and the DHS fever index. Without a matching index, Karamoja would carry about a quarter of South Buganda's HIV need per adult (prevalence 2.1% against 8.1%) but the same HIV deaths per head (scripts/derive_dhs_rates.py, section 3d). The index gives deaths the same geography as need.

Table 12.2: District mortality indices (population-weighted mean 1)

Outcome	Districts	Lowest	Highest	Source
hiv	122	0.37	1.44	UPHIA 2020-2021 Summary Sheet (Aug 2022), adult HIV prevalence by region
malaria	122	0.35	2.00	DHS/MIS child fever index, as for the malaria need rate
under5	122	0.79	1.22	HealthModelling Fay-Herriot EBLUP of under-five mortality, DHS 2016 sub-regions (vendored), shape only

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_mortality_index.csv).

- **HIV** follows adult HIV prevalence by region from the UPHIA 2020–2021 Summary Sheet (national 5.8%). The index runs from 0.37 in Karamoja (prevalence 2.1%) to 1.44 in South Buganda (8.1%). UPHIA reports 11 regions, so the resolution is the UPHIA region. Acholi and Lango share Mid North's 7.6% and an index of 1.35. West Nile (2.8%) has an index of 0.50.
- **Malaria** uses the same DHS/MIS child fever index as the malaria need rate (Chapter 5), bounded to between 0.35 and 2.50. Lango has the highest value (2.00), followed by Teso (1.80) and Acholi (1.51). Kigezi (0.35), Ankole (0.36) and Tooro (0.49) are the lowest.
- **Under-five mortality** takes its shape from the HealthModelling Fay–Herriot EBLUP of the under-five mortality hazard, estimated on the DHS 2016 sub-regions and vendored into this repository (Table 12.3). Only the shape is used. The level stays at the DHS 2022 national rate.

$$\hat{\theta}_r = x'_r \hat{\beta} + g_r (y_r - x'_r \hat{\beta}), \quad g_r = \frac{\sigma_u^2}{\sigma_u^2 + V_r} \quad (12.3)$$

$$I_{d, u5} = \frac{\hat{\theta}_{r(d)}}{\bar{\theta}} \quad (12.4)$$

where:

- y is the direct survey estimate for sub-region r and V its sampling variance;
- $x'_r \hat{\beta}$ is the model prediction;
- σ_u^2 is the between-area variance;
- g is the shrinkage weight on the direct estimate (the "Shrinkage" column of Table 12.3);
- $\hat{\theta}$ is the smoothed estimate, the EBLUP;
- $r(d)$ is the sub-region containing district d , and $\bar{\theta}$ is the mean of $\hat{\theta}$ weighted by under-fives.

Table 12.3: Under-five mortality hazard by sub-region (HealthModelling Fay-Herriot EBLUP, DHS 2016)

Sub-region	Direct	EBLUP	Index (mean 1)	Shrinkage
Karamoja	0.0193	0.0164	1.22	0.50
Bunyoro	0.0174	0.0154	1.15	0.51
West Nile	0.0158	0.0147	1.10	0.55
Tooro	0.0153	0.0147	1.09	0.66
Busoga	0.0153	0.0147	1.09	0.66

Sub-region	Direct	EBLUP	Index (mean 1)	Shrinkage
Bukedi	0.0137	0.0136	1.01	0.72
North Buganda	0.0136	0.0135	1.01	0.55
Kampala	0.0124	0.0131	0.97	0.37
Ankole	0.0127	0.0130	0.97	0.67
Acholi	0.0122	0.0127	0.95	0.59
Lango	0.0121	0.0125	0.93	0.69
Bugisu	0.0118	0.0123	0.92	0.66
Kigezi	0.0115	0.0123	0.91	0.60
South Buganda	0.0114	0.0121	0.90	0.65
Teso	0.0098	0.0106	0.79	0.78

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_sae_under5.csv).

The EBLUP matters most where the survey is thinnest. Karamoja's direct estimate of 0.0193 is pulled to 0.0164, with a shrinkage weight of 0.50. Kampala's weight is only 0.37, so its estimate moves from 0.0124 to 0.0131, towards the national model. Teso, which has the most precise estimate (weight 0.78), keeps most of its low direct value. The resulting under-five index runs from 0.79 in Teso to 1.22 in Karamoja. Bunyoro (1.15), West Nile, Tooro and Busoga (1.09–1.10) are the other high sub-regions.

The other outcomes carry no index. Neonatal and maternal deaths vary only with births. The code states why: no sub-regional estimate the survey can support exists for them. TB and cardiovascular deaths vary only with population.

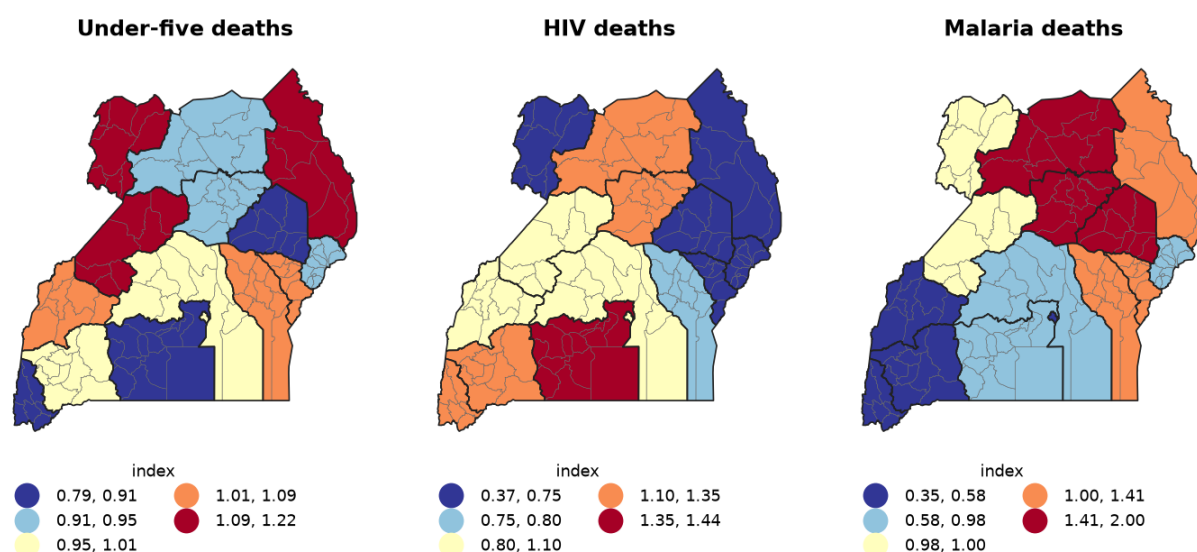


Figure 12.1: District mortality indices (population-weighted mean 1): the geography of baseline deaths

Source: HPRAS database, run uga-unconstrained-2026. Boundaries (c) OpenStreetMap contributors (ODbL).

Figure 12.1 shows that the three indices have almost unrelated geographies.

- **Under-five mortality** is highest in the north-east (Karamoja) and the west (Bunyoro, Tooro, West Nile). It is lowest in Teso and South Buganda.
- **HIV mortality** is highest in the central south and the mid-north, and lowest in Karamoja and West Nile.
- **Malaria mortality** is highest in a northern and eastern band from Lango through Acholi and Teso, and lowest in the south-west highlands.

A district's baseline mortality profile therefore depends on which outcome dominates its services. This is why the geography of deaths averted differs so much between allocations.

12.2 Deaths averted

12.2.1 Combining interventions

For each outcome in each district, the engine multiplies together the survival effects of every service whose coverage the allocation changes. This is the Lives Saved Tool / CHERG form.

$$\Delta D_{d,j} = D_{d,j}^0 \left[1 - \prod_s (1 - AF_{s,j} E_{s,j} \Delta c_{d,s}) \right] \quad (12.5)$$

$$\Delta D_{d,j}^{\text{lin}} = D_{d,j}^0 \min \left(\sum_s AF_{s,j} E_{s,j} \Delta c_{d,s}, 0.8 \right) \quad (12.6)$$

where:

- ΔD is the deaths averted from outcome j in district d ;
- AF is the affected fraction, the share of deaths from outcome j that service s can reach at all;
- E is the efficacy of the service against those deaths at full coverage;
- Δc is the change in coverage of service s bought by the allocation;
- ΔD^{lin} is the linear approximation.

The multiplicative form is the one reported. Adding effects linearly double-counts. For example, skilled delivery, antenatal care, caesarean section, obstetric complication care, postnatal care and family planning all act on maternal deaths, and a linear sum could exceed the deaths there are to avert. The product cannot.

The linear form exists only because the optimiser in Chapter 11 needs a linear objective. The documentation requires the difference between the two forms to be stated. Measured on the OPT allocation, it is:

$$\epsilon = \frac{\left| \sum_{d,j} \Delta D_{d,j}^{\text{lin}} - \sum_{d,j} \Delta D_{d,j} \right|}{\sum_{d,j} \Delta D_{d,j}} = 0.059 \quad (12.7)$$

A difference of 5.9% is inside the 10% tolerance. Above that level, the documentation says the optimiser's objective would be materially distorted, and the service set should be re-partitioned.

12.2.2 Uncertainty

Each effectiveness parameter carries a published 95% confidence interval (Table 12.4). The engine recomputes Equation (12.5) with the efficacy set to its lower bound, and again at its upper bound, for every service at once. This gives a low and a high estimate beside the central one. This is the documentation's "phase 1" uncertainty method. Monte Carlo propagation over effectiveness and unit costs is specified but not yet implemented. The range therefore reflects uncertainty in efficacy only. It does not reflect uncertainty in baseline mortality, in the affected fractions, in unit costs or in the coverage the money buys. It is a lower bound on the true uncertainty.

Table 12.4: Effectiveness parameters (Lives Saved Tool / CHERG)

Service	Outcome	Affected fraction	Efficacy	95% CI	Source
Caesarean section	maternal	0.30	0.65	0.45-0.80	LiST/CHERG emergency obstetric care
Inpatient bed-day	under5	0.25	0.15	0.07-0.24	inpatient case management, indicative
Sick newborn care	neonatal	0.50	0.30	0.18-0.42	facility care of sick and small newborns: sepsis, prematurity, asphyxia
Complicated SAM, inpatient stabilisation	under5	0.02	0.50	0.35-0.65	inpatient stabilisation of complicated SAM

Service	Outcome	Affected fraction	Efficacy	95% CI	Source
Obstetric complications (non-surgical)	maternal	0.25	0.35	0.20-0.50	management of haemorrhage, pre-eclampsia/eclampsia and sepsis
Severe childhood illness, admission	under5	0.25	0.40	0.25-0.55	inpatient case management of severe malaria, pneumonia and dehydration
Antenatal care visit	maternal	0.50	0.20	0.10-0.31	LiST/CHERG antenatal care
Antenatal care visit	neonatal	0.45	0.18	0.09-0.28	LiST/CHERG antenatal care
Normal delivery	maternal	0.85	0.42	0.25-0.58	LiST/CHERG skilled birth attendance
Normal delivery	neonatal	0.60	0.25	0.14-0.37	LiST/CHERG skilled birth attendance
Family planning	maternal	0.40	0.30	0.18-0.42	family planning averts unintended pregnancy and therefore maternal risk
Antiretroviral therapy	hiv	0.95	0.80	0.70-0.88	ART survival benefit, UNAIDS/WHO
Prevention of mother-to-child transmission	under5	0.05	0.85	0.72-0.92	PMTCT vertical transmission prevention
HIV testing and counselling	hiv	0.35	0.25	0.12-0.38	testing acts through linkage to treatment
BCG immunisation	under5	0.01	0.70	0.50-0.85	BCG against TB meningitis and miliary TB
Pentavalent immunisation (DTP-HepB-Hib)	under5	0.08	0.85	0.72-0.93	LiST/CHERG DTP-HepB-Hib
Measles-rubella immunisation	under5	0.04	0.85	0.72-0.93	measles vaccination, LiST/CHERG
Pneumococcal immunisation	under5	0.12	0.55	0.40-0.68	pneumococcal conjugate vaccine
Polio immunisation	under5	0.00	0.95	0.85-0.99	polio, residual burden only
Rotavirus immunisation	under5	0.08	0.50	0.35-0.62	rotavirus vaccine
Malaria diagnosis and treatment	malaria	0.90	0.60	0.44-0.75	LiST/CHERG ACT case management
Hypertension management	cvd	0.45	0.25	0.15-0.35	treated hypertension on CVD deaths; ~half of CVD deaths attributable to raised BP
NCD screening (blood pressure, glucose)	cvd	0.45	0.05	0.02-0.08	screening acts only through linkage to treatment
Severe acute malnutrition treatment	under5	0.06	0.55	0.40-0.70	community management of SAM on SAM-attributable child deaths
Outpatient consultation	under5	0.15	0.12	0.05-0.20	outpatient case management, indicative
Postnatal care contact	maternal	0.20	0.15	0.08-0.25	postnatal checks after discharge: late haemorrhage, sepsis, hypertension
Postnatal care contact	neonatal	0.25	0.20	0.10-0.30	postnatal home/facility visits, LiST neonatal effect
Tuberculosis treatment course	tb	0.95	0.70	0.55-0.82	WHO TB treatment outcome

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_effectiveness.csv).

Most of the parameters in Table 12.4 are LiST/CHERG estimates. A few are flagged in their own source string as indicative: inpatient bed-days and outpatient consultations against under-five deaths. Two act only through linkage to treatment: HIV testing (efficacy 0.25) and NCD screening (0.05). Their efficacies are deliberately low, because a test saves no life unless it leads to treatment. The largest single effects are:

- ART against HIV deaths: affected fraction 0.95, efficacy 0.80;
- TB treatment against TB deaths: 0.95 and 0.70;

- malaria case management against malaria deaths: 0.90 and 0.60;
- skilled delivery against maternal deaths: 0.85 and 0.42.

12.2.3 DALYs

DALYs averted are computed as years of life lost only. Each death averted is multiplied by a fixed number of years of life lost per death for its outcome (Table 12.1). The values run from 62.8 years for a neonatal death and 61.5 for an under-five death to 18.0 for a cardiovascular death.

$$DALY_{d,j} = \Delta D_{d,j} \times YLL_j \quad (12.8)$$

The convention follows GBD 2019, as `scripts/seed_data.py` records: no age weighting and no discounting in the headline figure. Years lived with disability are not yet computed, because the morbidity and incidence part of the design (docs §9.2) is not implemented. The DALY figures therefore understate the gain from services whose benefit is mainly in morbidity, such as hypertension management, mental health care and nutrition.

12.3 Results

12.3.1 By scenario

Table 12.5 gives deaths and DALYs averted in 2026 for each allocation, with the range.

Table 12.5: Deaths and DALYs averted by scenario, 2026, with the uncertainty range

Scenario	Deaths averted	Low	High	DALYs averted
OPT Optimised (max lives)	20,053	13,381	26,299	1,080,380
E Geographic equity	15,010	10,321	19,293	806,905
D Hospital expansion	11,470	7,484	15,256	649,265
B Universal basic services	10,503	6,889	13,928	588,333
C Primary healthcare emphasis	10,024	6,596	13,267	558,508
A Current trajectory	9,150	6,133	11,975	519,551
F Disease burden	5,558	3,758	7,222	310,898

Source: HPRAS database, run `uga-unconstrained-2026 (report/build/data/t_outcomes_scenario.csv)`.

The ranking is as follows.

1. **The OPT allocation**, which maximises lives saved on its stated objective, averts 20,053 deaths (range 13,381–26,299) and 1,080,380 DALYs.
2. **Scenario E (geographic equity)** averts 15,010 (range 10,321–19,293).
3. **Scenario D (hospital expansion)** averts 11,470 (range 7,484–15,256).
4. **Scenario B (universal basic services)** averts 10,503 (range 6,889–13,928).
5. **Scenario C (PHC emphasis)** averts 10,024 (range 6,596–13,267).
6. **Scenario A (current trajectory)** averts 9,150 (range 6,133–11,975).
7. **Scenario F (disease burden)** averts 5,558 (range 3,758–7,222).

The ranges overlap heavily. The low estimate for OPT (13,381) lies below the central estimate for E (15,010), and the ranges of B, C, D and A all overlap one another. **Given the effectiveness evidence, the report cannot distinguish B, C and D from each other or from A.** It can say with more confidence that OPT averts more than A to D, because its low bound (13,381) is above all four central estimates. It can also say that F averts fewer than any of them, because its high bound (7,222) is below all their central estimates. The ranking is the same at the low, central and high bounds, because the same efficacy bound is applied to every scenario. The ranges are therefore more informative about the level of deaths averted than about the differences between scenarios.

In proportion to the baseline, the OPT allocation averts about 9% of the 221,627 baseline deaths implied by the rates. It does so with an envelope equal to 21% of the 1,966 bn requirement. The gap between those two shares reflects diminishing returns. The largest killers are already partly served, and most of the envelope buys contacts that avert few deaths each.

Chapter 11 set out the other dimension of the comparison: deaths averted per shilling spent. Scenario E averts 65.5 deaths per bn UGX spent, compared with 48.5 for OPT. It also leaves 184 bn of its envelope unspent. Both facts belong beside the totals in Table 12.5.

12.3.2 By cause

Table 12.6 and Figure 12.2 break the deaths averted down by outcome.

Table 12.6: Deaths averted by cause and scenario, 2026 (point estimates; ranges in the scenario table)

Cause	Baseline deaths	A	B	C	D	E	F	OPT
Cvd	23,720	280	661	668	635	2,040	405	2,302
Hiv	19,891	643	609	610	608	395	305	1,021
Malaria	14,232	608	671	671	671	144	285	671
Maternal	3,671	227	235	230	241	381	89	513
Neonatal	42,726	1,244	1,302	1,176	1,551	2,264	431	3,479
Tb	16,604	104	19	20	18	387	10	415
Under5	100,784	6,045	7,004	6,650	7,746	9,400	4,034	11,652

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_outcomes_cause.csv).

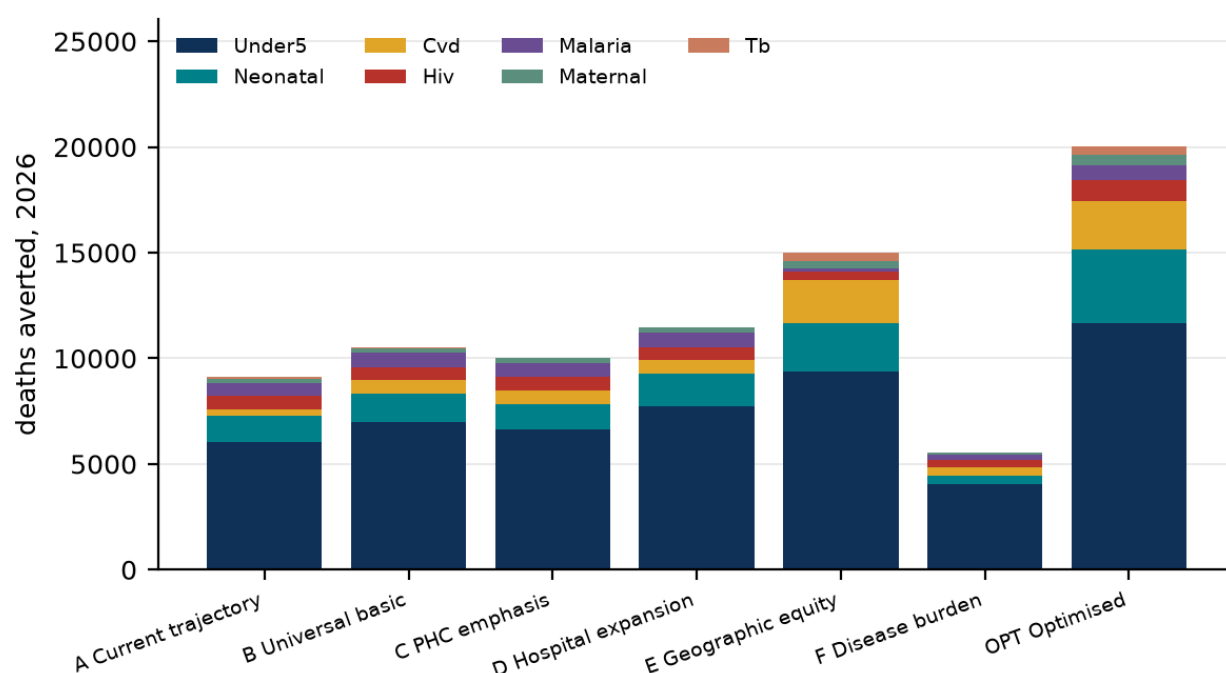


Figure 12.2: Deaths averted by cause and scenario, 2026 (point estimates; ranges in Figure of scenarios)

Source: HPRAS database, run uga-unconstrained-2026

A note on the "Baseline deaths" column. The outcome table records a district-outcome pair only where a scenario changes coverage of at least one service acting on that outcome, so its baseline column counts only the deaths a scenario touches. For scenario A that is 187,870. The baseline column of Table 12.6 is instead the full baseline from Equation (12.1) for every district and cause, which totals 221,627 and matches the rates above. An earlier version of this table, and of the baseline map, used the funded-only figure. The difference was largest for malaria (5,784 against 14,232) and TB (5,032 against 16,604), which scenario A funds in only part of the country. The engine now stores the full baseline separately (table `baseline_death`), and a regression test checks it.

Four patterns stand out.

- **Under-five deaths dominate every scenario.** The OPT allocation averts 11,652 under-five deaths, 58% of its total, and scenario E averts 9,400. Many services act on under-five mortality: paediatric admission, inpatient bed-days, outpatient consultation, the vaccines, PMTCT and SAM treatment. The under-five baseline is also the largest of the seven.
- **Neonatal deaths are where the scenarios differ most.** OPT averts 3,479 neonatal deaths and E 2,264, but F averts only 431 and A 1,244. Sick newborn care (affected fraction 0.50, efficacy 0.30) and skilled delivery are the levers. Scenarios that fund hospital newborn units and deliveries in the districts with shortfalls gain most.
- **Cardiovascular deaths averted depend almost entirely on whether hypertension is funded.** Scenario E averts 2,040 and OPT 2,302, against 280 to 668 under A to D. Hypertension management has the lowest capacity ratio of any service after mental health, and only E and OPT fund NCDs at scale (Chapter 11).
- **HIV, malaria and TB deaths averted are small in every scenario.** HIV deaths averted run from 305 to 1,021, malaria from 144 to 671 and TB from 10 to 415. This is not because these services are ineffective: ART, TB treatment and malaria treatment have the highest efficacies in the table. It is because their capacity already roughly matches the requirement, so there is little shortfall for the money to close. Malaria deaths averted are identical, at 671, under B, C, D and OPT. In each of these allocations every malaria shortfall is fully funded, and no further malaria gain is available.

The last point connects to the earmark finding in Chapter 11. The communicable-disease services, where donor money is earmarked, are also where the modelled allocation has least left to buy. This does not mean HIV, TB and malaria deaths are low. On the rates used here they total over 50,000 a year. It means the modelled shortfall in those services is small, because the existing programmes, largely donor-financed, already deliver close to the requirement. Sustaining that delivery is a baseline question, not an allocation question (Chapter 13).

12.3.3 The geography of outcomes

Each map shows the value per 100,000 population (left) and the local Moran clusters (right).

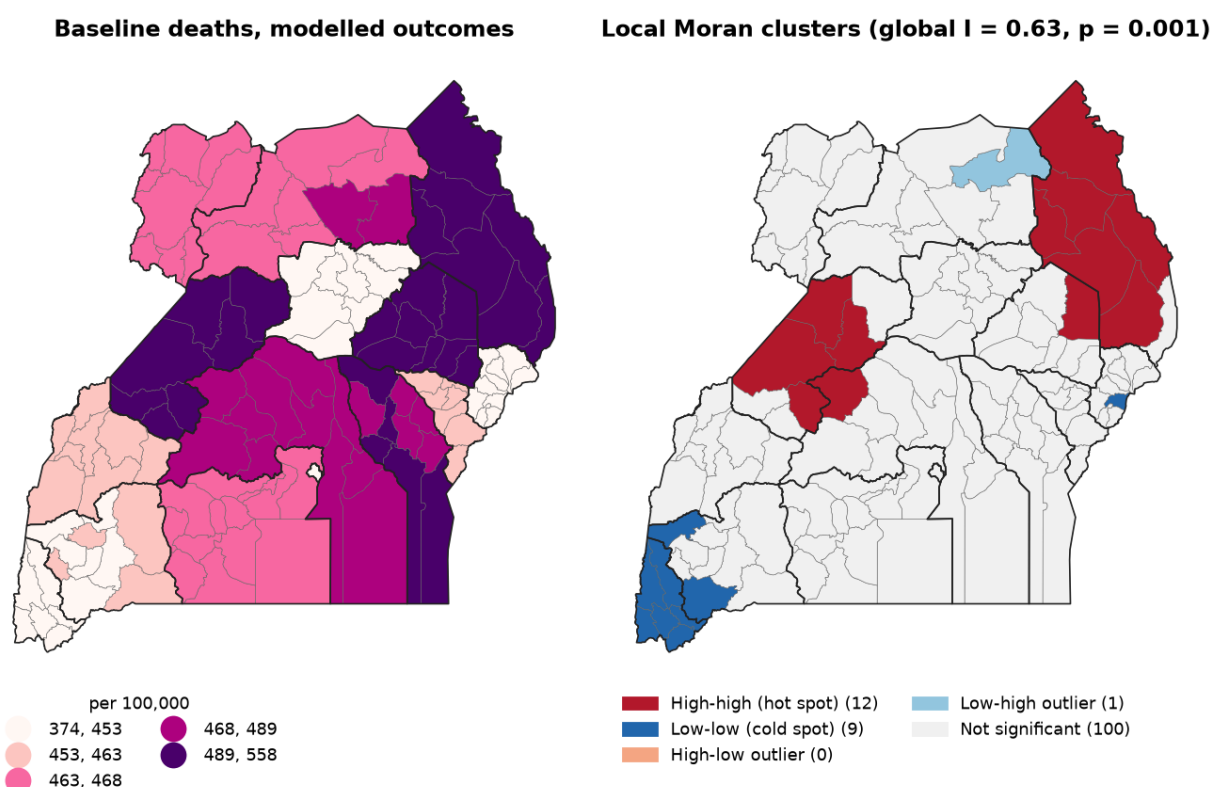


Figure 12.3: HM-09 - Baseline deaths, modelled outcomes (per 100,000), by district, 2026; right: local Moran (LISA) clusters, 999 permutations

Source: HPRAS database, run uga-unconstrained-2026; quality tier derived. Boundaries (c) OpenStreetMap contributors (ODbL).

Baseline deaths (Figure 12.3; Moran's $I = 0.63$, 12 hot and 9 cold districts). The layer is the full baseline from Equation (12.1) for every district and cause: the national rates applied to each district's births or population and scaled by the mortality indices. It ranges from 374 to 558 deaths per 100,000, around a district median of 466. Karamoja is highest: Kaabong, Kotido, Abim, Moroto, Nakapiripirit, Napak and Amudat are each at 558 per 100,000. This reflects Karamoja's under-five index of 1.22 and its high birth rate: 48.2 births per 1,000 people, against a district median of 41.0. The hot spot joins Karamoja (Kaabong, Kotido, Abim, Moroto, Nakapiripirit, Napak) with Bunyoro (Buliisa, Hoima, Kakumiro, Masindi) and with Katakwi and Kyankwanzi. The cold spot is Kigezi (Kabale, Kisoro, Rukiga, Kanungu, Rubanda, Rukungiri, all at 374), together with Ntungamo, Rubirizi and Bududa. Kigezi has the lowest malaria index and a below-average under-five index. Because the baseline is driven by rates and indices defined at sub-region level, it is strongly clustered by construction.

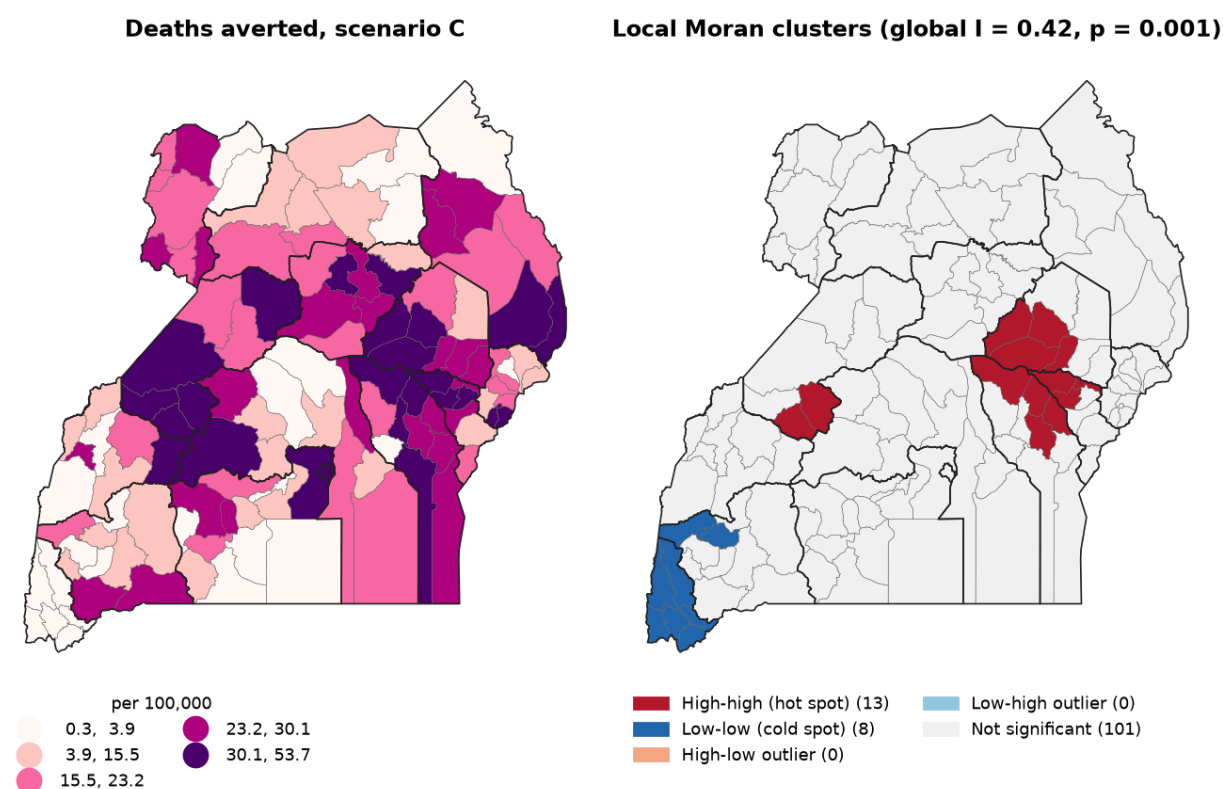


Figure 12.4: HM-09 - Deaths averted, scenario C (per 100,000), by district, 2026; right: local Moran (LISA) clusters, 999 permutations

Source: HPRAS database, run uga-unconstrained-2026; quality tier derived. Boundaries (c) OpenStreetMap contributors (ODbL).

Deaths averted under scenario C (Figure 12.4; $I = 0.42$, 13 hot and 8 cold districts). The map is almost a copy of the scenario C allocation map in Chapter 11. The same 13 districts form the hot spot: Serere, Kakumiro, Buyende, Pallisa, Kaliro, Kibaale, Kaberamaido, Soroti, Kibuku, Ngora, Iganga, Namutumba and Butebo. Serere is highest, at 53.7 per 100,000, followed by Budaka (45.1) and Kakumiro (44.0). The cold spot is Kigezi with Rubirizi and Buhweju. Under a rule driven by shortfall, outcomes follow money, and money follows the eastern shortfalls.

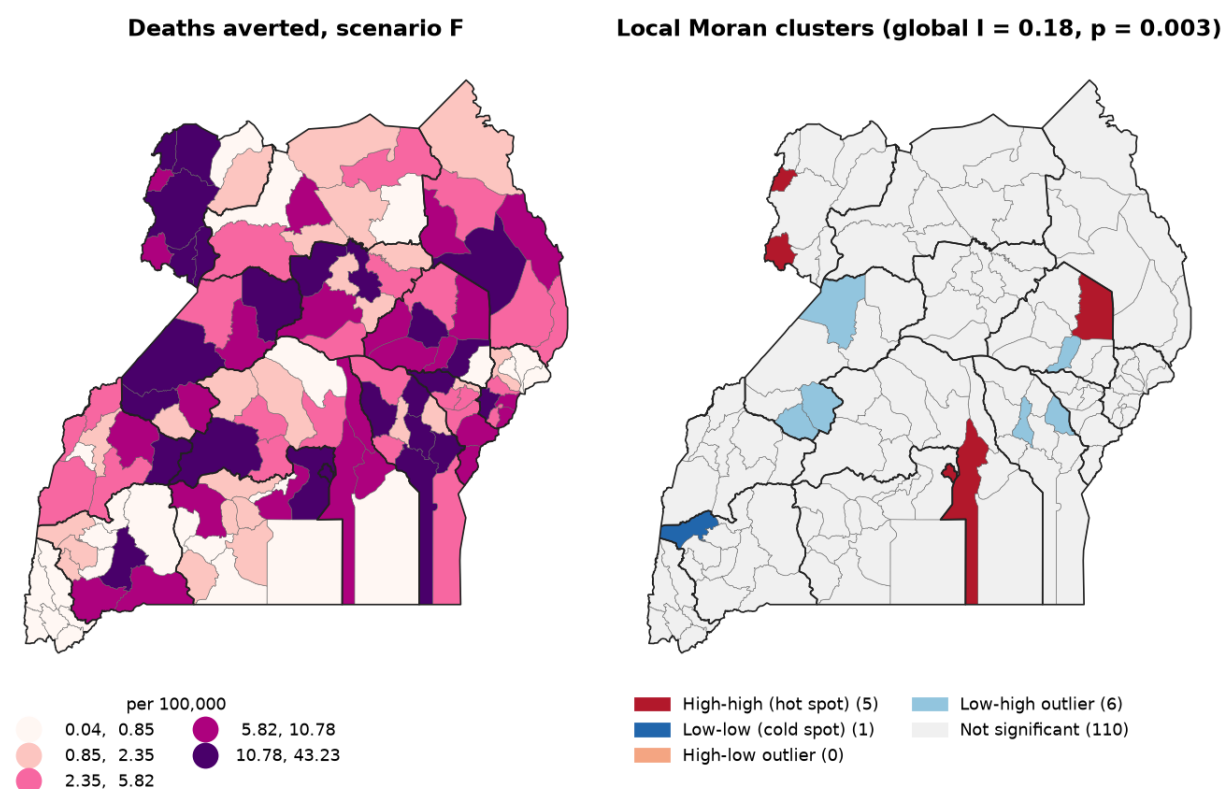


Figure 12.5: HM-09 - Deaths averted, scenario F (per 100,000), by district, 2026; right: local Moran (LISA) clusters, 999 permutations

Source: HPRAS database, run uga-unconstrained-2026; quality tier derived. Boundaries (c) OpenStreetMap contributors (ODbL).

Deaths averted under scenario F (Figure 12.5; $I = 0.18$, $p = 0.003$, 5 hot and 1 cold district). The map follows recorded facility deaths. Kampala (43.2 per 100,000), Wakiso (33.5), Hoima (32.4), Soroti (29.0) and Iganga (28.8) are highest. The hot spot is Kampala and Mukono, with Maracha, Zombo and Katakwi. Six districts are low-high outliers, low values next to high neighbours: Ngora, Kakumiro, Buliisa, Namutumba, Luuka and Kibaale. These are exactly the eastern and Bunyoro districts that every other scenario funds. The median district averts only 3.3 deaths per 100,000. The map shows why a facility-death signal is a poor guide to burden: it sends money and outcomes to where hospitals record deaths, and away from the rural shortfalls.

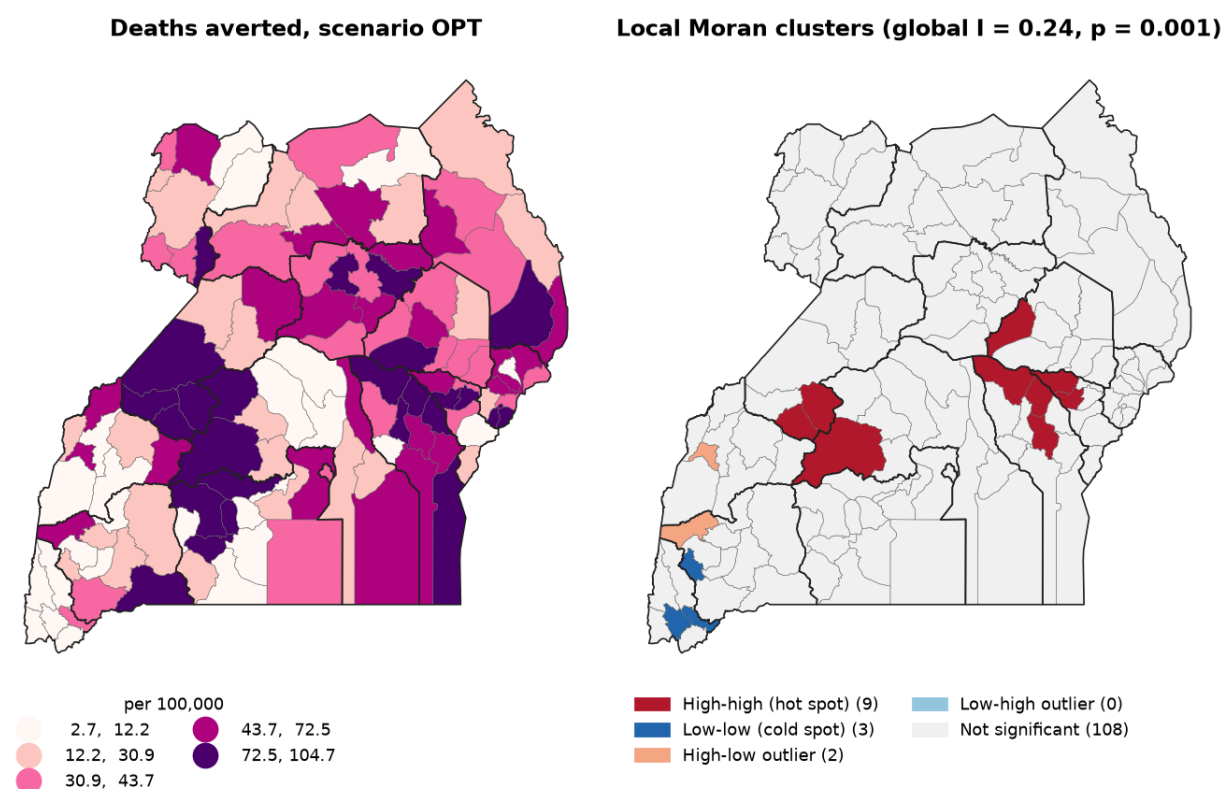


Figure 12.6: HM-09 - Deaths averted, scenario OPT (per 100,000), by district, 2026; right: local Moran (LISA) clusters, 999 permutations

Source: HPRAS database, run uga-unconstrained-2026; quality tier derived. Boundaries (c) OpenStreetMap contributors (ODbL).

Deaths averted under the OPT allocation (Figure 12.6; $I = 0.24$, 9 hot and 3 cold districts). The median district averts 36.0 deaths per 100,000, and the range is 2.7 to 104.7. Kakumiro (104.7) and Serere (104.2) are highest. They are followed by Nakapiripirit (98.5), Buyende (96.0) and Budaka (95.4). Nakapiripirit's appearance reflects both money and mortality. It receives 4.23 USD per person under OPT, against a median of 2.00. Karamoja's under-five index of 1.22 also raises the deaths each unit of coverage averts there. The hot spot spans Bunyoro (Kakumiro, Kibaale), Busoga (Buyende, Kaliro, Iganga), Bukedi (Kibuku, Pallisa), Kaberamaido and Mubende. The cold spot is Rukiga, Rubanda and Mitooma in the south-west.

Across all four maps, the south-west highlands (Kigezi and parts of Ankole) sit at the bottom. They have the lowest malaria and under-five indices and the smallest shortfalls. The belt from Teso through Busoga to Bunyoro sits at the top whenever the allocation follows shortfall.

12.4 Data quality and limitations

The outcome estimates stack several layers of uncertainty. They should be read as a consistent yardstick for comparing allocations, not as forecasts of mortality.

1. **Baseline rates are national and imputed at district level.** The seven rates come from published national reports. The district indices apportion them by survey geography: UPHIA regions for HIV, DHS sub-regions for malaria and under-five mortality. All three indices carry the *imputed* quality tier. Neonatal, maternal, TB and cardiovascular deaths vary only with demography.
2. **The under-five index is from 2016.** The Fay–Herriot shape rests on DHS 2016 sub-regional estimates, while the level is from DHS 2022. If the geography of child mortality has shifted since 2016, the index will not show it.
3. **Coverage means coverage of the requirement.** The Δc used in Equation (12.5) is the change in delivered volume over required volume at the target coverage (Chapter 11). Treating it as the change in population

coverage assumed by the LiST parameters is an approximation. It overstates the effect where the target is well below full coverage.

4. **No lags, no morbidity and no binding-constraint check.** Effects are counted in the year the coverage changes. The documentation's distributed lags (§9.4), incidence effects (§9.2) and YLD are not yet implemented. Nor is the separate check that complementary inputs are funded (§9 step 2). Coverage is capped only by the requirement. Long-payoff services, such as hypertension care and nutrition, are therefore understated. Services that need several inputs at once may be overstated.
5. **The range is efficacy-only.** It is a lower bound on the true uncertainty.
6. **The causes overlap.** Under-five deaths include neonatal deaths, and the totals by cause should not be summed into a national count of deaths.
7. **Two reporting artefacts.** The "Baseline deaths" column of Table 12.6 and the baseline-deaths map count only the district-outcome pairs that scenario A touches. The optimiser's per-unit objective omits the district mortality index (Chapter 11).

12.5 Implications for planning

- **Where the money goes matters more than how much of it there is.** On the same envelope, deaths averted in 2026 range from 5,558 (range 3,758–7,222) to 20,053 (range 13,381–26,299). The differences come mainly from newborn care, hospital care for children and hypertension management. Allocations that fund these in the districts with large shortfalls avert the most.
- **The ranges are wide, and the middle scenarios cannot be separated.** Scenarios A to D overlap within the effectiveness uncertainty. A choice among them should rest on the other criteria in Chapter 11: floors met, equity and absorption. Their differences in deaths averted are too small to decide it.
- **The geography of mortality should shape the geography of money.** The mortality indices show that under-five risk is highest in Karamoja, Bunyoro and West Nile, HIV risk in South Buganda and the mid-north, and malaria risk in Lango, Teso and Acholi. An allocation that ignores these differences, as a per-capita or current-spending rule does, gives up deaths averted for the same money.
- **Better mortality data would sharpen every comparison.** District mortality estimates for neonatal and maternal deaths, an under-five index from DHS 2022 microdata, and a Monte Carlo treatment of uncertainty would all narrow the ranges. The first two depend on survey data the Ministry and UBOS can release. The third is an engine task already specified in the documentation.

CHAPTER 13

13 Budget, MTEF and fiscal space

A plan that cannot be read by a Ministry of Finance is an analysis nobody can act on. This chapter turns the requirement into the documents a finance ministry processes, and sets it beside the budget Uganda actually approves. It answers four questions.

1. What does the health budget look like, and how has it changed since FY2015/16?
2. How does the modelled requirement compare with it, line by line?
3. Is the requirement affordable over the plan horizon, and what does it commit the government to in the outer years of the medium-term expenditure framework (MTEF)?
4. How much of the sector rests on external financing, and on which funders?

This is HM-10, the budget and MTEF module (`docs/12_HM10_BUDGET_MTEF.md`, `src/Budget.jl`). It also reports the cross-checks against independent sources (`src/CrossChecks.jl`).

One principle governs the whole chapter. **The requirement and the budget are different objects.**

- The requirement costs 28 modelled services at their target coverage.
- The budget funds everything the health sector does now. That includes headquarters, specialised institutes, public health programmes, training, regulation and all the services outside the catalogue.

The ratio of the two is therefore a number to read, not a gap to close. Where this chapter sets the requirement against the budget, it does so to show the scale and the structure of the plan, not to claim that the budget is too large or too small.

13.1 The health budget, FY2015/16 to FY2026/27

13.1.1 Source and coverage

The budget series is read directly from the Ministry of Finance, Planning and Economic Development's item-level approved budget files by `scripts/load_budget.py`. The files cover FY2015/16 to FY2026/27, with expenditure for FY2021/22 and the year to date for FY2025/26. They come in six different layouts, and the script has one adapter for each.

What counts as health. The script counts the health votes in full: the Ministry of Health, National Medical Stores, the referral hospitals, the Uganda Cancer Institute, the Uganda Heart Institute, Butabika, the Uganda Blood Transfusion Service, the Uganda AIDS Commission, the Health Service Commission and the Uganda Virus Research Institute. It adds the health lines of the consolidated local-government vote and of KCCA.

Plan years. The plan year is the year in which the financial year ends. FY2025/26 is plan year 2026, which aligns the budget with the plan horizon and with the NDP IV PIAP.

Two features of the source shape the series.

- **Three years are missing.** There are no files for FY2017/18, FY2018/19 or FY2023/24. The growth figures in Table 13.1 are between consecutive *available* years. The 40.0% shown for FY2019/20 therefore spans three years, not one.
- **Vote numbers were reassigned when programme budgeting came in.** Votes 161–180 were hospitals before FY2022/23 and are now bodies such as the National Council of Sports. Votes 501–850 were local

governments and are now embassies. The script therefore takes only stable vote codes by number, and recognises hospitals, local governments and health agencies by name. In FY2022/23 this recognition fails for local-government health: the local-government PHC line reads zero. **The apparent 20.3% fall in FY2022/23 is an artefact of the file, not a cut in health spending.** The wage fund falls from 709 bn to 297 bn that year because the local-government health wage bill is missing. The affordability projection below excludes FY2022/23 for this reason.

13.1.2 Trends

Table 13.1: Approved health budget by fund, FY2015/16-FY2026/27 (bn UGX; years without files omitted)

FY	Wage	Non-wage recurrent	GoU development	External financing	AIA	Arrears	Total	Growth
2015/16	334	416	97	452	18	0	1,317	-
2016/17	382	406	148	903	23	4	1,866	41.8%
2019/20	630	665	192	1,119	0	6	2,613	40.0%
2020/21	658	740	209	1,198	0	8	2,813	7.7%
2021/22	709	984	322	1,343	0	25	3,383	20.3%
2022/23	297	872	170	1,354	0	4	2,696	-20.3%
2024/25	1,245	1,302	307	1,283	0	1	4,138	53.5%
2025/26	1,329	1,391	421	1,371	0	102	4,614	11.5%
2026/27	1,475	1,862	675	1,255	0	4	5,271	14.2%

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_budget_history.csv).

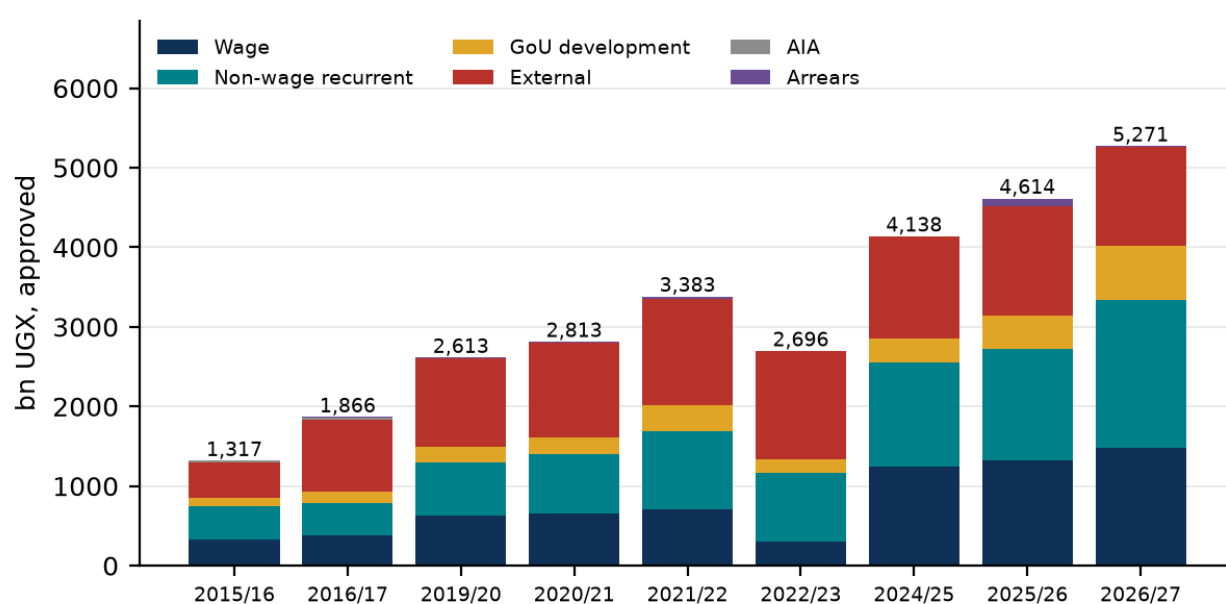


Figure 13.1: Approved health budget by fund, FY2015/16-FY2026/27 (years with budget files)

Source: MoFPED approved budget estimates, item level (scripts/load_budget.py)

Table 13.1 and Figure 13.1 show the approved health budget by fund. The total rose from 1,317 bn UGX in FY2015/16 to 4,614 bn in FY2025/26 and 5,271 bn in FY2026/27, four times its level eleven years earlier. The growth came from every fund, but not evenly.

- **The wage bill** rose from 334 bn to 1,475 bn. It stayed just below external financing through FY2025/26, at 1,329 bn against 1,371 bn. In FY2026/27 it overtakes it, at 1,475 bn against 1,255 bn.
- **Non-wage recurrent spending** rose from 416 bn to 1,862 bn. The largest step came in FY2026/27, up 471 bn in one year.
- **GoU development spending** rose from 97 bn to 675 bn, including a rise of 254 bn in FY2026/27 alone.

- **External financing** rose from 452 bn in FY2015/16 to a peak of 1,371 bn in FY2025/26. It then **falls by 116 bn to 1,255 bn in FY2026/27**, the only fund to decline in the latest year. Its share of the total has fallen from about a third in FY2015/16 to under a quarter in FY2026/27.

The government is financing a growing share of health from its own resources. The fall in external financing in the latest budget is the first sign of the donor transition that the engine documentation calls the largest single fiscal risk in low-income health sectors (\$10.6).

13.1.3 By institution

Table 13.2: Approved health budget by institution (bn UGX)

Institution	FY2025/26	FY2026/27	Share FY2025/26
Ministry of Health	1,632	1,524	35.4%
Local government PHC	1,208	1,268	26.2%
National Medical Stores	718	863	15.6%
Specialised institutes	422	683	9.2%
Regional referral hospitals	265	395	5.7%
National referral hospitals	226	294	4.9%
Agencies and commissions	102	194	2.2%
KCCA health	40	50	0.9%

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_budget_institution.csv).

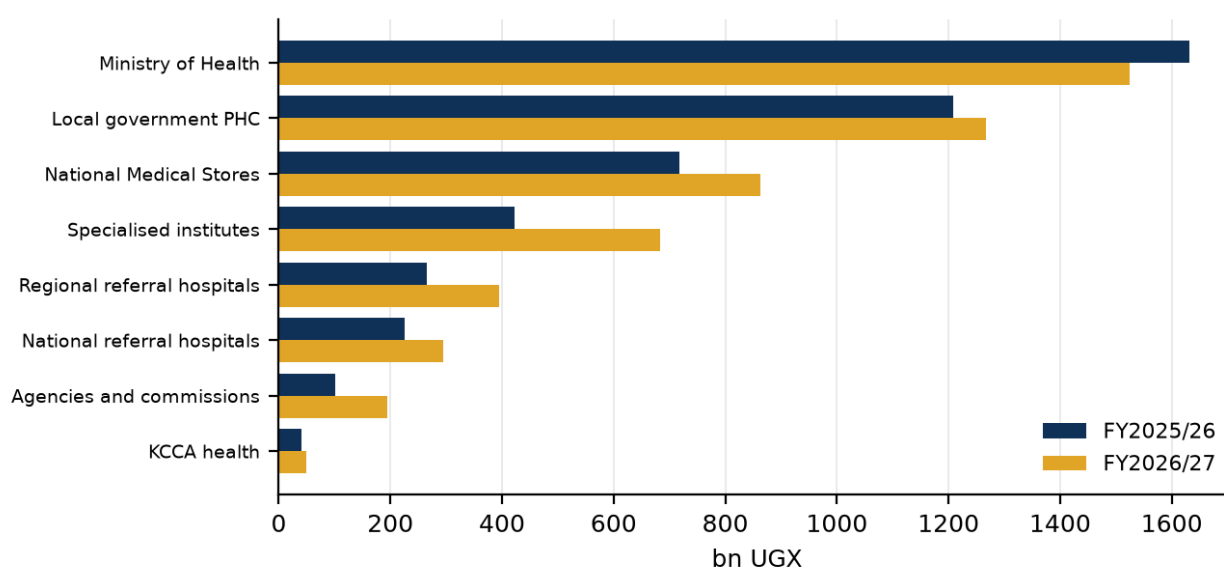


Figure 13.2: Approved health budget by institution, FY2025/26 and FY2026/27

Source: MoFPED approved budget estimates

Table 13.2 and Figure 13.2 show how the budget is spread across institutions.

- **The Ministry of Health headquarters vote** is the largest, with 1,632 bn (35.4%) in FY2025/26.
- **Local-government PHC** follows with 1,208 bn (26.2%).
- **National Medical Stores** has 718 bn (15.6%).
- **The specialised institutes** have 422 bn (9.2%).
- **The regional and national referral hospitals** have 265 bn and 226 bn.

In FY2026/27 the Ministry's vote falls to 1,524 bn. Every other institution grows:

- the specialised institutes by 261 bn, to 683 bn;
- NMS by 145 bn;

- the regional referral hospitals by 130 bn;
- agencies and commissions by 92 bn;
- the national referral hospitals by 68 bn;
- local-government PHC by 60 bn;
- KCCA by 10 bn.

The five institutions that deliver the modelled services are local-government PHC, KCCA, NMS and the regional and national referral hospitals. Together they grow by 413 bn. This is the incremental envelope that Chapter 11 allocates.

13.1.4 By cost class

Table 13.3: Approved FY2025/26 health budget by cost class

Cost class	FY2025/26 (bn UGX)	Share
Staff	1,434	31.1%
Commodities	1,254	27.2%
Operations	900	19.5%
Transfer	456	9.9%
Capital	375	8.1%
Arrears	100	2.2%
Pension	93	2.0%

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_budget_class.csv).

Table 13.3 classifies the FY2025/26 budget by cost class, using the item codes (`cost_class` in `scripts/load_budget.py`):

- staff: 1,434 bn (31.1%);
- commodities: 1,254 bn (27.2%);
- operations: 900 bn (19.5%);
- transfers: 456 bn (9.9%);
- capital: 375 bn (8.1%);
- arrears: 100 bn (2.2%);
- pensions: 93 bn (2.0%).

The staff class (1,434 bn) is wider than the wage fund (1,329 bn). It includes staff-cost items paid from non-wage and external funds as well as the wage bill proper. The commodity class captures medicines, vaccines, laboratory supplies, blood, contraceptives, nets and ARVs wherever they appear, including in transfers.

13.2 Budget execution

Approval is not spending. The engine documentation requires the observed rate of execution to be fed back into planning, both as a basis for absorptive-capacity limits and as a warning on any plan that assumes more (§10.7).

$$\rho_{v,t} = \frac{X_{v,t}}{B_{v,t}} \quad (13.1)$$

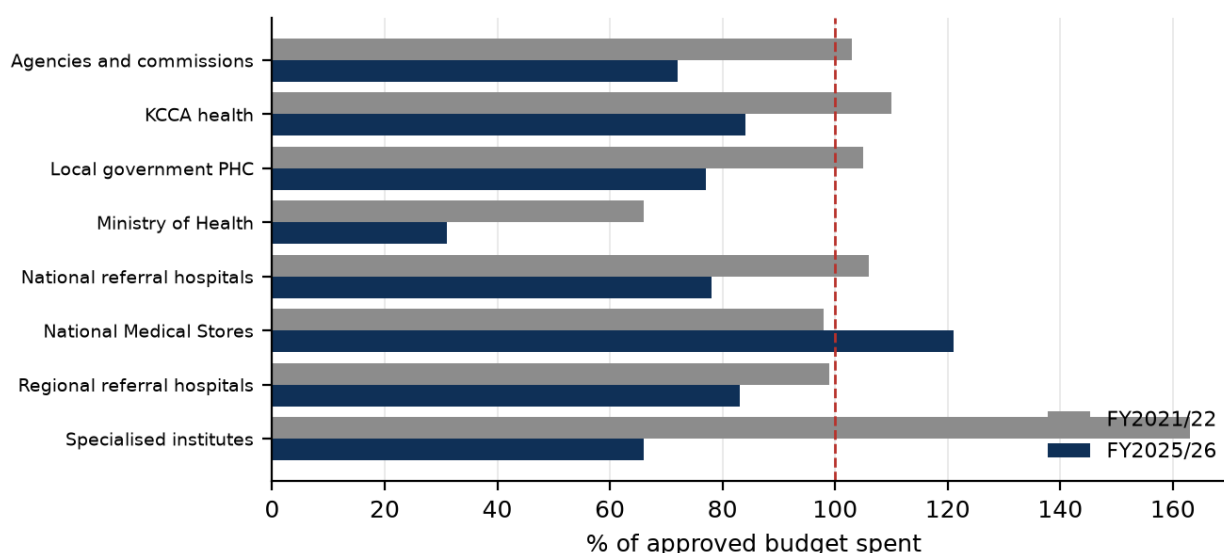
where:

- ρ is the execution rate of institution v in financial year t ;
- X is its expenditure and B its approved budget.

Table 13.4: Budget execution: spent against approved

FY	Institution	Approved (bn)	Spent (bn)	Execution
2021/22	Agencies and commissions	80	83	103%
2021/22	KCCA health	14	15	110%
2021/22	Local government PHC	735	771	105%
2021/22	Ministry of Health	1,532	1,016	66%
2021/22	National referral hospitals	41	44	106%
2021/22	National Medical Stores	600	589	98%
2021/22	Regional referral hospitals	233	230	99%
2021/22	Specialised institutes	147	240	163%
2025/26	Agencies and commissions	102	73	72%
2025/26	KCCA health	40	34	84%
2025/26	Local government PHC	1,208	932	77%
2025/26	Ministry of Health	1,632	500	31%
2025/26	National referral hospitals	226	177	78%
2025/26	National Medical Stores	718	869	121%
2025/26	Regional referral hospitals	265	219	83%
2025/26	Specialised institutes	422	278	66%

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_execution.csv).

**Figure 13.3:** Budget execution by institution (FY2025/26 is the year to date in the quarterly release)

Source: MoFPED approved estimates and expenditure releases

Table 13.4 and Figure 13.3 show execution for the two years with expenditure data.

FY2021/22, a full year. Health as a whole spent 88.3% of its approved budget. The average hides a sharp split.

- The Ministry of Health headquarters vote spent 66%: 1,016 bn of 1,532 bn.
- Almost every other institution spent its full budget or more. Local-government PHC spent 105%, the national referral hospitals 106%, KCCA 110%, NMS 98% and the regional referral hospitals 99%.
- The specialised institutes spent 163% of their approved budget, 240 bn against 147 bn. The approved estimates alone cannot explain an outturn this far above them.

FY2025/26, year to date. The figures come from the quarterly release, so they are not a full-year outturn. Health as a whole has spent 66.8%. The Ministry's vote has spent 31%, 500 bn of 1,632 bn. NMS has already spent 121%, and local-government PHC 77%.

The pattern is consistent across both years. **Service-delivery institutions spend what they are given, while the Ministry's headquarters vote under-spends.** This has two implications for the allocation in Chapter 11.

- Money routed through local governments, NMS and the referral hospitals is likely to be spent.
- The absorption ceiling used in HM-08, which rests on staffing fill rates, is probably loose for these institutions. Budget execution is held only by institution, however, not by district. It cannot yet replace the fill-rate proxy at district level.

13.3 Reconciling the requirement with the budget

The engine sets the 2026 requirement beside the FY2025/26 approved budget, line by line (budget_reconciliation in src/Budget.jl). The plan log labels the result "a ratio to read, not a gap to close".

$$q_k = \frac{C_k^{\text{req}}}{B_k} \quad (13.2)$$

where:

- q is the ratio for budget line k ;
- C^{req} is the requirement mapped to that line;
- B is the approved budget for the same line.

Table 13.5: The 2026 requirement against the FY2025/26 approved health budget (plan log, RECONCILIATION)

Line	Requirement (bn UGX)	Budget (bn UGX)	Ratio
Total health budget	1,966	4,614	0.43
Salaries and wages	827	1,329	0.62
Medicines and supplies	858	1,254	0.68
Capital	158	375	0.42
Primary health care (HC II–IV)	1,376	1,248	1.10
Hospitals (general and referral)	590	913	0.65
Per capita, USD	11.2	26.3	0.43

Table 13.5 reads as follows.

- **Total.** The 28 modelled services at target coverage would cost 43% of the whole approved health budget, or 11.2 USD per person against 26.3 USD.
- **Salaries and medicines.** The requirement's staff time and commodities are about two-thirds of the corresponding budget lines, at 0.62 and 0.68. Both sides include ARVs and vaccines.
- **Capital.** The annualised capital in the requirement is 42% of the capital items in the approved budget.
- **Primary health care is the one line where the ratio exceeds 1.** At the facility levels HC II to HC IV, including the community, the requirement is 1,376 bn. The budgets of local-government PHC and KCCA health together are 1,248 bn. The code's note on this line matters: NMS supply to primary care sits in the NMS vote, not in the local-government line. The ratio of 1.10 therefore overstates the shortfall in primary care. But it confirms that **primary care is where the modelled requirement presses hardest against the budget.** The rest of the health budget, including 35% in the Ministry's headquarters vote, pays largely for things the catalogue does not contain.
- **Hospitals.** The general and referral hospital requirement is 65% of the budgets of the regional, national and specialised hospitals. General hospitals are run by local governments, so part of their cost sits in the PHC line.

13.4 Affordability, 2026–2030

The requirement grows by 56.9% between 2026 and 2030, from 1,966 bn to 3,084 bn, with population growth and rising coverage targets. The question is whether the health envelope grows with it. The engine uses the approved budget where one exists, which is for 2026 and 2027. For later years it grows the last approved year at the compound rate observed across the approved series (affordability in `src/Budget.jl`).

$$g = \left(\frac{B_{y_1}}{B_{y_0}} \right)^{1/(y_1 - y_0)} - 1 \quad (13.3)$$

$$B_y = B_{y_1} (1 + g)^{y - y_1}, \quad y > y_1 \quad (13.4)$$

where:

- B is the approved total health budget;
- y_0 and y_1 are the first and last plan years with a complete approved budget, FY2015/16 and FY2026/27;
- g is the compound growth rate.

A year without local-government PHC, FY2022/23, is treated as incomplete and not used. The rate is 13.4% a year.

Table 13.6: Affordability: the modelled requirement against the health envelope (plan log)

Year	Requirement (bn UGX)	Envelope (bn UGX)	Share	Envelope basis
2026	1,966	4,614	43%	approved
2027	2,220	5,271	42%	approved
2028	2,490	5,979	42%	projected at 13.4%/yr
2029	2,778	6,783	41%	projected at 13.4%/yr
2030	3,084	7,694	40%	projected at 13.4%/yr

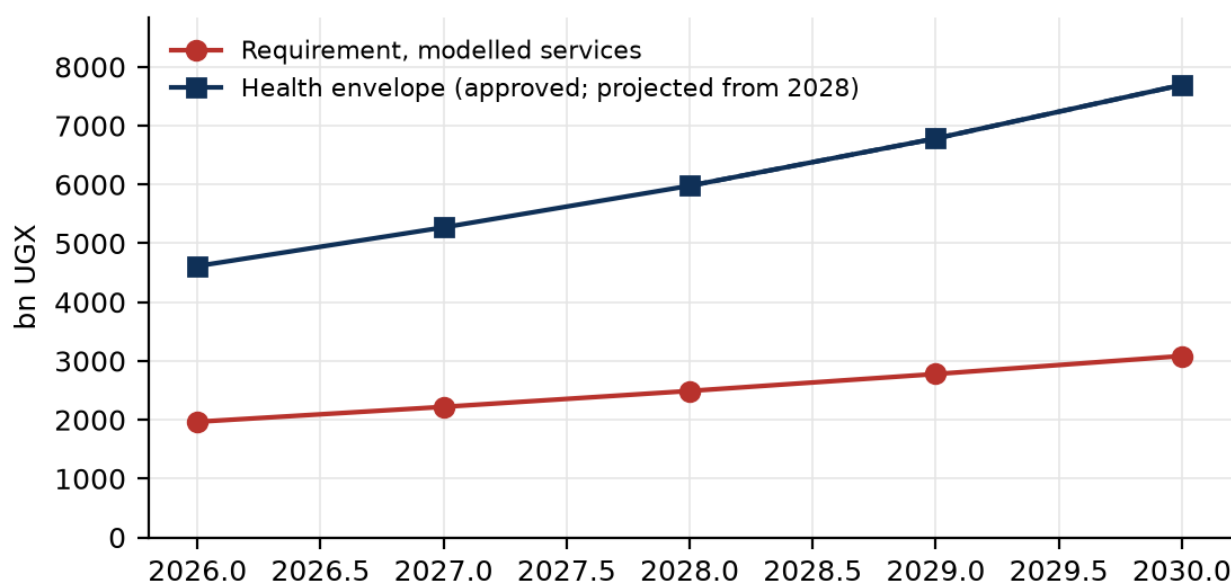


Figure 13.4: Affordability: the modelled requirement against the whole health envelope

Source: HPRAS database, run uga-unconstrained-2026

Table 13.6 and Figure 13.4 show the result. If the health budget keeps growing as it has over the past decade, the modelled services would claim a slowly *falling* share of it: 43% in 2026 and 40% in 2030. The envelope growth of 13.4% a year outpaces the requirement's roughly 12% a year.

Two cautions apply.

- **The projection is nominal, and it is a trend, not a ceiling.** The growth rate is a nominal trend between two endpoints, and it includes inflation. No MTEF ceiling was available: the plan log records the FINEX envelope and the MTEF ceilings as stubs with a fallback in use. The log warns that no figure derived from the fallback may be presented as a FINEX result.
- **The requirement is priced at 2026 prices throughout.** The comparison is therefore favourable to affordability wherever health prices rise.

13.5 The requirement as a budget

13.5.1 Three views that reconcile exactly

HM-10 presents the same computed cost cells in three ways, for three audiences.

- **The programme view** is vote × programme × output, for the Ministry and Parliament.
- **The economic view** is GFS class × line item, for the Treasury and the Accountant General.
- **The administrative view** is vote × district, for local-government transfers.

$$T^{\text{prog}} = T^{\text{econ}} = T^{\text{admin}} = \sum_{d, s, r} C_{d, s, r} \quad (13.5)$$

where:

- C is the cost of resource r for service s in district d;
- each T is the sum of the same cells grouped differently.

The engine asserts the identity rather than leaving it to a spreadsheet. For 2026 all three views total 1,966 bn UGX, and the largest difference between any two is 0.0017 UGX, which is rounding.

In the economic classification, the 2026 requirement divides into three GFS classes:

- use of goods and services (class 22): 982 bn;
- compensation of employees (class 21): 827 bn;
- acquisition of non-financial assets (class 31): 158 bn.

The share of staff costs, 42%, is lower than in the approved budget. This is because the requirement is commodity-heavy. ART, the largest service at 471.5 bn, is dominated by ARVs, which account for 284 bn.

13.5.2 Outputs with their physical deliverables

What turns a programme budget into more than a relabelled line budget is the output indicator. HPRAS can fill it automatically, because it computed the volume. Every one of the 28 outputs carries its 2026 physical target (Table 13.7).

Table 13.7: Budget outputs and their physical indicators, 2026

Output	Name	Indicator	2026 value
OUT-001	Outpatient services delivered	Outpatient attendances	19,287,133
OUT-002	Antenatal care delivered	Antenatal visits provided	5,394,354
OUT-003	Skilled deliveries attended	Deliveries attended by skilled personnel	1,437,148
OUT-004	Emergency obstetric surgery provided	Caesarean sections performed	60,360
OUT-005	Immunisation services delivered	Pentavalent doses administered	3,954,804

Output	Name	Indicator	2026 value
OUT-006	Tuberculosis treatment delivered	TB patients treated	61,994
OUT-007	Malaria case management delivered	Malaria cases diagnosed and treated	10,113,481
OUT-008	Inpatient services delivered	Inpatient bed-days provided	1,808,863
OUT-009	HIV testing services delivered	HIV tests performed	5,987,951
OUT-010	Antiretroviral therapy delivered	Patients retained on ART	1,350,011
OUT-011	PMTCT services delivered	HIV-exposed infants managed	54,408
OUT-012	BCG immunisation delivered	BCG doses administered	1,592,838
OUT-013	Polio immunisation delivered	Polio doses administered	4,565,143
OUT-014	Measles-rubella immunisation delivered	Measles-rubella doses administered	2,004,693
OUT-015	Pneumococcal immunisation delivered	PCV doses administered	3,920,069
OUT-016	Rotavirus immunisation delivered	Rotavirus doses administered	2,315,652
OUT-017	HPV immunisation delivered	HPV doses administered	579,794
OUT-018	Family planning services delivered	Contraceptive user-years provided	2,823,304
OUT-019	Postnatal care delivered	Postnatal contacts after discharge	873,941
OUT-020	Severe acute malnutrition treated	Children treated for SAM	80,687
OUT-021	NCD screening delivered	Adults screened for hypertension and diabetes	1,874,459
OUT-022	Hypertension managed	Patients on hypertension treatment	854,644
OUT-023	Paediatric inpatient care delivered	Paediatric bed-days provided	1,112,001
OUT-024	Sick newborn care delivered	Newborn unit bed-days provided	339,866
OUT-025	Obstetric complications managed	Obstetric complication bed-days provided	256,356
OUT-026	Complicated SAM stabilised	Stabilisation-centre bed-days provided	23,238
OUT-027	Major surgery performed	Major surgical procedures	18,976
OUT-028	Severe mental disorders and epilepsy managed	Patients in care	48,387

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_outputs.csv).

The largest outputs by cost are:

- patients retained on ART: 1.35 million, at 471.5 bn;
- outpatient attendances: 19.3 million, at 228.3 bn;
- deliveries attended by skilled personnel: 1.44 million, at 201.7 bn;
- inpatient bed-days: 1.81 million, at 190.0 bn;
- malaria cases diagnosed and treated: 10.1 million, at 162.1 bn.

A budget submitted in this form tells Parliament what each shilling is meant to buy. It also gives the monitoring system a target to check actual delivery against.

13.6 The MTEF and the outer years

13.6.1 Composition

The MTEF projects the requirement forward and adds the two costs that plans routinely leave out: the recurrent cost induced by new assets, and wage drift (`mtef` in `src/Budget.jl`).

$$T_t = R_t + I_t + W_t + K_t \quad (13.6)$$

$$I_t = \lambda \sum_{\tau < t} \max(K_\tau - K_{\tau-1}, 0) \quad (13.7)$$

$$W_t = w_t [(1 + \delta)^{t-t_0} - 1] \quad (13.8)$$

where:

- T is the MTEF total in year t ;
- R is the recurrent requirement and K the annualised capital requirement;
- I is the induced recurrent cost. It is the share $\lambda = 0.15$ of the cumulative *new* capital, meaning the year-on-year growth in the capital line, commissioned before year t ;
- W is the wage drift: the requirement's wage bill w compounded at the salary drift $\delta = 0.025$ a year from the base year $t_0 = 2026$.

Table 13.8: MTEF projection of the requirement, with induced recurrent cost (bn UGX)

Year	Recurrent	Induced Recurrent	Wage Drift	Capital	Total	Wage Bill	New Capital	Pct Govt Expenditure	Pct Gdp	Wage Share Of Recurrent
2026	1,808.7	0.0	0.0	157.5	1,966.2	826.8	0.0	2.7	0.9	45.7
2027	2,040.6	0.0	23.8	179.3	2,243.7	973.9	21.8	3.1	1.0	47.7
2028	2,287.8	3.3	54.8	202.6	2,548.4	1,136.8	23.2	3.5	1.2	49.7
2029	2,550.9	6.8	94.0	227.3	2,879.0	1,316.9	24.7	3.9	1.3	51.6
2030	2,830.8	10.5	142.5	253.6	3,237.4	1,515.6	26.3	4.4	1.5	53.5

Source: HPRAS database, run `uga-unconstrained-2026 (report/build/data/t_mtef.csv)`.

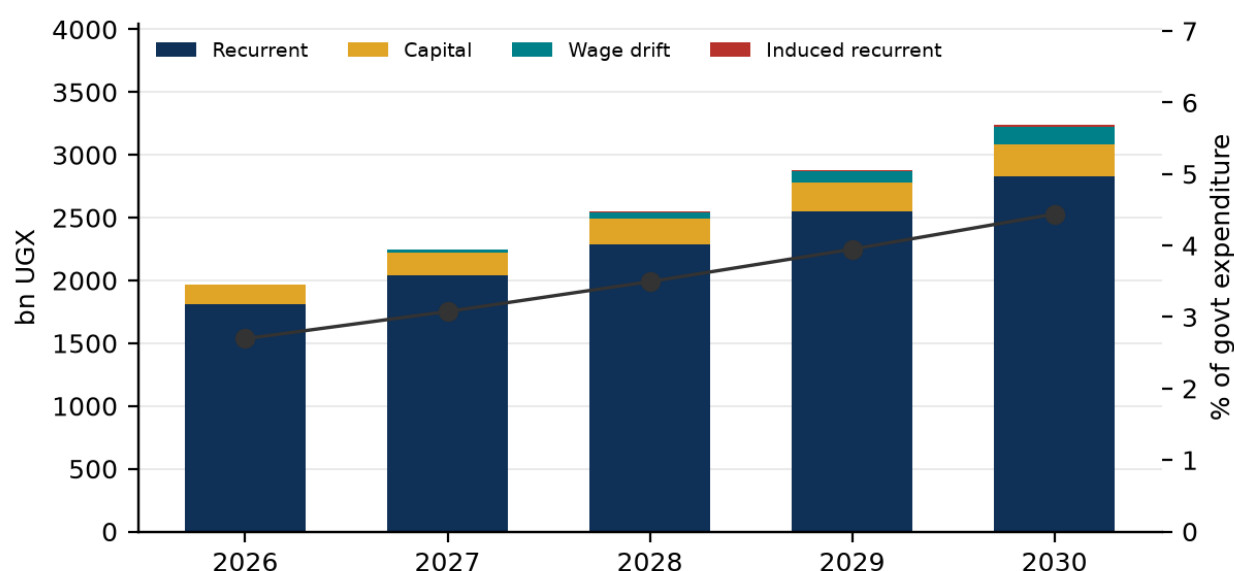


Figure 13.5: MTEF projection of the requirement, 2026-2030, with its share of government expenditure

Source: HPRAS database, run uga-unconstrained-2026

Table 13.8 and Figure 13.5 show the projection.

- **The total rises from 1,966 bn in 2026 to 3,237 bn in 2030.** Recurrent cost rises from 1,809 bn to 2,831 bn.
- **Wage drift adds 142.5 bn by 2030.** This is the difference between the MTEF total and the requirement in the affordability table: 3,237 bn against 3,084 bn in 2030.
- **The wage bill rises from 45.7% of recurrent cost in 2026 to 53.5% in 2030.** This follows from the growing workforce requirement (Chapter 6) and from drift.
- **Measured against government expenditure, the total rises from 2.7% to 4.4%.** Against GDP it rises from 0.9% to 1.5%. Both denominators are held at their 2026 values in the fiscal parameters, 72,900 bn and 220,000 bn UGX. The shares in the outer years therefore overstate the burden, because the economy and the budget will grow too.

Induced recurrent cost reaches 10.5 bn a year by 2030. The run log calls this "the row that should determine approval": at steady state, the plan's capital creates a recurrent obligation of 10 bn UGX a year that outlives the capital programme. The log also carries a caveat. The capital line here is an annualised allocation per service unit, so induced recurrent cost is derived from its year-on-year growth, 21.8 to 26.3 bn a year. A real figure needs the HM-07 investment programme, which lists what is actually built. Chapter 10 sets out that programme with its own induced recurrent cost. Until the two are joined, the 10 bn figure should be read as a lower bound.

13.6.2 Fiscal cross-checks

The engine applies a set of cross-checks last, never as a method (`fiscal_crosschecks`). A check that fails is a prompt to examine the norms, not a reason to override the result.

Table 13.9: Fiscal cross-checks on the 2026 requirement (plan log)

Check	Value	Expected range	Verdict
Wage bill share of recurrent	45.7%	45.0–70.0%	within range
PHC share of total (by service tier)	79.4%	35.0–60.0%	ABOVE
HC II–IV share (by facility level)	70.0%	35.0–60.0%	ABOVE
Health as % of government expenditure	2.7%	0.0–20.0%	within range
Per-capita cost	11.2 USD	5.0–80.0 USD	within range

Three checks pass. The **PHC share is above the expected range** on both measures in Table 13.9: 79.4% when services are classed by tier, and 70.0% when their cost is apportioned to the facility levels where they are delivered. The second measure exists because a tier label can mislead. ART is a "primary" service, yet the code notes that a quarter of it is delivered in hospitals.

The finding is a property of the catalogue, not of Uganda's health system. Of the 28 modelled services, 21 are primary tier. The catalogue omits most of what hospitals and national institutions spend money on: specialist care, most surgery, cancer, cardiac care, diagnostics beyond the tracer set, and training. A requirement built only from these services will always look primary-heavy against a benchmark drawn from whole-sector budgets. The check is therefore a reminder of scope. It is not evidence that the plan under-provides for hospitals.

13.7 External financing

13.7.1 By funder

Table 13.10: External health financing by funder, FY2026/27

Financier	Type	Instrument	bn UGX	Projects
The Global Fund	MULTILATERAL	GRANT	835	1
UNKNOWN	UNKNOWN	UNKNOWN	241	5
GAVI Alliance	MULTILATERAL	GRANT	165	1

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_external_funders.csv).

Table 13.10 shows external financing in the FY2026/27 fiscal extract vendored from HealthModelling:

- The Global Fund: 835 bn UGX, one project;
- GAVI: 165 bn, one project;
- five projects with no funder recorded in the extract: 241 bn.

The engine sets each funder beside the requirement lines it mainly pays for (external_finance_check).

Table 13.11: External financing against the requirement lines each funder mainly pays for (plan log)

Comparison	Requirement (bn UGX)	External (bn UGX)	Share of requirement
Global Fund vs ARVs	284	835	294%
Global Fund vs HIV, TB and malaria medicines	358	835	233%
GAVI vs vaccines	80	165	205%
Unattributed external projects	–	241	–
All external financing vs total requirement	1,966	1,241	63%

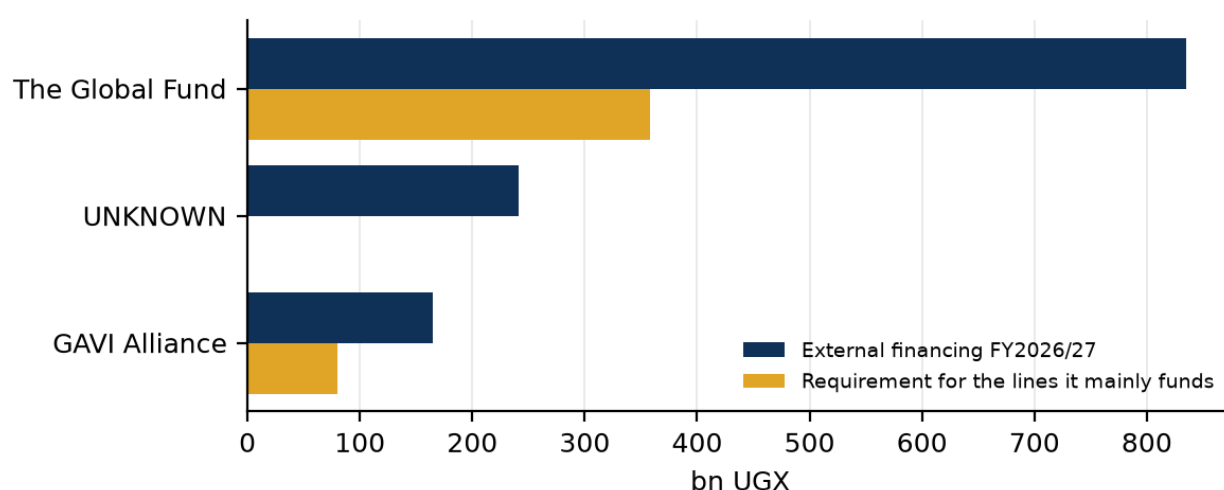


Figure 13.6: External financing by funder against the requirement lines each mainly funds

Source: HealthModelling fiscal extract (vendered); HPRAS requirement

The shares in Table 13.11 and Figure 13.6 are not measures of over-funding.

- **The Global Fund grant** buys much more than the medicines in the catalogue: nets, diagnostics, TB and malaria programme costs and health-system support. The share of 2.3 to 2.9 times the medicine requirement shows how much of the HIV, TB and malaria response depends on one funder, not how much of it is surplus.
- **GAVI money** includes health-system strengthening, campaigns and cold chain as well as vaccine co-financing.

Two readings follow.

- **Concentration.** Two multilateral funders provide 1,000 bn UGX, 81% of the 1,241 bn of external health financing in the extract. The medicines and vaccines they cover are among the most effective interventions in the catalogue (Chapter 12). A shortfall in either grant would fall directly on the lines where deaths averted per unit are highest.
- **Scale.** All external financing together equals 63% of the modelled requirement. It fell by 116 bn in FY2026/27. The documentation asks the MTEF to show the domestic requirement rising as external financing declines (§10.6). That transition path is not yet implemented. It is the most important fiscal extension this module needs.

The comparison sets FY2026/27 external money against the 2026 requirement, one year earlier. The two are close enough for the shares to be read as orders of magnitude, not exact ratios.

13.7.2 An independent check on the budget total

The engine's own reading of the FY2026/27 budget files can be compared with the fiscal extract of the same year produced independently by HealthModelling (`fiscal_total_check`).

Table 13.12: Two independent parses of the FY2026/27 approved health budget (plan log)

Item	Engine (bn UGX)	HealthModelling (bn UGX)	Difference
Approved total	5,271	5,242	+0.5%
Wage	1,475	1,486	-0.7%
External	1,255	1,241	+1.1%
Domestic	4,016	4,002	+0.4%

The two parses in Table 13.12 agree to within about 1% on every line. They differ only in which items each one's health mask includes. This is the strongest evidence available that the budget series in this chapter is read correctly.

Table 13.13: FY2026/27 health fiscal extract (HealthModelling, vendored)

Metric	Value
approved total	5,242 bn
recurrent	3,332 bn
development	1,910 bn
wage	1,486 bn
external	1,241 bn
domestic	4,002 bn
new capital	420 bn
equipment	125 bn
share of national budget	6.21%

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_fiscal_summary.csv).

Table 13.14: FY2026/27 health envelope by sub-sector

Sub-sector	Recurrent (bn)	Development (bn)	Total (bn)	Lines
Primary Health	3,265	250	3,515	3608
Public Health	26	1,038	1,064	156
Hospital Services	0	310	310	128
Specialized Services	0	301	301	42
Pharmaceuticals	41	0	41	3
Health Workforce	0	8	8	8
Health Regulation	0	3	3	4

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_fiscal_envelope.csv).

The HealthModelling extract adds detail the engine does not hold.

- **Table 13.13.** Of the 5,242 bn total, 3,332 bn is recurrent and 1,910 bn development. New capital is 420 bn and equipment 125 bn. Health is 6.21% of the national budget.
- **Table 13.14.** By sub-sector, primary health accounts for 3,515 bn across 3,608 budget lines, most of the total. Public health follows with 1,064 bn, almost all of it development spending, then hospital services with 310 bn and specialised services with 301 bn.

The sub-sector labels are the extract's own. They do not match the engine's institution classes, so the two tables should not be combined.

13.8 The NDP IV PIAP: an indicative comparison

The National Planning Authority costs the NDP IV Human Capital Development programme in its Programme Implementation Action Plan (PIAP). Every strategic intervention has a block of actions with a budget for FY2025/26 to FY2029/30, closed by a sub-total. The PIAP is published as a PDF whose tables are images. The engine reads it by OCR, fitting a fixed column grid to the ruling lines of each page (`scripts/parse_piap.py`).

The parser checks every sub-total against the sum of the actions read above it. A year that differs only by a decimal point lost in one action is repaired and flagged. Anything else is left as read and reported. Nothing is silently corrected.

The check exposes how uncertain the extraction is. **Across the whole Human Capital Development PIAP, 18 of 106 sub-totals verify.** For the health interventions (objective 3.1.1: health promotion, communicable and non-

communicable disease, maternal and child health, and curative care), 2 of 21 sub-totals verify. On the figures as read (`raw_piap_interventions.csv`), these interventions cost:

- 3,785 bn UGX in FY2025/26;
- 4,227 bn in FY2026/27;
- 4,196 bn in FY2027/28;
- 4,097 bn in FY2028/29;
- 4,469 bn in FY2029/30.

Adding health research, disability-friendly services and population planning (objective 3.1.7) raises these to between 3,849 and 4,491 bn a year.

These figures are of the same order as the approved health budget, 4,614 bn in FY2025/26. They are about twice the modelled requirement. But with nine in ten of their sub-totals unverified, they are **indicative only**. They should not be used as a planning ceiling or as evidence of a gap until the PIAP tables are available in machine-readable form.

13.9 The geography of the requirement budget

The national budget holds local government as one vote, so the approved budget cannot be mapped by district. The two HM-10 maps therefore show the requirement's own budget structure.

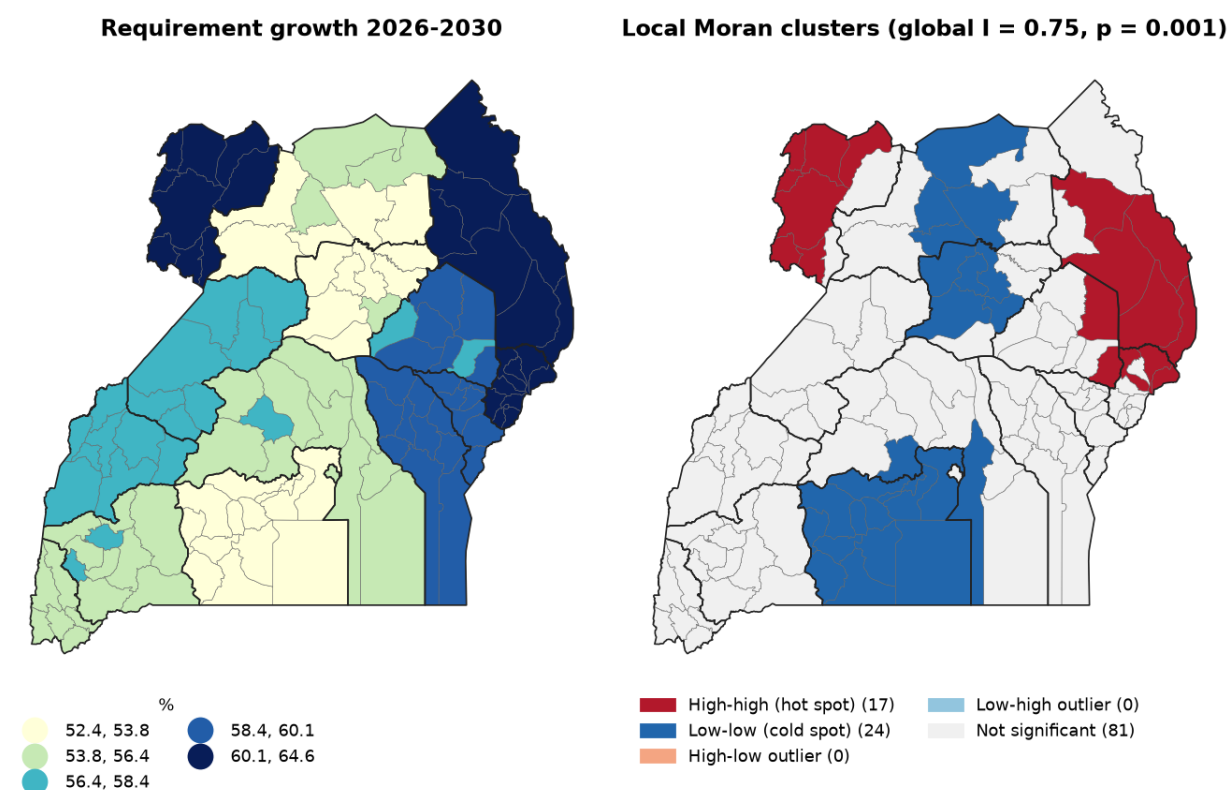


Figure 13.7: HM-10 - Requirement growth 2026-2030 (%), by district, 2026; right: local Moran (LISA) clusters, 999 permutations

Source: HPRAS database, run `uga-unconstrained-2026`; quality tier derived. Boundaries (c) OpenStreetMap contributors (ODbL).

Requirement growth, 2026–2030 (Figure 13.7; Moran's $I = 0.75$, 17 hot and 24 cold districts). The growth of each district's requirement over the plan period runs from 52.4% to 64.6%, around a national figure of 56.9%. The clustering is among the strongest of any layer in the atlas.

- **The hot spot** covers all of Karamoja (Kotido, Napak, Moroto, Abim and Kaabong at about 64.5%) and most of West Nile, with Bulambuli, Bukwo and Kween in Bugisu and Katakwi and Bukedea in Teso.

- **The cold spot** covers South Buganda (Masaka, Rakai, Lwengo, Sembabule and Wakiso at 52.4%) with Acholi, Lango and parts of North Buganda.

The values are nearly identical within sub-regions. This shows that the pattern is driven by sub-regional parameters, such as the age structure, fertility and survey coverage baselines of HM-01 and HM-02, not by district data. It also has a direct budget reading. **The requirement grows fastest in Karamoja**, whose birth rate (48.2 per 1,000) is well above the district median (41.0), and in West Nile. An MTEF that shares out growth in proportion to current spending would fall steadily further behind need in Karamoja and West Nile.

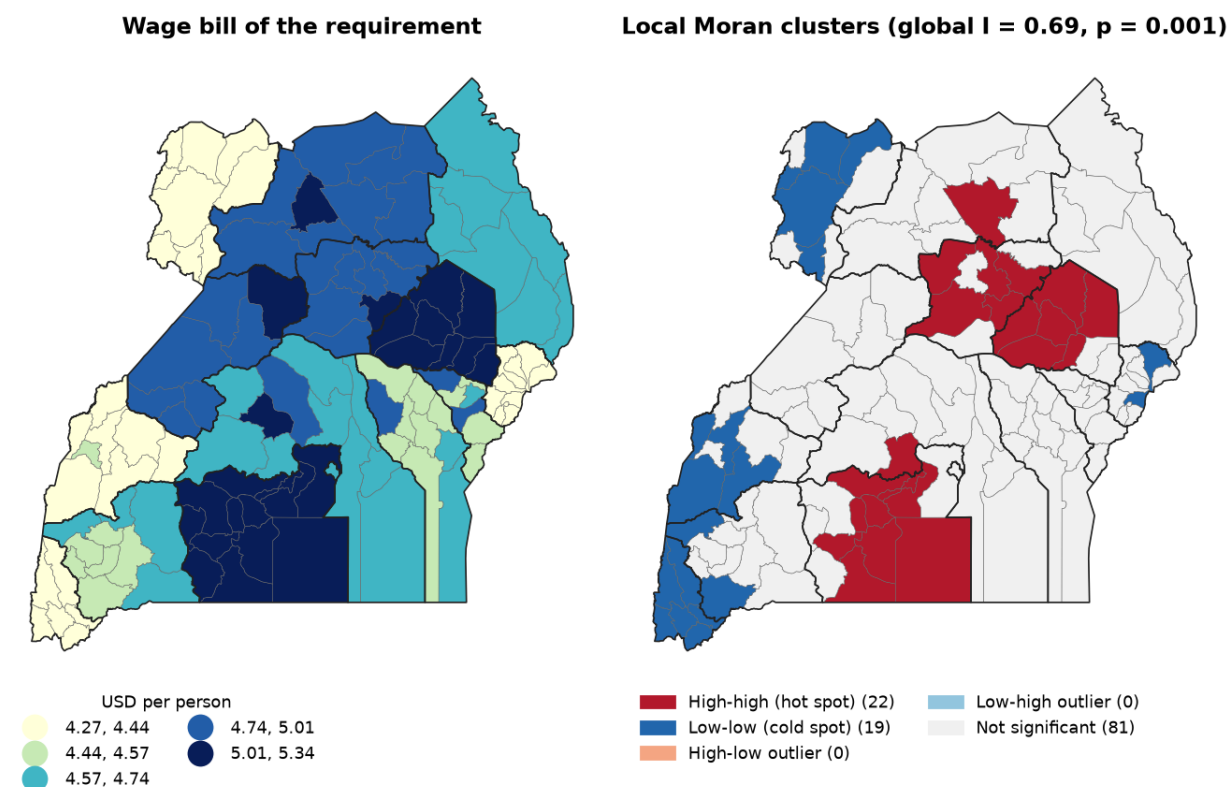


Figure 13.8: HM-10 - Wage bill of the requirement (USD per person), by district, 2026; right: local Moran (LISA) clusters, 999 permutations

Source: HPRAS database, run uga-unconstrained-2026; quality tier derived. Boundaries (c) OpenStreetMap contributors (ODbL).

Wage bill of the requirement per person (Figure 13.8; $I = 0.69$, 22 hot and 19 cold districts). The staff cost of delivering the requirement runs from 4.27 USD per person in Kigezi (Rubanda, Kabale, Rukungiri, Kanungu, Kisoro) to 5.34 USD in Serere. The median is 4.63 USD.

- **The hot spot** covers Teso (Serere, Amuria, Soroti, Ngora, Katakwi, Kaberamaido), Lango (Dokolo, Alebtong, Apac, Lira, Oyam) and South Buganda.
- **The cold spot** covers Kigezi, West Nile, Tooro, western Ankole and parts of Bugisu.

The pattern follows the two largest workload drivers in the catalogue. Malaria case management is heaviest in Lango and Teso, which have the highest malaria index. ART is heaviest in South Buganda and the mid-north, which have the highest HIV prevalence. Kigezi sits at the bottom on both. Even so, the per-person wage requirement varies by only a quarter from lowest to highest.

13.10 Data quality and limitations

1. **Budget data are measured, but incomplete.** Three financial years have no files. FY2022/23 lacks local-government health. Expenditure is held for only one full year and one part-year. The series is otherwise a direct read of the approved estimates, and an independent parse agrees within 1.1% on every line checked.

2. **The budget is national.** Local-government health is one vote, so neither the approved budget nor its execution can be set against district requirements. District-level comparison needs the local-government budget files.
3. **The requirement is partial.** It covers 28 modelled services. Every ratio against the budget must be read with that in mind, and the PHC-share cross-check fails for this reason.
4. **The MTEF is a placeholder in two respects.** Induced recurrent cost is derived from the growth of an annualised capital line, not from the HM-07 investment programme. The shares of government expenditure and GDP use denominators fixed at 2026. No MTEF ceiling or FINEX envelope was available, and the fallback is labelled as such.
5. **The external financing shares compare adjacent years** (FY2026/27 money against the 2026 requirement). 241 bn of external money has no recorded funder.
6. **The PIAP figures are indicative.** Only 18 of 106 sub-totals verify.

13.11 Implications for planning

- **The modelled requirement fits within the health budget's recent growth.** If approved health budgets keep growing at the 13.4% a year observed since FY2015/16, the 28 modelled services would claim a falling share of the envelope, from 43% in 2026 to 40% in 2030. The binding question is not the total. It is whether the growth reaches the institutions and districts that deliver the services.
- **Primary care is where the requirement presses hardest.** It is the only line where the requirement exceeds the corresponding budget (ratio 1.10). The fall of the Ministry's headquarters vote in FY2026/27, set against increases in local-government PHC, NMS and the referral hospitals, moves in the direction the plan requires. The 60 bn increase for local-government PHC is the smallest among the service-delivery institutions after KCCA.
- **Execution matters as much as allocation.** Service-delivery institutions spend what they are given. The headquarters vote spent 66% in FY2021/22 and 31% by the time of the FY2025/26 quarterly release. Routing increases through institutions with high execution rates would raise what the health budget buys, before any change in its size.
- **Plan now for donor transition.** Two funders provide 81% of external health financing, and external money fell by 116 bn in FY2026/27. The MTEF should carry an explicit transition path for the Global Fund and GAVI lines, showing the domestic requirement that would replace them. The engine documentation specifies such a path. It is the next priority for this module.
- **Approve capital with its recurrent tail.** The MTEF adds 10 bn a year of induced recurrent cost by 2030 on the requirement's own capital line, and wage drift of 142.5 bn. Chapter 10's investment programme should be costed through the same MTEF before it is approved, so that its recurrent obligation is visible in the year it is decided.

CHAPTER 14

14 Equity: wealth, residence and geography

This chapter asks who the health system reaches and who it leaves behind. Everything earlier in the report is organised by district: population, need, demand, capacity, gaps, costs and allocations. District averages hide two other divisions that matter to Uganda's commitment to universal health coverage. The first is household wealth: whether a mother in the poorest fifth of households is as likely to deliver in a facility, or her child to be protected from stunting, as a mother in the richest fifth. The second is where people live: urban or rural, near a facility or far from one, in a district whose supply matches its need or in one whose supply does not.

Equity is treated here as a cross-cutting lens, not as a module of its own. It draws on four sources that the engine already computes:

- survey-weighted breakdowns by wealth quintile and residence, computed directly from the Uganda DHS 2016 microdata;
- a concentration index of supply against need across the 122 districts;
- the equity metrics recorded for each allocation scenario of HM-08;
- physical access to a facility, read from the SDI travel-time layer.

These are four separate views. They are not combined into an equity score, for the same reason that the four gap dimensions of HM-05 are never combined (principle P3): a district that is poor, remote and under-staffed faces three different problems, and a planner acts on each with a different instrument.

14.1 What equity means in a planning engine

A normative planning engine computes what each district needs at target coverage. It does not, by itself, say anything about the distribution of health within a district. The DHS, by contrast, observes individual women and children, and can be tabulated by any household characteristic. Bringing the two together answers two questions that the requirement alone cannot:

1. **Is coverage today distributed fairly within the population?** If the richer are better served, the gap between current coverage and target is concentrated among the poor. Closing it requires reaching people who do not come to facilities now, which is costlier per contact than serving people who already come.
2. **Is supply distributed where need is?** If health workers and facilities are concentrated where need is low, an allocation formula that follows need has to push resources against the grain of the existing establishment.

The first is answered with survey data; the second with the engine's own district results. The chapter takes them in turn.

14.2 Wealth and residence from the DHS microdata

14.2.1 How the breakdowns are computed

`scripts/load_dhs.py` reads the Uganda DHS 2016 recode files one at a time, computes survey-weighted aggregates, and deletes each extracted file in a `finally` block, so that no microdata is ever written into the repository. For nine indicators it computes a national estimate, one estimate for each of the five household wealth quintiles (DHS variable `v190`), and one each for urban and rural residence (`v025`). The weighted mean of an indicator in a group `g` is

$$\hat{p}_g = \frac{\sum_{k \in g} v_k y_k}{\sum_{k \in g} v_k} \quad (14.1)$$

where:

- y_k is the 0/1 outcome for woman or child k (for example, four or more antenatal visits);
- v_k is the DHS sample weight ($v005$, divided by one million);
- g is the group: the whole country, one wealth quintile, or urban or rural residence.

Missing and "don't know" codes are excluded from both numerator and denominator. The denominators follow the published DHS definitions: DPT3 and measles among children aged 12–23 months; antenatal care, facility delivery and postnatal care for the most recent birth in the five years before the survey; modern contraception among currently married women; stunting (height-for-age below –2 SD), wasting (weight-for-height below –2 SD) and severe wasting (below –3 SD) among children under five with a plausible measurement.

Two safeguards govern what is stored. First, any cell with fewer than **25** unweighted cases is not stored. This is the disclosure threshold HealthModelling applies to its own exports, and a test asserts that no stored cell falls below it. Second, the breakdowns live in a table of their own, `dhs_equity`, which the sub-regional need calculations never read. The equity breakdowns describe the population; they do not feed the requirement.

14.2.2 Reproducing HealthModelling's export

HealthModelling, the AICTEM survey-estimation system, publishes its own equity breakdowns from the same survey. They serve as an independent check on the loader. For four indicators the definitions are identical, and the engine reproduces HealthModelling's estimates to within 1e-6 with identical unweighted case counts in every cell (Table 14.1). The 32 cells are national, five wealth quintiles, urban and rural, for each of ANC4, modern contraception, stunting and wasting.

Table 14.1: Equity estimates reproduced against HealthModelling's export

Indicator	Dimension	Level	This engine	HealthModelling	n (engine)	n (reference)
ANC4+	national	all	60.22%	60.22%	10219	10219
ANC4+	residence	rural	58.48%	58.48%	8195	8195
ANC4+	residence	urban	66.08%	66.08%	2024	2024
ANC4+	wealth_q	1	53.91%	53.91%	2534	2534
ANC4+	wealth_q	2	57.42%	57.42%	2197	2197
ANC4+	wealth_q	3	59.29%	59.29%	1938	1938
ANC4+	wealth_q	4	63.12%	63.12%	1763	1763
ANC4+	wealth_q	5	67.49%	67.49%	1787	1787
Modern contraception (married)	national	all	34.76%	34.76%	11379	11379
Modern contraception (married)	residence	rural	32.97%	32.97%	9108	9108
Modern contraception (married)	residence	urban	40.56%	40.56%	2271	2271
Modern contraception (married)	wealth_q	1	22.42%	22.42%	2615	2615
Modern contraception (married)	wealth_q	2	32.19%	32.19%	2396	2396
Modern contraception (married)	wealth_q	3	35.81%	35.81%	2223	2223
Modern contraception (married)	wealth_q	4	40.20%	40.20%	2077	2077
Modern contraception (married)	wealth_q	5	42.11%	42.11%	2068	2068
Stunting (<5)	national	all	28.16%	28.16%	4423	4423
Stunting (<5)	residence	rural	29.63%	29.63%	3683	3683
Stunting (<5)	residence	urban	22.39%	22.39%	740	740
Stunting (<5)	wealth_q	1	32.51%	32.51%	1187	1187
Stunting (<5)	wealth_q	2	32.31%	32.31%	936	936
Stunting (<5)	wealth_q	3	31.59%	31.59%	868	868
Stunting (<5)	wealth_q	4	26.56%	26.56%	768	768
Stunting (<5)	wealth_q	5	16.63%	16.63%	664	664

Indicator	Dimension	Level	This engine	HealthModelling	n (engine)	n (reference)
Wasting (<5)	national	all	3.76%	3.76%	4413	4413
Wasting (<5)	residence	rural	3.96%	3.96%	3673	3673
Wasting (<5)	residence	urban	2.97%	2.97%	740	740
Wasting (<5)	wealth_q	1	5.98%	5.98%	1188	1188
Wasting (<5)	wealth_q	2	4.23%	4.23%	933	933
Wasting (<5)	wealth_q	3	3.43%	3.43%	863	863
Wasting (<5)	wealth_q	4	2.20%	2.20%	768	768
Wasting (<5)	wealth_q	5	2.43%	2.43%	661	661

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_equality_validation.csv).

Facility delivery is the exception, and the difference is one of definition rather than error. This engine counts the **most recent birth** of each woman in the five years before the survey, the denominator the planning engine needs, because the coverage baseline for PHC.DEL.NORMAL is a share of births. HealthModelling counts **all births** in the five years. The two measure different things: a woman with several recent births contributes each of them under the second definition, so the two denominators weight women differently. The effect is visible in the national figures used in this report. The engine's microdata estimate for the most recent birth is 76.3%; the DHS trend round for 2016 on the all-births definition, used in Chapter 16, is 73.4%.

The reproduction matters for more than bookkeeping. It shows that the loader handles weights, missing codes, denominators and the disclosure rule exactly as an independent implementation does. Two denominator errors were found and fixed in the loader during development: immunisation over all under-fives rather than children aged 12–23 months, and women with no recent birth counted as "no ANC4". Both are now pinned by tests against the published DHS 2016 figures.

14.2.3 The concentration index over quintiles

The standard summary of a wealth gradient is the concentration index. For grouped data with five equal-sized quintiles, the engine computes

$$C = \frac{2}{\mu} \sum_{i=1}^5 w_i x_i R_i - 1 \quad (14.2)$$

$$\mu = \sum_{i=1}^5 w_i x_i, \quad w_i = 0.2, \quad R_i \in \{0.1, 0.3, 0.5, 0.7, 0.9\} \quad (14.3)$$

where:

- i indexes the wealth quintiles, from the poorest ($i = 1$) to the richest ($i = 5$);
- x_i is the indicator's value in quintile i ;
- w_i is the population share of quintile i , one fifth by construction;
- R_i is the fractional rank of quintile i , the midpoint of its position on the cumulative population distribution;
- μ is the mean of the indicator over the quintiles.

The index lies between -1 and $+1$. It is zero when every quintile has the same value. A test pins three known answers: equal values give 0; an indicator present only in the richest quintile gives $+0.8$; one present only in the poorest gives -0.8 . The bound is ± 0.8 rather than ± 1 because the grouped form treats each quintile as a block, so it slightly understates the individual-level index. The engine uses the index for its sign and for ordering indicators, not as a precise magnitude.

The **reading depends on the kind of indicator**:

- For a **coverage** indicator (a good thing, such as a facility delivery), a positive index means the richer are better served. That is an inequity.
- For a **burden** indicator (a bad thing, such as stunting), a negative index means the poorer carry more of the burden. That is also an inequity.

A positive index for coverage and a negative index for burden therefore point the same way: towards disadvantage among the poor. The engine attaches a plain reading to each indicator, using a band of ± 0.02 around zero for "little wealth gradient".

14.2.4 Results

Figure 14.1 and Table 14.2 set out the nine indicators.

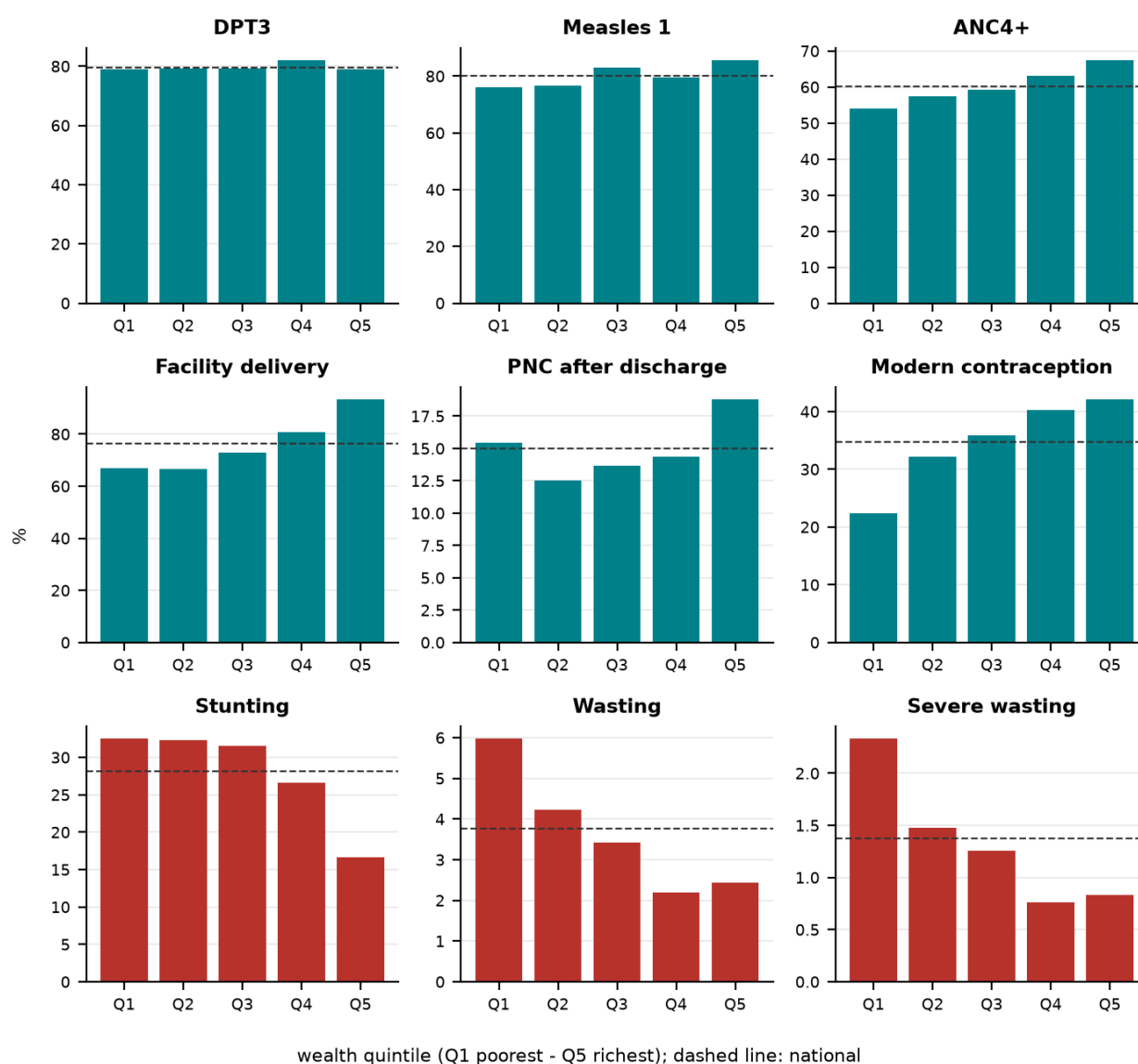


Figure 14.1: Coverage (teal) and malnutrition (red) by household wealth quintile

Source: Uganda DHS 2016 microdata, survey-weighted (scripts/load_dhs.py)

Table 14.2: Coverage and nutrition by household wealth and residence, Uganda DHS 2016 (computed from the microdata)

Indicator	National	Poorest	Q2	Q3	Q4	Richest	Urban	Rural	Richest/poorest	Conc. index
ANC4+	60.2%	53.9%	57.4%	59.3%	63.1%	67.5%	66.1%	58.5%	1.25	+0.044
DPT3, 12-23 months	79.7%	78.9%	79.3%	79.3%	82.1%	79.0%	78.0%	80.2%	1.00	+0.003
Facility delivery (last birth)	76.3%	67.0%	66.7%	73.0%	80.6%	93.4%	89.4%	72.3%	1.39	+0.070
Measles 1, 12-23 months	80.2%	76.1%	76.6%	83.2%	79.6%	85.7%	84.2%	78.9%	1.13	+0.022
PNC after discharge	15.0%	15.4%	12.5%	13.6%	14.4%	18.8%	17.2%	14.4%	1.22	+0.046

Indicator	National	Poorest	Q2	Q3	Q4	Richest	Urban	Rural	Richest/poorest	Conc. index
Modern contraception (married)	34.8%	22.4%	32.2%	35.8%	40.2%	42.1%	40.6%	33.0%	1.88	+0.110
Severe wasting (<5)	1.4%	2.3%	1.5%	1.3%	0.8%	0.8%	1.0%	1.5%	0.36	-0.223
Stunting (<5)	28.2%	32.5%	32.3%	31.6%	26.6%	16.6%	22.4%	29.6%	0.51	-0.107
Wasting (<5)	3.8%	6.0%	4.2%	3.4%	2.2%	2.4%	3.0%	4.0%	0.41	-0.200

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_equity_wealth.csv).

Every coverage indicator favours the richer, but by very different amounts. The index ranges from +0.003 for DPT3 to +0.110 for modern contraception.

- **Modern contraception** has the steepest gradient. Among married women, 22.4% in the poorest quintile use a modern method, against 42.1% in the richest, a ratio of 1.88. The step from the poorest to the second quintile, to 32.2%, is the largest single step in the table. It suggests that the barrier is concentrated among the very poorest households rather than spread evenly along the wealth distribution.
- **Facility delivery** rises from 67.0% in the poorest quintile to 93.4% in the richest (index +0.070). The gradient is not smooth: the two poorest quintiles are almost identical (67.0% and 66.7%), and the jump comes in the upper three, with the richest quintile 12.8 points above the fourth. Residence tells a similar story: 89.4% of urban births against 72.3% of rural births. The richest quintile is largely urban, so wealth and residence overlap here.
- **ANC4** runs from 53.9% to 67.5% (index +0.044, ratio 1.25), a smooth and moderate gradient. Urban women (66.1%) are more likely than rural women (58.5%) to complete four visits.
- **Measles first dose** runs from 76.1% to 85.7% (index +0.022), with an irregular profile: the third quintile (83.2%) is above the fourth (79.6%).
- **Postnatal care after discharge** is low in every group, between 12.5% and 18.8%. Its gradient (+0.046) comes mostly from the richest quintile. The poorest quintile (15.4%) is actually above the second, third and fourth. The indicator is uniformly low: it is a system-wide failure more than an equity failure.
- **DPT3** shows essentially no wealth gradient. Coverage lies between 78.9% and 82.1% in every quintile, and the richest quintile (79.0%) is no better served than the poorest (78.9%). Rural children (80.2%) are slightly more likely to be covered than urban children (78.0%). Uganda's routine immunisation programme reaches the poor about as well as the rich. It is the clearest evidence in the table that a wealth gradient is not inevitable.

Every burden indicator is concentrated among the poorer.

- **Stunting** affects 32.5% of children in the poorest quintile and 16.6% in the richest (index -0.107). The first three quintiles are almost identical (32.5%, 32.3%, 31.6%). The fall comes only in the fourth (26.6%) and, sharply, in the richest (16.6%). Stunting is a problem of the majority, not a problem of the poorest fifth. Rural children (29.6%) are more often stunted than urban children (22.4%).
- **Wasting** falls from 6.0% in the poorest quintile to 2.2–2.4% in the two richest (index -0.200).
- **Severe wasting**, the prevalence behind the SAM need in HM-02, is 2.3% in the poorest quintile and 0.8% in the two richest (index -0.223, the most concentrated of the nine indicators). The poorest children are almost three times as likely to be severely wasted as the richest.

The indices for the burden indicators are larger in magnitude than those for coverage. That is partly arithmetic: an indicator with a low mean, such as severe wasting at 1.4% nationally, has a larger index for the same absolute gap between quintiles, because the index is relative to μ . The richest-to-poorest ratio makes the same point in plain terms: 0.36 for severe wasting, 0.41 for wasting and 0.51 for stunting.

14.2.5 What the gradients mean for the requirement

The requirement in HM-03 is built from district need and national coverage targets. It carries no wealth dimension. The gradients above therefore describe **who is in the gap**, not how large the gap is. Three consequences follow for planners.

First, where coverage is concentrated among the richer, the people not yet reached are disproportionately poor and rural. Facility delivery is the clearest case. Raising coverage towards the target means reaching women in the lower quintiles. In the poorest quintile, 33.0% of most recent births took place outside a facility, five times the 6.6% in the richest. The unit cost in the engine is the cost of a delivery once the woman is in the facility; it does not include the demand-side costs of bringing her there, such as transport, vouchers or maternity waiting homes. Those costs sit outside the modelled catalogue.

Second, the burden gradients mean that need for nutrition services is concentrated in poor households. The SAM need in HM-02 is imputed from sub-regional severe-wasting prevalence. Within any sub-region, the cases will fall disproportionately on the poorest households.

Third, DPT3 shows that the gradient is not inevitable. Immunisation, which the norms plan with outreach and village health team time built in, reaches the poor as well as the rich.

14.3 Geographic concentration of supply against need

14.3.1 The question and the index

The second view turns from households to districts. It asks whether the existing health workforce and facility network sit where need is. The engine answers with a population-weighted concentration index computed in `src/GIS.jl` (`concentration_index`). Districts are ranked by need, and the index measures whether supply per person rises or falls along that ranking:

$$C_{geo} = \frac{2}{\mu} \sum_d w_d s_d \left(R_d - \frac{1}{2} \right) \quad (14.4)$$

$$w_d = \frac{P_d}{\sum_k P_k}, \quad R_d = \sum_{k < d} w_k + \frac{w_d}{2}, \quad \mu = \sum_d w_d s_d \quad (14.5)$$

where:

- d indexes the 122 districts, sorted in ascending order of need;
- s_d is supply per person in district d : health workers in post, or, separately, public and PNFP facilities;
- P_d is the district population, and w_d its share of the national total;
- R_d is the district's fractional rank on the cumulative population distribution ordered by need;
- μ is the population-weighted mean supply per person;
- need is the need-driven workload, the WISN full-time equivalents required per 10,000 people from HM-03.

Because the weights sum to one, Equation (14.4) is algebraically the same as the grouped formula of Equation (14.2), with districts ranked by need taking the place of quintiles ranked by wealth. A **positive** index means supply is concentrated where need is high (pro-need). A **negative** index means supply is concentrated where need is low. A test on a synthetic chain of eight districts pins the sign: supply that rises with need gives an index above 0.1, and supply that falls with need gives one below -0.1.

14.3.2 Result: supply is not pro-need

The index is **-0.042** for health workers in post and **-0.049** for public and PNFP facilities. Both are negative: existing supply sits slightly more where need is lower. Figure 14.2 shows the two concentration curves. Each plots the cumulative share of supply against the cumulative share of population, with districts ordered from lowest to highest need. Both curves lie just above the diagonal over most of the range, which is what a negative index looks like. The districts with the lowest need hold a slightly larger share of workers and facilities than of population.

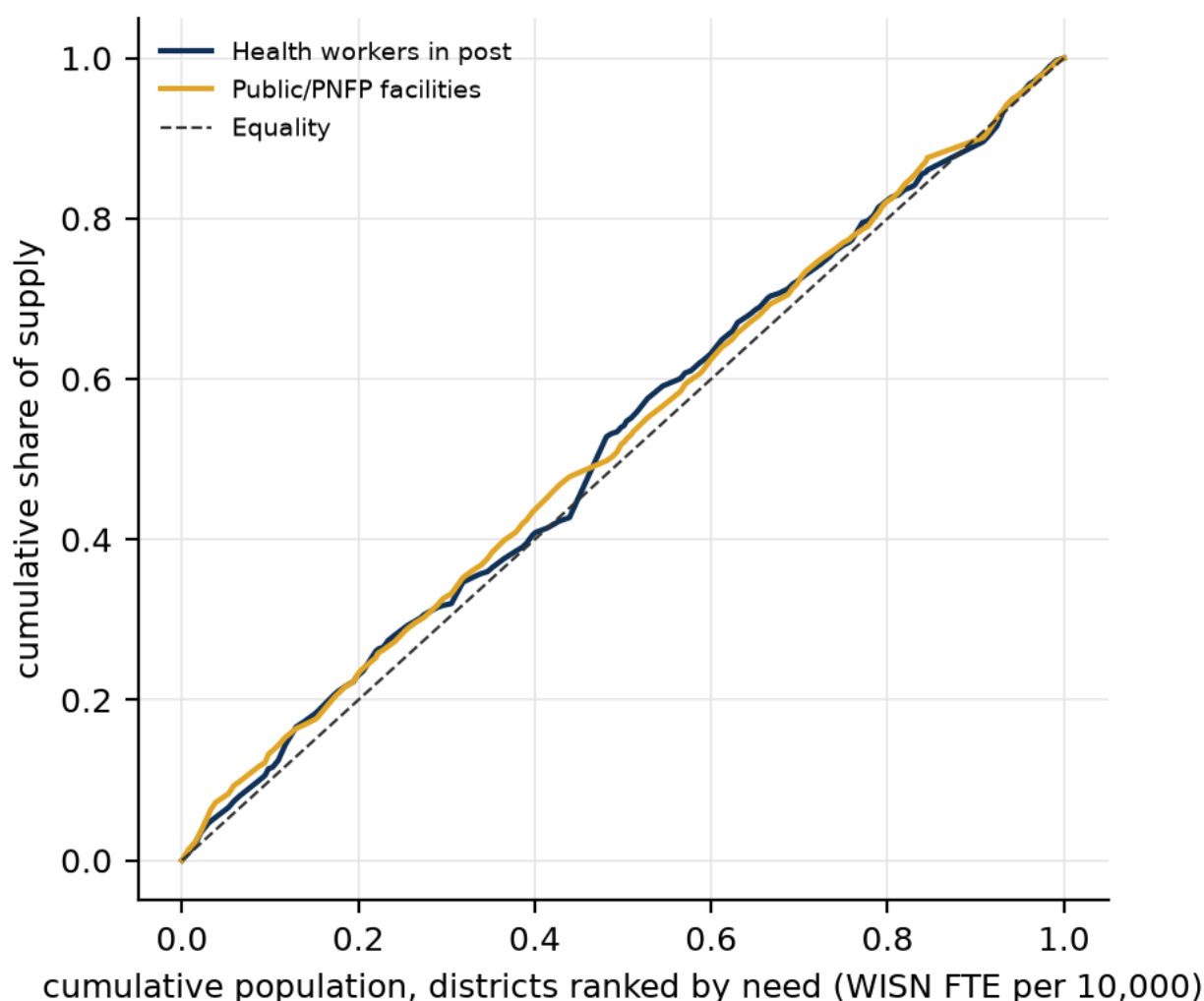


Figure 14.2: Concentration curves of supply against need: curves above the diagonal mean supply sits where need is lower

Source: HPRAS database, run uga-unconstrained-2026

Two readings are needed to avoid over-interpretation.

The magnitudes are small. An index of -0.04 is closer to proportionality than to severe concentration. The curves never stray far from the diagonal. Uganda's workforce and facilities are, broadly, spread in proportion to population. What they do **not** do is lean towards need. Given that the need-driven workload per person varies across districts (the WISN requirement layer has a Moran's I of 0.69 ; Chapter 15), a network spread in proportion to population is, in effect, a network that under-serves the high-need districts.

The sign is what matters for allocation. A negative index is the pattern that makes a need-based allocation formula necessary. If supply already followed need, allocating new money by need would simply scale the existing pattern. Because it does not, every need-weighted scenario in HM-08 has to push resources against the grain of the establishment. It also means that money directed to high-need districts runs into the absorptive-capacity ceiling of HM-08 sooner, because that ceiling is proportional to what a district already spends and to its establishment fill rate.

The concentration index uses the whole population as the denominator of supply per person. It does not adjust for private facilities, which are excluded from the facility count, nor for the private workforce, which is outside the establishment data. Where private provision is concentrated in low-need, urban districts, as the equity breakdowns above suggest, including it would most likely make the index more negative, not less.

14.4 Equity across the allocation scenarios

14.4.1 Two equity metrics

HM-08 distributes the incremental envelope of 413 bn UGX under six rule-based scenarios (A–F) and an optimiser (OPT). For each, `src/Allocation.jl` records two measures of how evenly the result is spread.

Districts above the floor counts the districts in which, after allocation, every basic-package service meets its minimum coverage floor from the target set. Coverage after allocation for service s in district d is

$$c_{sd} = \frac{K_{sd} + u_{sd}}{Q_{sd}} \quad (14.6)$$

where:

- K_{sd} is existing capacity (units deliverable today);
- u_{sd} is the additional units the scenario funds;
- Q_{sd} is the required volume at target coverage.

A district counts as above the floor only if $c_{sd} \geq f_s$ for every service s with a floor f_s .

The **equity ratio** compares the best- and worst-served districts. Each district's mean coverage, $\bar{c}_d$, is the average of c_{sd} over its services. The districts are sorted by $\bar{c}_d$, and the ratio is taken between the district at the boundary of the best-served decile and the district at the boundary of the worst-served decile:

$$E = \frac{\bar{c}_{(n - \lfloor n/10 \rfloor)}}{\bar{c}_{(\lfloor n/10 \rfloor)}} \quad (14.7)$$

where:

- $\bar{c}_k$ is the k -th smallest district mean coverage after allocation;
- n is the number of districts (122), so the ratio is between the 110th and the 12th district in the ranking.

A ratio of 1 means the two deciles are equally served; a larger ratio means a wider spread.

14.4.2 Results

Table 14.3 reports both metrics beside the coverage gain and the deaths averted. The full comparison of what each scenario buys is in Chapter 11; the equity columns are read here.

Table 14.3: Equity metrics of the allocation scenarios, 2026 (incremental envelope of 413 bn UGX; no scenario is recommended)

Scenario	Equity ratio	Districts above floor	Coverage gain (pp)	Spent (bn UGX)	Deaths averted (range)
A Current trajectory	2.47	40	11.99	207.9	9,150 (6,133–11,975)
B Universal basic services	2.32	45	13.20	270.3	10,503 (6,889–13,928)
C Primary healthcare emphasis	2.33	45	13.53	265.5	10,024 (6,596–13,267)
D Hospital expansion	2.17	45	15.06	289.2	11,470 (7,484–15,256)
E Geographic equity	1.75	37	23.41	229.2	15,010 (10,321–19,293)
F Disease burden	3.26	35	5.55	132.7	5,558 (3,758–7,222)
OPT Maximises lives saved on its stated objective	1.75	119	22.44	413.2	20,053 (13,381–26,299)

The equity ratio separates the scenarios clearly:

- **F (disease burden)** leaves the widest spread, with an equity ratio of **3.26** and only 35 districts above the floor. It weights allocations by facility deaths corrected for reporting completeness. Money follows districts where many deaths are recorded in facilities, which are not necessarily the worst-served. It also spends least: 132.7 bn UGX, leaving 280.4 bn unspent.

- **A (current trajectory)** allocates in proportion to what is already delivered. It reproduces the existing pattern: equity ratio **2.47**, 40 districts above the floor.
- **B, C and D** close shortfalls by service tier or basic package. They give equity ratios between **2.17** (D) and **2.33** (C), and 45 districts above the floor each.
- **E (geographic equity)** weights each district-service cell by population times the coverage deficit raised to the power $\gamma = 1.5$, which concentrates money on the worst-served cells. It narrows the equity ratio to **1.75** and delivers the largest coverage gain of the rule-based scenarios (23.41 percentage points). It brings fewer districts above the floor (37) than B, C or D, because its weights follow coverage deficits across all services rather than the basic-package floors.
- **OPT (the allocation that maximises lives saved on its stated objective)** reaches the same equity ratio as E, **1.75**, and brings **119** of 122 districts above the floor. The floors are soft constraints in the optimiser, with a large penalty on any shortfall, so it funds floors wherever the envelope allows.

These results show why the report does not rank scenarios. E and OPT narrow the gap between the best- and worst-served districts to the same ratio, but by different routes and with different results in deaths averted. OPT averts **20,053** deaths (range 13,381–26,299) and E averts **15,010** (range 10,321–19,293). B, C and D bring more districts above the floor than E, with a wider spread between deciles. F leaves the widest spread and averts the fewest deaths (5,558, range 3,758–7,222). Whether to prefer a narrower spread, more districts above a floor, or more deaths averted is a political choice. The engine's task is to make the choice legible.

The equity metrics measure the spread of service coverage across districts. They say nothing about the wealth gradient within districts, which the allocation cannot see. A district that reaches its floor for facility delivery may still have reached mostly its richer households.

14.5 Access equity

14.5.1 Physical access by sub-region

Physical distance to a facility is the dimension of equity most directly under the control of an investment plan. The engine does not compute travel time. That work belongs to the SDI, and its `health_accessibility` layer arrives as an inbound file (Chapter 15). Each district has the share of its population within 60 minutes' walk, and within 60 minutes' drive, of a functional facility. Nationally, **87.5%** of people live within 60 minutes' walk and **98.9%** within 60 minutes' drive. That leaves about **5.3 million** people beyond an hour's walk.

Table 14.4 shows how unevenly that access is distributed.

Table 14.4: Physical access by sub-region, ordered by walking access (SDI travel-time layer, 2020, folded to the 122 plan districts)

Sub-region	Within 60 min walk	Within 60 min drive	People beyond 60 min walk
Karamoja	69.1%	84.8%	364,049
Lango	72.6%	99.4%	682,629
Acholi	73.0%	98.3%	491,107
Bunyoro	74.4%	99.7%	679,864
Teso	79.3%	98.9%	466,486
North Buganda	85.3%	98.2%	652,510
Tooro	85.5%	99.8%	463,623
Ankole	89.6%	99.6%	350,699
West Nile	89.7%	99.5%	329,855
Busoga	92.9%	99.2%	303,797
South Buganda	93.9%	99.2%	342,868
Kampala	94.4%	100.0%	95,584
Kigezi	98.3%	100.0%	25,125
Bugisu	98.8%	99.1%	26,010

Sub-region	Within 60 min walk	Within 60 min drive	People beyond 60 min walk
Bukedi	99.6%	100.0%	10,147

The sub-regions fall into three groups:

- **Karamoja** is in a category of its own: **69.1%** within an hour's walk and **84.8%** within an hour's drive. It is the only sub-region where driving access falls meaningfully below 98%. Its people are scattered over a large, sparsely populated area, and the road network does not reach them.
- **Lango (72.6%), Acholi (73.0%), Bunyoro (74.4%) and Teso (79.3%)** have poor walking access but near-universal driving access (98.3–99.7%). The facilities are reachable by road, but not on foot. For a population that mostly walks, that is the access that matters. Lango has the largest number of people beyond an hour's walk of any sub-region (**682,629**), with Bunyoro close behind (**679,864**).
- **Bukedi (99.6%), Bugisu (98.8%) and Kigezi (98.3%)** have almost universal walking access. These are densely settled highland and eastern sub-regions with a dense network of lower-level facilities.

Walking access and poverty overlap geographically. Karamoja, Acholi, Lango and Teso are the sub-regions where the wealth gradients bite hardest: rural, poorer households with the lowest facility delivery and the highest prevalence of wasting. Distance is one mechanism behind the wealth gradient in facility delivery. A woman who lives beyond an hour's walk of a facility, and cannot pay for transport, delivers at home.

The districts with the lowest walking access are island and remote districts: **Buvuma** and **Amudat** (36% each) and **Kalangala** (42%). They also have the longest referral distances: the furthest health centres from a hospital are in Amudat (62 km), Nakapiripirit (54 km) and Kotido (49 km), all in Karamoja.

14.5.2 Access is shown beside the gaps, not folded into them

The engine keeps access apart from the four gap dimensions. A district with a large workforce gap and good access needs recruitment. A district with no workforce gap and poor access needs new sites or outreach. Folding access into a single score would make the two indistinguishable. In the GIS atlas, people beyond 60 minutes' walk is a separate layer beside the four gap layers, and in the HM-07 investment programme the access columns sit beside the facility gap, which remains the ranking.

14.6 Data quality and limitations

The wealth breakdowns are a decade old. They rest on the DHS 2016, the only full DHS among the three surveys the loader reads. The loader computes no equity breakdowns from the two malaria indicator surveys (2018–19 and 2024–25). The gradients may have changed since 2016, particularly for facility delivery, which has been rising fast (Chapter 16).

The breakdowns are national. Each wealth quintile is estimated for the whole country, not by sub-region or district. A cross-tabulation of wealth by sub-region would put many cells below the disclosure threshold of 25 cases. The engine therefore cannot say whether the gradient in facility delivery is steeper in Karamoja than in Kigezi.

The wealth index is relative. DHS wealth quintiles rank households by an asset index within the survey. They are not income groups, and the poorest quintile in 2016 is not a fixed group of people.

The grouped concentration index understates. Computed over five quintiles, the index is bounded at ± 0.8 and slightly smaller in magnitude than the individual-level index. It is used for sign and ordering.

Quality tiers. The DHS equity cells are survey observations, the *measured* tier, at national level. The geographic concentration index combines workforce and facilities in post (*measured* for all 122 districts) with the need-driven

WISN requirement, which inherits the tiers of its inputs: normed time standards and, for several services, imputed sub-regional need rates. Access is imputed: it is a modelled raster product of the SDI.

The allocation equity metrics measure districts, not people. The equity ratio compares two districts in the ranking. It is insensitive to what happens elsewhere in the distribution, and to anything within districts.

14.7 Implications for planning

- **Target the lower quintiles explicitly where the gradient is steep.** Facility delivery and modern contraception carry the strongest pro-rich gradients among the coverage indicators. Raising them to target means reaching poor, rural women who do not come to facilities today. The requirement costs the service inside the facility; the demand-side measures that bring these women in are outside the modelled catalogue and need their own budget line.
- **Learn from immunisation.** DPT3 shows no wealth gradient. How the immunisation programme reaches poor households is worth studying for services where the gradient is steep, particularly family planning, and for postnatal care, which is low for everyone.
- **Nutrition need falls on the poor.** Severe wasting is almost three times as prevalent in the poorest quintile as in the richest, and stunting affects roughly a third of children in each of the three poorest quintiles. Nutrition services planned from sub-regional prevalence should be delivered through channels that reach poor households, such as community management and village health teams.
- **Existing supply does not lean towards need.** With a concentration index of -0.042 for workers and -0.049 for facilities, any allocation that follows need works against the existing pattern and will meet absorptive limits in high-need districts. Postings and recruitment, not only recurrent money, are the instruments that change the index.
- **The equity choice is political.** Scenario E and the optimiser both narrow the spread between the best- and worst-served deciles to 1.75. B, C and D bring more districts above the floor than E, with a wider spread. The report sets these results side by side and recommends none of them.

CHAPTER 15

15 Spatial analysis and the GIS atlas

Every module of the engine, from population in HM-01 to the budget in HM-10, produces results by district. This chapter asks what the geography of those results says. Is need scattered at random across Uganda, or do high-need districts sit next to each other? Does supply follow the same pattern as need? Where are the clusters, and at what scale should a planner act on them?

The answers matter for how the plan is organised. A pattern that forms large, contiguous regional clusters is best addressed by regional programmes and regional referral hospitals. A pattern that varies district by district with no regional structure has to be managed district by district, through postings, facility siting and district allocations. The engine measures which kind of pattern each layer shows, using standard spatial statistics on a common geometry. It maps the result in an atlas of 41 layers, one set per module, each layer shown beside its map of local clusters.

15.1 What the engine computes, and what the SDI computes

The Master Command keeps geoprocessing out of this repository: no routing, no travel-time surfaces, no raster computation. That work belongs to the Spatial Data Infrastructure (SDI), which already holds Uganda's administrative hierarchy, a routable road network and a `health_accessibility` layer giving the population within 30, 60 and 120 minutes of a functional facility by district. The engine keeps that line. Three components share the GIS work (Table 15.1).

Table 15.1: The three GIS components and the boundary with the SDI

Component	What it does	What it never does
<code>scripts/build_geo.py</code>	Reads vector boundaries, folds them onto the plan's 2018 districts, records adjacency, exports the located facilities	Route, rasterise, compute access
<code>src/GIS.jl</code>	Joins each module's results to districts, computes spatial statistics on the joined values, reads the SDI's access results	Touch geometry
<code>scripts/render_maps.py</code>	Draws the atlas from values already in the database	Compute anything

Travel-time access therefore arrives as an inbound file. The file in place today is the SDI `health_accessibility` layer for 2020, covering 135 districts, as vendored from HealthModelling. `scripts/load_healthmodelling.py` folds it onto the 122 plan districts, weighting by population, and marks it as a snapshot. Every run reports the SDI interface as a *snapshot*, not as live. A real SDI export placed in the same folder replaces it with no code change.

The division has a practical consequence for this chapter. The two access layers (population within 60 minutes' drive, and within 60 minutes' walk) are the SDI's results, not the engine's. The engine computes only a straight-line **referral distance** from each health centre to its nearest hospital. That is a lower bound on travel, because roads are longer than straight lines, and it is never presented as travel time.

15.2 The geometry

15.2.1 Districts

District boundaries come from OpenStreetMap at administrative level 4, in the Geofabrik extract of August 2026, under the Open Database Licence. Uganda has created many districts and cities since 2018, but the plan's population, facility and budget data are organised on the **2018 set of 122 districts**. `build_geo.py` therefore folds every post-2018 district and city into its 2018 parent, using the same rules as the data loaders (`uga_districts.canonical`), so that every layer joins on one district identifier. The run stops if any plan district has no boundary.

Areas are computed in an equal-area projection (UTM zone 36N, EPSG:32636). The 122 districts sum to **241,413 km²**, against Uganda's official **241,550 km²**, a difference of 0.06%. A test asserts that the total stays within 1% of the official figure. For drawing, the boundaries are simplified to a 250 m tolerance; the analytics use the full geometry. The 15 DHS sub-regions are formed by dissolving districts along the DHS crosswalk.

Of the 6,800 facilities in the National Health Facility Registry, **3,169** carry coordinates. They are overlaid on the HM-04 maps and are the basis of the referral distances.

15.2.2 Neighbours: queen contiguity

Spatial statistics need a definition of who is whose neighbour. The engine uses **queen contiguity**: two districts are neighbours if they share any part of a boundary, even a single corner. OSM polygons of adjacent districts do not always meet exactly; small slivers and gaps would break contiguity between districts that touch in reality. Each polygon is therefore buffered by **50 m** before the intersection test.

The result is **321 district borders**. Every district has at least two neighbours and at most eight, with a median of five. No district is left without a neighbour, a condition a test enforces along with symmetry (if A neighbours B, B neighbours A).

15.2.3 Row-standardised weights

The neighbour relation is turned into a weight matrix W , row-standardised so that each district's neighbours share a total weight of one:

$$w_{ij} = \frac{1}{|N(i)|} \quad \text{if } j \in N(i), \quad w_{ij} = 0 \quad \text{otherwise} \quad (15.1)$$

where:

- $N(i)$ is the set of queen neighbours of district i , and $|N(i)|$ their number;
- w_{ij} is the weight of district j in the neighbourhood of district i ; $w_{ii} = 0$.

With these weights, the **spatial lag** of a variable, the sum of $w_{ij} z_j$ over j , is simply the average of its values in the neighbouring districts. Row-standardisation keeps a district with eight neighbours from weighing more than one with two.

15.3 Spatial statistics

15.3.1 Normalising the layers

Every layer is a value per district, with a unit and a quality tier. Counts are normalised by population, or by area for density, before any statistic is computed. A map of raw counts mostly maps population: Wakiso and Kampala would dominate every layer. Need is therefore expressed per 1,000 or per 100,000 people, workforce per 10,000, cost and allocation per person, and deaths averted per 100,000.

15.3.2 Global Moran's I

Global Moran's I measures whether a layer is geographically clustered: whether districts resemble their neighbours more than chance would produce. With row-standardised weights it is

$$I = \frac{\sum_i z_i \sum_j w_{ij} z_j}{\sum_i z_i^2}, \quad z_i = x_i - \bar{x} \quad (15.2)$$

where:

- x_i is the layer's value in district i , and $\bar{x}$ its mean over the $n = 122$ districts;
- z_i is the deviation of district i from the mean;
- w_{ij} are the row-standardised weights of Equation (15.1).

Under no spatial pattern, the expected value of I is

$$E[I] = -\frac{1}{n-1} \quad (15.3)$$

which is $-1/121$, or about -0.008 . A value well above $E[I]$ means like values cluster: high next to high, low next to low. A value below it means they alternate, as on a chessboard. Values near zero mean no spatial structure.

15.3.3 Permutation inference

Whether an observed I could have arisen by chance is judged by a permutation test, not by a normal approximation. The values of the layer are shuffled at random across the districts 999 times, and I is recomputed each time. The two-sided p-value is

$$p = \frac{1 + \#\{k : |I_k^* - E[I]| \geq |I - E[I]|\}}{1 + 999} \quad (15.4)$$

where:

- I_k^* is Moran's I for the k -th random permutation, $k = 1, \dots, 999$;
- the count in the numerator is the number of permutations at least as far from $E[I]$ as the observed value.

The smallest attainable p-value is $1/1,000 = 0.001$. That is the value reported for most layers in this chapter: none of the 999 random arrangements produced a pattern as strong as the observed one. The random number generator is seeded with the fixed value **20260921**, so two runs with the same inputs give the same p-values and the same maps. A test asserts this.

15.3.4 Local Moran (LISA)

Global Moran's I says whether a layer clusters; it does not say where. The local indicator of spatial association (LISA) does, one district at a time:

$$I_i = \frac{z_i}{m_2} \sum_j w_{ij} z_j, \quad m_2 = \frac{1}{n} \sum_i z_i^2 \quad (15.5)$$

where:

- I_i is the local Moran statistic of district i ;
- m_2 is the variance of the layer across districts;
- the sum is the average deviation among district i 's neighbours (its spatial lag).

Significance is judged by **conditional permutation**. District i 's own value is held fixed; its k_i neighbours are replaced 999 times by k_i values drawn at random, without replacement, from the other 121 districts; and the

local statistic is recomputed. A district is significant if its p-value is at most $\alpha = 0.05$. It is then classified by the signs of its own deviation and of its neighbours' average (Table 15.2).

Table 15.2: The five LISA classes

Class	Own value	Neighbours	Reading
HH	above the mean	above the mean	hot spot: a high value among high neighbours
LL	below the mean	below the mean	cold spot: a low value among low neighbours
HL	above the mean	below the mean	outlier: a high value among low neighbours
LH	below the mean	above the mean	outlier: a low value among high neighbours
ns	–	–	not significant at $\alpha = 0.05$

With 122 districts each tested at $\alpha = 0.05$, around six districts per layer would appear significant by chance even with no spatial pattern. The LISA classes are read as a map of where a clustered layer's clusters lie, not as 122 independent findings, and they are interpreted only for layers whose global I is significant.

15.3.5 Concentration of supply against need

The concentration index of supply against need is defined and interpreted in Chapter 14. Districts are ranked by need (WISN full-time equivalents required per 10,000), and supply per person is weighted by population. For health workers in post the index is **–0.042**, and for public and PNFP facilities **–0.049**: supply sits slightly more where need is lower.

15.3.6 Catchment population and referral distance

Two descriptive layers complete the toolkit. **Catchment population** is people per public or PNFP facility, by district and level:

$$\text{catchment}_{dl} = \frac{P_d}{F_{dl}} \quad (15.6)$$

where P_d is the district population and F_{dl} the number of facilities of level l in district d . It is **descriptive only**. The Master Command forbids people-per-facility ratios as a planning method (principle P4); capacity in HM-04 comes from throughput norms.

Referral distance is the straight-line (great-circle) distance from each located, operational public or PNFP health centre (HC II, HC III, HC IV) to the nearest located general or referral hospital:

$$d = 2R \arcsin \sqrt{\sin^2 \frac{\Delta\phi}{2} + \cos \phi_1 \cos \phi_2 \sin^2 \frac{\Delta\lambda}{2}} \quad (15.7)$$

where:

- ϕ_1, ϕ_2 are the latitudes of the health centre and the hospital, and $\Delta\phi$ their difference, in radians;
- $\Delta\lambda$ is the difference in longitude, in radians;
- $R = 6,371$ km is the Earth's radius.

The distances are summarised by district as the median, the 90th percentile and the share of centres more than 50 km from a hospital.

15.4 Results: the 41 layers

15.4.1 Overview

Table 15.3 lists all 41 layers with their global Moran's I , the permutation p-value and the number of hot spots (HH) and cold spots (LL). Figure 15.1 ranks them by I .

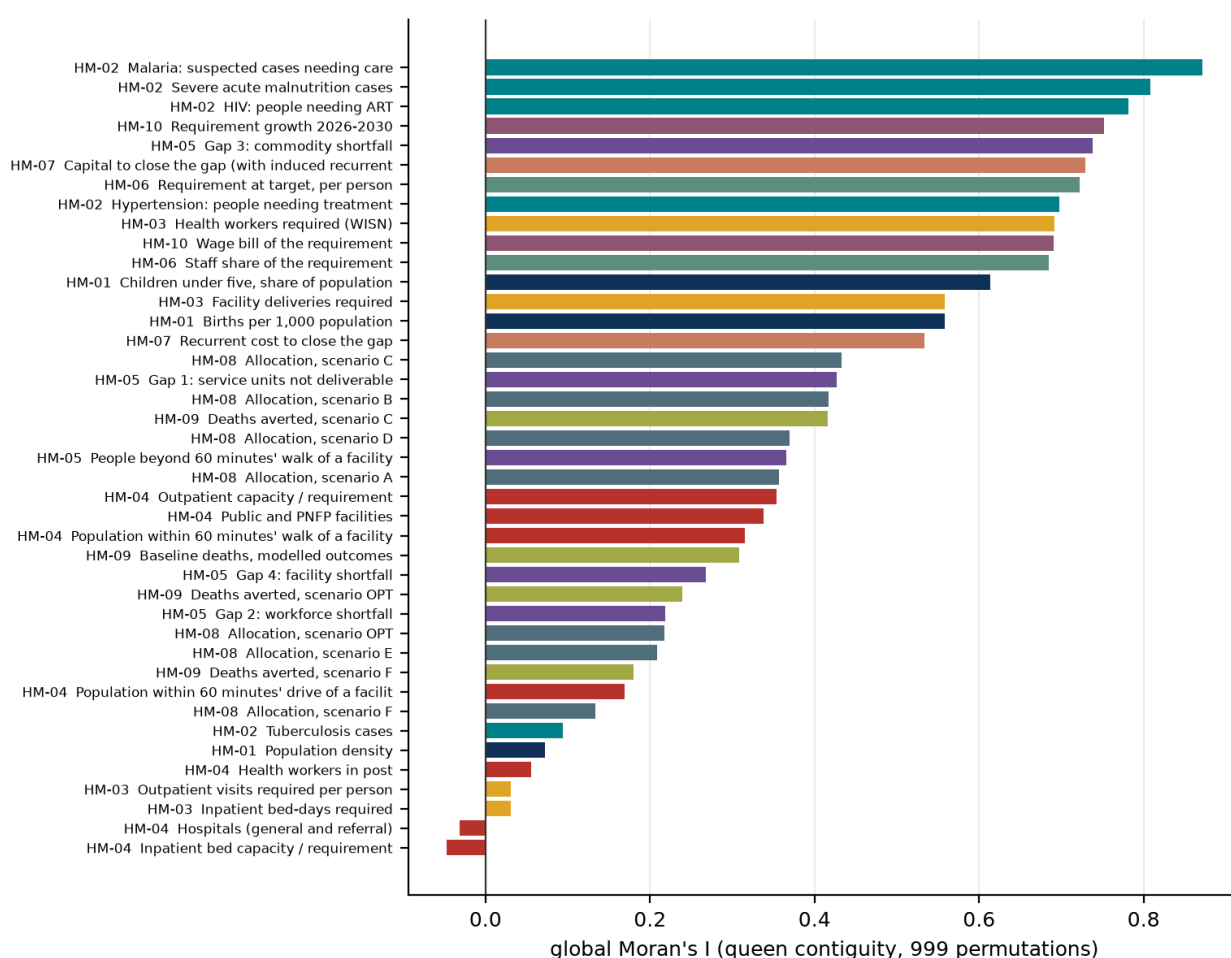


Figure 15.1: Spatial clustering of every GIS layer: positive I means neighbouring districts resemble each other

Source: HPRAS database, run uga-unconstrained-2026

Table 15.3: All 41 GIS layers with their global spatial autocorrelation

Module	Layer	Unit	Moran's I	p	Hot spots (HH)	Cold spots (LL)
HM-01	Births per 1,000 population	per 1,000	+0.56	0.001	10	12
HM-01	Population density	persons / km2	+0.07	0.002	5	8
HM-01	Children under five, share of population	%	+0.61	0.001	10	14
HM-02	HIV: people needing ART	per 1,000	+0.78	0.001	22	20
HM-02	Hypertension: people needing treatment	per 1,000	+0.70	0.001	20	13
HM-02	Malaria: suspected cases needing care	per 1,000	+0.87	0.001	25	29
HM-02	Severe acute malnutrition cases	per 1,000	+0.81	0.001	13	9
HM-02	Tuberculosis cases	per 100,000	+0.09	0.065	3	0
HM-03	Inpatient bed-days required	per 1,000	+0.03	0.461	3	0
HM-03	Facility deliveries required	per 1,000	+0.56	0.001	10	12
HM-03	Outpatient visits required per person	visits / person	+0.03	0.461	3	0
HM-03	Health workers required (WISN)	FTE per 10,000	+0.69	0.001	20	19

Module	Layer	Unit	Moran's I	p	Hot spots (HH)	Cold spots (LL)
HM-04	Population within 60 minutes' drive of a facility	%	+0.17	0.003	0	7
HM-04	Population within 60 minutes' walk of a facility	%	+0.32	0.001	9	16
HM-04	Inpatient bed capacity / requirement	ratio	-0.05	0.499	0	3
HM-04	Public and PNFP facilities	per 10,000	+0.34	0.001	11	3
HM-04	Hospitals (general and referral)	per 100,000	-0.03	0.699	2	4
HM-04	Outpatient capacity / requirement	ratio	+0.35	0.001	7	5
HM-04	Health workers in post	per 10,000	+0.06	0.263	1	6
HM-05	People beyond 60 minutes' walk of a facility	thousand persons	+0.37	0.001	16	8
HM-05	Gap 3: commodity shortfall	UGX per person	+0.74	0.001	24	10
HM-05	Gap 4: facility shortfall	facility-equivalents per 100,000	+0.27	0.001	7	4
HM-05	Gap 1: service units not deliverable	per 1,000	+0.43	0.001	12	8
HM-05	Gap 2: workforce shortfall	FTE per 10,000	+0.22	0.001	5	2
HM-06	Requirement at target, per person	USD per person	+0.72	0.001	24	12
HM-06	Staff share of the requirement	%	+0.68	0.001	15	20
HM-07	Capital to close the gap (with induced recurrent as range high)	USD per person	+0.73	0.001	19	19
HM-07	Recurrent cost to close the gap	USD per person	+0.53	0.001	18	9
HM-08	Allocation, scenario A	USD per person	+0.36	0.001	15	7
HM-08	Allocation, scenario B	USD per person	+0.42	0.001	13	7
HM-08	Allocation, scenario C	USD per person	+0.43	0.001	13	8
HM-08	Allocation, scenario D	USD per person	+0.37	0.001	14	5
HM-08	Allocation, scenario E	USD per person	+0.21	0.001	7	3
HM-08	Allocation, scenario F	USD per person	+0.13	0.014	3	0
HM-08	Allocation, scenario OPT	USD per person	+0.22	0.001	7	4
HM-09	Baseline deaths, modelled outcomes	per 100,000	+0.63	0.001	12	9
HM-09	Deaths averted, scenario C	per 100,000	+0.42	0.001	13	8
HM-09	Deaths averted, scenario F	per 100,000	+0.18	0.003	5	1
HM-09	Deaths averted, scenario OPT	per 100,000	+0.24	0.001	9	3
HM-10	Requirement growth 2026-2030	%	+0.75	0.001	17	24
HM-10	Wage bill of the requirement	USD per person	+0.69	0.001	22	19

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_gis_layers.csv).

Of the 41 layers, **35** are significantly clustered at the 5% level. Thirty-one of them reach the floor p-value of 0.001; the other four have p-values between 0.002 and 0.014. The six that are not clustered are tuberculosis need ($p = 0.065$), inpatient bed-days and outpatient visits required (both $p = 0.461$), health workers in post ($p = 0.263$), inpatient bed capacity against requirement ($p = 0.499$) and hospitals per 100,000 ($p = 0.699$).

The layers fall into three groups:

- **Strongly clustered ($I \geq 0.5$):** 15 layers, mostly need and the requirement, cost, gap and budget layers built on it.
- **Moderately clustered (I between 0.1 and 0.5):** most supply, access, allocation and outcome layers.
- **Not clustered (I below 0.1):** tuberculosis need, population density, the outpatient and bed-day requirements, health workers in post, hospitals and bed capacity.

15.4.2 Need is strongly clustered

The four need layers with sub-regional evidence are among the most clustered in the atlas.

- **Malaria: $I = 0.87$,** the highest of all 41 layers, with 25 hot spots and 29 cold spots. The hot spots form a single northern and eastern belt: 8 districts in Lango, 7 in Teso, 5 in Acholi (Agago, Gulu, Lamwo, Omoro, Pader), 2 in Karamoja (Nakapiripirit, Napak), 2 in Bukedi (Butebo, Pallisa) and Buyende in Busoga. The cold spots are in the south-west: 10 districts in Ankole, 7 in South Buganda, and 6 each in Tooro and Kigezi. This is the geography of the DHS child-fever index multiplied by malaria test positivity, the covariate that apportions the national malaria incidence to sub-regions in HM-02.
- **Severe acute malnutrition: $I = 0.81$,** with 13 hot spots and 9 cold spots. The hot spots are 9 districts in West Nile, 3 in Karamoja (Amudat, Kotido, Moroto) and Kween in Bugisu; the cold spots are 9 districts in South Buganda.
- **HIV (people needing ART): $I = 0.78$,** with 22 hot spots and 20 cold spots. The hot spots are 13 districts in South Buganda, 3 each in Lango (Apac, Lira, Oyam) and Acholi (Gulu, Omoro, Pader), 2 in North Buganda (Mityana, Mukono) and Kiruhura in Ankole. The cold spots are 7 districts in West Nile, 5 in Karamoja, and 3 each in Teso and Bugisu. The pattern follows UPHIA 2020–21 regional prevalence, from 2.1% in Karamoja to 8.1% in South Buganda.
- **Hypertension: $I = 0.70$,** with 20 hot spots and 13 cold spots. The hot spots are 13 districts in South Buganda and 5 in Kigezi; the cold spots are 7 districts in Busoga and 3 in Karamoja. Hypertension need is a single national prevalence applied to adults aged 15 and over, so its pattern is entirely that of the adult share of the population, taken from the DHS sub-regional age structure.

A caution applies to all four. Each need rate varies **at the resolution of its evidence**: the DHS sub-region (15 areas) for malaria, SAM and adult age structure, and the UPHIA region (11 areas) for HIV. Every district in a sub-region receives the same rate, adjusted only by its own demography. With 122 districts nested in 15 sub-regions, neighbouring districts share a rate far more often than chance would produce, so a high Moran's I is partly **built in** by the resolution of the survey evidence. The clustering is real, in the sense that the surveys show large differences between sub-regions. But the layers cannot show variation *within* a sub-region, because the evidence does not resolve it. The district maps draw a sub-regional pattern at district scale.

15.4.3 The requirement, cost and gaps inherit the pattern

Everything built on need inherits its clustering. The WISN workforce requirement ($I = 0.69$, 20 hot and 19 cold spots) has hot spots in South Buganda (8 districts), Teso (6) and Lango (4), and cold spots in Kigezi (6), West Nile (5) and Tooro (4). The requirement at target per person (**0.72**), its staff share (**0.68**) and its wage bill per person (**0.69**) follow, as do the commodity gap (**0.74**, hot spots in South Buganda, Lango and Acholi) and the capital cost to close the gap (**0.73**).

The requirement's growth from 2026 to 2030 ($I = 0.75$) is clustered in the opposite direction: hot spots in West Nile (7 districts), Karamoja (5), Bugisu (3) and Teso (2); cold spots in South Buganda (13), Lango (5) and Acholi (4). Growth is fastest where the requirement per person is lowest today, which is consistent with coverage targets that lift low-coverage districts furthest.

The demographic layers are also clustered: the under-five share (0.61) and births per 1,000 (0.56) reflect sub-regional fertility and age structure from the DHS. The facility deliveries required (0.56) follow births.

15.4.4 What is not clustered, and why

The layers with no spatial structure are as informative as the clustered ones, but for different reasons.

Tuberculosis need ($I = 0.09$, $p = 0.065$) is uniform by construction. HM-02 applies a single national TB incidence rate of 198 per 100,000 to every district's population, because no sub-regional TB evidence is loaded. The district values differ only at the level of floating-point rounding, so the Moran's I computed on them carries no information about the geography of TB. Its three "hot spots" (Maracha, Yumbe and Isingiro) are artefacts. The honest reading is that the engine has no evidence on where TB is concentrated.

Outpatient visits required per person ($I = 0.03$, $p = 0.461$) vary district by district. The outpatient contact rate is the one need rate in the set that is observed district by district, from the MoH league table (29 distinct district rates), with every district lifted to at least the national 75th percentile. Many districts sit at that floor, and the rest vary without regional structure. **Inpatient bed-days ($I = 0.03$, $p = 0.461$)** are a referral service derived from outpatient volume. They carry the same geography, and give the same statistic to three decimal places.

Health workers in post ($I = 0.06$, $p = 0.263$), hospitals per 100,000 ($I = -0.03$, $p = 0.699$) and bed capacity against requirement ($I = -0.05$, $p = 0.499$) are not clustered either. These are the supply layers that reflect individual decisions: where a hospital was built, where staff were posted. A district with a hospital is not more likely to neighbour another district with one. Their significant LISA districts are few and scattered. For health workers in post there is one hot spot (Kaabong), six small cold spots (Bugiri, Iganga and Kaliro in Busoga, with Mubende, Kakumiro and Pallisa), and six low outliers among better-staffed neighbours, Wakiso and Lamwo among them.

Population density ($I = 0.07$, $p = 0.002$) is significant but weak. It has hot spots in the densely settled east (Bududa, Manafwa, Namisindwa, Budaka, Butaleja) and cold spots in Karamoja and Acholi. Kampala, at about 10,200 persons per km², is nearly eight times as dense as the next district (Mbale), and a single extreme value of that kind weakens the global statistic.

15.4.5 Supply and access: moderate clustering

Public and PNFP facilities per 10,000 ($I = 0.34$) are moderately clustered. The hot spots are in Kigezi (Kabale, Kanungu, Rubanda, Rukiga, Rukungiri) and South Buganda (Kalungu, Kyotera, Masaka), with isolated low values in Kaberamaido, Kibaale and Pallisa. Outpatient capacity against requirement (0.35) has hot spots in the same five Kigezi districts: the south-west has more facilities and more capacity per person than it needs for outpatient care at target, and is also a malaria cold spot.

Walking access ($I = 0.32$) has 16 cold spots. Five are in Bunyoro (Hoima, Kagadi, Kakumiro, Kibaale, Kiryandongo) and three in Karamoja (Abim, Moroto, Nakapiripirit); the others are in Teso, Lango, Acholi, Tooro and North Buganda. The hot spots are in Bukedi, Bugisu and Kigezi. The number of people beyond 60 minutes' walk (0.37) has hot spots in Bunyoro (6 districts), Lango (4), Tooro (2) and North Buganda (2). Driving access (0.17) has no hot spots and 7 cold spots, because nearly every district outside Karamoja has almost universal driving access.

15.4.6 Allocations and outcomes

The allocation layers show how each scenario's rule translates into geography. Scenario C ($I = 0.43$) and B (0.42) follow the shortfall and inherit part of the need pattern. Scenario E (0.21) and the optimiser (0.22) are less clustered: they direct money to specific worst-served district-service cells rather than to whole regions. Both have

hot spots in Busoga (Iganga, Kaliro and, for E, Buyende), in Bukedi (Pallisa, and for the optimiser Kibuku), in Bunyoro (Kakumiro, and for E Kibaale), and in Mubende. Both have cold spots in Kigezi (Rubanda, Rukiga) and Mitooma. Scenario F (**0.13**, $p = 0.014$) is the least clustered. It follows facility deaths recorded in HMIS, and has hot spots in Kampala, Mukono and Maracha.

Deaths averted mirror the allocations. The optimiser's layer (**I = 0.24**) has hot spots in Busoga (Buyende, Iganga, Kaliro), Bunyoro (Kakumiro, Kibaale), Bukedi (Kibuku, Pallisa), Kaberamaido and Mubende. Scenario C's deaths averted (**0.42**) are more clustered, like its allocation. Baseline deaths (**0.63**) follow the mortality indices, which give HIV, malaria and under-five deaths the geography of their need. The result is strongly clustered: Karamoja and Bunyoro form the hot spot and Kigezi the cold spot.

15.5 Reading the patterns for planning scale

The statistics support a simple division of labour between regional and district planning.

Need is a regional phenomenon, and should be planned regionally. Malaria, HIV, SAM and hypertension need, and the requirement built on them, form large contiguous clusters that coincide with sub-regions. A malaria programme that concentrates on the Lango–Teso–Acholi belt, a nutrition programme focused on West Nile and Karamoja, and an HIV programme weighted to South Buganda match the scale of the evidence. District-level differences within these regions are not identified by the current evidence. A district allocation that ranks districts within a sub-region by these need layers is ranking on demography, not on disease.

Supply is a district phenomenon, and has to be managed district by district. The workforce in post, hospitals and bed capacity show no regional structure. Whether a district is well staffed depends on its own history of postings and facility construction, not on its region. Correcting the supply pattern is therefore a matter of district-by-district decisions on postings, recruitment and siting.

The two do not line up. Need is regional and clustered; supply is idiosyncratic and unclustered, and its concentration index against need is slightly negative. A district in a high-need cluster is no more likely than any other to be well supplied. This is the spatial expression of the finding in Chapter 14, and it is why the allocation scenarios produce such different maps.

Access has its own geography. Poor walking access is concentrated in Bunyoro, Karamoja and parts of Lango, Acholi and Teso. That partly overlaps the malaria belt and the SAM hot spots in Karamoja, but not the HIV and hypertension hot spots of South Buganda. Siting decisions in HM-07 should read the access layers beside the facility gap, not merge them.

15.6 Data quality and limitations

- **Resolution of evidence.** The need layers vary at sub-regional (15) or UPHIA-regional (11) resolution. Their high Moran's I partly reflects that resolution. Only the outpatient contact rate is observed district by district, and TB need is uniform by construction.
- **Boundaries.** OSM boundaries are community-mapped and may differ from the official Uganda Bureau of Statistics boundaries in detail. The area check (0.06% below the official total) shows the difference is small in aggregate.
- **Folded geography.** Folding post-2018 districts and cities into their 2018 parents hides variation within the newer units.
- **Located facilities.** Only 3,169 of 6,800 registry facilities carry coordinates, so the referral distances rest on a subset of health centres and hospitals. A missing hospital makes nearby distances too long; a missing health centre drops out of its district's median.

- **Straight lines, not roads.** Referral distance is a lower bound on travel, not a measure of it. The national median is 17 km. The longest are in Karamoja: Amudat 62 km, Nakapiripirit 54 km and Kotido 49 km. Real journeys are longer.
- **Access is a snapshot.** The SDI layer is from 2020 and is folded from 135 districts to 122 by population weighting. Its quality tier is *imputed*, because it is a modelled raster product.
- **Multiple testing.** LISA tests 122 districts per layer at $\alpha = 0.05$, so a few significant districts per layer are expected by chance. Isolated HL and LH outliers should be checked before they are acted on.
- **No district budget layer.** The national budget holds local governments as a single vote, so the HM-10 layers map the requirement's own budget structure, not the approved budget.

15.7 Implications for planning

- **Plan need-driven programmes at regional scale.** Malaria ($I = 0.87$), SAM (0.81), HIV (0.78) and hypertension (0.70) need form sub-regional clusters. Programme targeting, commodity distribution and regional referral planning should follow those clusters. District differences within a cluster are not supported by the evidence.
- **Manage supply district by district.** Health workers in post, hospitals and bed capacity show no regional clustering. Postings, recruitment and facility investment decisions have to be made on each district's own position, read from the HM-05 gap layers.
- **Invest in district-level evidence where it would change decisions.** TB has no sub-national evidence at all, and the other need layers stop at sub-regional resolution. District estimates of TB notification, HIV prevalence or malaria incidence from routine data (DHIS2) would let the district maps show district differences rather than sub-regional ones.
- **Keep access beside the gaps.** Walking access is poorest in Bunyoro and Karamoja, which do not coincide with every need cluster. Siting decisions should read the access layers next to the facility gap, never as a single combined score.
- **Replace the access snapshot with a live SDI export.** The 2020 access layer predates recent facility construction. A live `health.health_accessibility` export dropped into the inbound folder would update the access layers with no code change.

CHAPTER 16

16 Survey trends, small-area evidence and external cross-checks

The planning engine works from a baseline: coverage, prevalence and need measured at one point in time, and projected forward only through population growth and coverage targets. This chapter asks three questions about that baseline. How has it been moving, and what can honestly be said about where it stands today, a decade after the last round in the trend series? How far can the sub-regional survey estimates behind it be trusted? And do the engine's unit costs, workforce densities and coverage figures agree with the independent evidence held elsewhere in the AICTEM modelling system?

The answers come from two external sources: HealthModelling, the AICTEM survey-estimation system, and the unit-cost coefficients of UCSN (UnitCostModelling). Both are used under one strict rule. Their evidence **informs and cross-checks** the plan; it never silently changes a norm, a price or a budget line.

16.1 What the engine takes from HealthModelling

HealthModelling estimates population health from survey microdata; this engine plans services. Six things from HealthModelling strengthen the plan. Each is **copied** into this repository, code and data, so the engine runs and its tests pass without HealthModelling present. `data/vendor/healthmodelling/PROVENANCE.md` lists every copied file, and HealthModelling's MIT licence is kept beside them. Only aggregates are copied, never individual records: HealthModelling's disclosure control (at least 25 cases per cell) was applied before export. A test fails if any line of code, other than a provenance note, points at the HealthModelling directory.

Two pieces of code were copied with their logic unchanged: the Fay–Herriot small-area estimator (`src/SmallArea.jl`) and the local linear trend model (`src/Trends.jl`). A Python port of the Fay–Herriot estimator, `scripts/small_area.py`, serves the Python data loaders. A test checks it against the Julia original to 1e-10.

The six uses are:

1. **Physical access (HM-04, HM-05, HM-07).** The SDI travel-time layer gives the share of each district's population within 30, 60 and 120 minutes' drive, and 60 minutes' walk, of a functional facility. It feeds the SDI inbound interface, the access and people-beyond-reach map layers, and the access columns of the investment programme. Access is never merged with a gap into a score, and its quality tier is *imputed* because it is a modelled raster product.
2. **Small-area smoothing (HM-02 and HM-04 baselines).** Six sub-regional DHS indicators are passed through a Fay–Herriot estimator before use (next section). HealthModelling's own Fay–Herriot estimate of under-five mortality by sub-region gives HM-09 a district index for child deaths.
3. **UCSN cross-check (HM-06).** Five engine figures are compared with the UCSN coefficients. The comparison is reported, never applied.
4. **External financing and the budget total (HM-10).** Global Fund and GAVI grants are set beside the requirement lines they mainly pay for, and the engine's own parse of the MoFPED budget is compared with HealthModelling's fiscal extract.
5. **Equity by wealth and residence.** The engine computes its own breakdowns from the DHS 2016 microdata, and HealthModelling's export is the validation reference (Chapter 14).
6. **Survey trends.** The local linear trend is fitted to the DHS rounds for stunting and facility delivery.

16.2 Small-area evidence: how far to trust a sub-regional estimate

The need rates for malaria and SAM, and the coverage baselines for DPT3, ANC4, facility delivery and postnatal care, vary by DHS sub-region. Each sub-regional estimate rests on a few hundred children or women, so the direct values are noisy. A sub-region that happened to sample few severely wasted children would, if taken at face value, be planned with almost no SAM need.

The engine therefore smooths the six indicators with a Fay–Herriot estimator. It is the empirical best linear unbiased predictor (EBLUP), which shrinks each noisy direct estimate towards a model prediction in proportion to its sampling variance:

$$\hat{\theta}_i = x_i' \hat{\beta} + \gamma_i (y_i - x_i' \hat{\beta}), \quad \gamma_i = \frac{\sigma_u^2}{\sigma_u^2 + D_i} \quad (16.1)$$

where:

- y_i is the direct survey estimate for sub-region i ;
- D_i is its sampling variance;
- $x_i' \hat{\beta}$ is the model prediction: with an intercept only, the precision-weighted national mean;
- σ_u^2 is the variance of the true sub-regional values around the model, estimated by an iterated moment method;
- γ_i is the shrinkage weight, between 0 and 1: a precise estimate (small D_i) keeps most of its own value, and a noisy one moves towards the model.

The sampling variance is binomial, inflated by a DHS design effect of 2.0, and evaluated at the **pooled** proportion $\bar{p}$ rather than each sub-region's own:

$$D_i = \text{deff} \cdot \frac{\bar{p}(1-\bar{p})}{n_i}, \quad \text{deff} = 2.0 \quad (16.2)$$

where n_i is the unweighted sample in sub-region i . The pooled proportion matters. With each area's own proportion, a sub-region whose sample showed almost no severe wasting would get almost no variance, and the smoother would trust it most exactly where it is least reliable. Table `sae_estimate` keeps every direct and smoothed pair, with its shrinkage weight, so the adjustment is auditable. A test asserts that no smoothed SAM rate falls to zero.

For ANC4, the engine's EBLUPs fall within 1.7 percentage points of HealthModelling's own, in every one of the 15 sub-regions. HealthModelling used design-based standard errors, while the engine uses the binomial approximation of Equation (16.2), so exact agreement is not expected. The test tolerance is 3 points. The detailed small-area results are in Chapter 5.

16.3 Survey trends: the local linear trend model

16.3.1 Why a careful model is needed

The DHS is a periodic cross-sectional survey, not a time series. The trend series holds five national rounds for facility delivery (1995 to 2016) and three for stunting (2006 to 2016). Each round is itself an estimate with a sampling error. Joining the dots and extending the line is the usual way survey projections mislead: it treats noisy points as exact, and it invites a reader to trust a 2030 figure as much as a 2016 one.

The engine uses the model HealthModelling uses, copied with its logic unchanged. The model has three safeguards:

- it gives the survey sampling variance to the model as known observation noise, so the smoother does not chase survey noise;

- it labels every year by what kind of estimate it is;
- it refuses to project from too few rounds.

16.3.2 The model

The local linear trend is a state-space model with two unobserved states: the **level** μ_t (the true national value in year t) and the **slope** β_t (its annual change). On an annual grid from the first to the last survey:

$$y_t = \mu_t + \varepsilon_t, \quad \varepsilon_t \sim N(0, D_t) \quad (16.3)$$

$$\mu_t = \mu_{t-1} + \beta_{t-1} + \eta_t, \quad \eta_t \sim N(0, \sigma_\mu^2) \quad (16.4)$$

$$\beta_t = \beta_{t-1} + \zeta_t, \quad \zeta_t \sim N(0, \sigma_\beta^2) \quad (16.5)$$

where:

- y_t is the survey estimate in year t , observed only in survey years;
- D_t is its sampling variance, the square of the survey's standard error, supplied as **known**;
- σ_μ^2 and σ_β^2 are the variances of the random shocks to the level and the slope.

In matrix form the state $\alpha_t = (\mu_t, \beta_t)'$ evolves as $\alpha_t = T \alpha_{t-1} + (\eta_t, \zeta_t)'$, where T is the 2×2 matrix with rows $(1, 1)$ and $(0, 1)$, and $y_t = Z \alpha_t + \varepsilon_t$ with $Z = (1, 0)$.

The **Kalman filter** runs forward through the years. In each year it first predicts the state and its covariance P :

$$a_{t|t-1} = T a_{t-1}, \quad P_{t|t-1} = T P_{t-1} T' + Q \quad (16.6)$$

where Q is the diagonal matrix of σ_μ^2 and σ_β^2 . In a survey year it then updates the prediction with the observation:

$$v_t = y_t - Z a_{t|t-1}, \quad F_t = Z P_{t|t-1} Z' + D_t, \quad K_t = \frac{P_{t|t-1} Z'}{F_t} \quad (16.7)$$

$$a_t = a_{t|t-1} + K_t v_t, \quad P_t = P_{t|t-1} - K_t Z P_{t|t-1} \quad (16.8)$$

where v_t is the prediction error, F_t its variance and K_t the Kalman gain. Between surveys there is no observation, and the filter simply carries the prediction forward. The filter starts from the first observation as the level, a zero slope, and a wide initial covariance.

The two shock variances are chosen by a coarse grid search on the log-likelihood, the sum over survey years of

$$\ell_t = -\frac{1}{2} \left(\ln 2\pi F_t + \frac{v_t^2}{F_t} \right) \quad (16.9)$$

over five values of σ_μ^2 (10^{-6} to 10^{-2}) and five of σ_β^2 (0 to 10^{-3}). With three to five observations, finer optimisation would be false precision.

Finally, a **Rauch–Tung–Striebel smoother** runs backwards, so that every year's estimate uses all the surveys, not only the earlier ones:

$$J_t = P_t T' P_{t+1|t}^{-1}, \quad \tilde{a}_t = a_t + J_t (\tilde{a}_{t+1} - a_{t+1|t}) \quad (16.10)$$

$$\tilde{P}_t = P_t + J_t (\tilde{P}_{t+1} - P_{t+1|t}) J_t' \quad (16.11)$$

The smoothed level is the estimate, and its standard error s_t , the square root of the first diagonal element of $\tilde{P}_t$, gives the 95% interval, $\tilde{\mu}_t \pm 1.96 s_t$. Both are clamped to the range 0–100%.

16.3.3 Projection and the five products

Beyond the last survey, the state is projected forward with the prediction step of Equation (16.6) alone. With no new observation, the covariance, and so the interval, widens every year. Every year is labelled with its **product**, and products are drawn apart, never joined into one line (Table 16.1).

Table 16.1: The five products of the trend model

Product	Years	Meaning
observed	survey years	smoothed estimate in a year with a survey
interpolated	between surveys	model interpolation between two observed rounds
nowcast	up to 5 years after the last survey	within roughly one survey cycle of the last observation
forecast	6 to 10 years after	a projection valid only if the drivers behave as they did
extrapolation beyond evidence	more than 10 years after	returned, but never presented as a projection

A series with **fewer than three rounds is refused**: the function returns nothing rather than a projection. Two points define a line with no evidence about its stability, and an interval around such a line would mislead. A test asserts the refusal.

16.3.4 Backtesting

The model can be checked against its own history. `backtest_forecast` fits the model on the first k rounds, predicts round $k + 1$, and records the error and whether the actual value fell inside the interval, for every k from three upwards. Uganda's history allows very few such tests. Facility delivery, with five rounds, gives two: fitting on 1995–2006 to predict 2011, and on 1995–2011 to predict 2016. Stunting, with three rounds, gives none. The engine reports the individual errors rather than a summary statistic, because two tests cannot establish forecast reliability.

16.3.5 The rounds

Table 16.2 lists the national DHS estimates used.

Table 16.2: National DHS rounds used for the trends

Indicator	Survey year	Estimate	s.e.	n
Facility Delivery	1995	35.5%	1.67%	5,739
Facility Delivery	2000	36.8%	1.88%	7,072
Facility Delivery	2006	41.9%	1.26%	8,357
Facility Delivery	2011	57.4%	1.59%	7,869
Facility Delivery	2016	73.4%	0.89%	15,522
Stunting	2006	37.3%	1.17%	2,372
Stunting	2011	33.2%	1.37%	2,070
Stunting	2016	28.2%	0.87%	4,423

Source: HPRAS database, run `uga-unconstrained-2026 (report/build/data/t_trend_rounds.csv)`.

The standard errors range from 0.87 to 1.88 percentage points. The 2016 round, with the largest samples (15,522 births and 4,423 children), is the most precise, and the smoother leans on it accordingly. The 2016 facility-delivery figure of 73.4% counts all births in the five years before the survey, following HealthModelling's definition. The

engine's own microdata estimate for the most recent birth is 76.3% (Chapter 14). The two differ by definition, and the trend is kept on the all-births definition so that the rounds are comparable.

16.3.6 Results

Figure 16.1 shows the two fitted series, with each product drawn in its own style. Table 16.3 gives the observed, nowcast, forecast and beyond-evidence years; the interpolated years between surveys are drawn in the figure but omitted from the table.

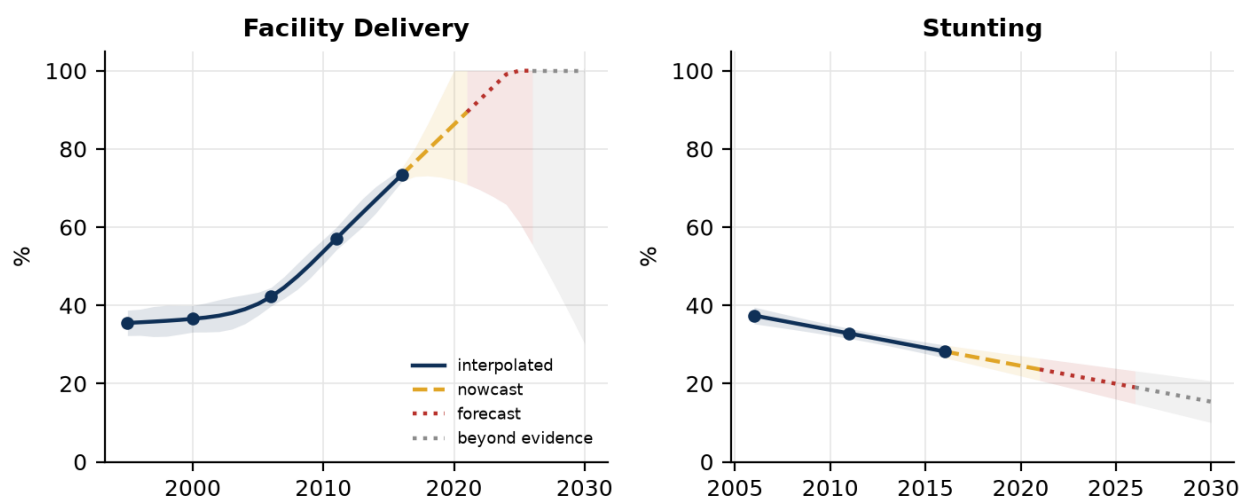


Figure 16.1: DHS trends fitted with a local linear trend: observed rounds, interpolation, nowcast, forecast and years beyond the evidence kept apart

Source: HPRAS database, run uga-unconstrained-2026

Table 16.3: DHS trend projections by product (local linear trend)

Indicator	Year	Product	Estimate	95% interval
Facility Delivery	1995	observed	35.5%	32.3% - 38.7%
Facility Delivery	2000	observed	36.6%	33.2% - 40.0%
Facility Delivery	2006	observed	42.2%	39.9% - 44.6%
Facility Delivery	2011	observed	57.1%	54.2% - 60.0%
Facility Delivery	2016	observed	73.4%	71.6% - 75.1%
Facility Delivery	2017	nowcast	76.6%	73.0% - 80.2%
Facility Delivery	2018	nowcast	79.8%	73.1% - 86.5%
Facility Delivery	2019	nowcast	83.0%	72.8% - 93.2%
Facility Delivery	2020	nowcast	86.2%	72.0% - 100.0%
Facility Delivery	2021	nowcast	89.4%	70.9% - 100.0%
Facility Delivery	2022	forecast	92.6%	69.5% - 100.0%
Facility Delivery	2023	forecast	95.9%	67.8% - 100.0%
Facility Delivery	2024	forecast	99.1%	65.8% - 100.0%
Facility Delivery	2025	forecast	100.0%	61.3% - 100.0%
Facility Delivery	2026	forecast	100.0%	55.5% - 100.0%
Facility Delivery	2027	extrapolation beyond evidence	100.0%	49.6% - 100.0%
Facility Delivery	2028	extrapolation beyond evidence	100.0%	43.3% - 100.0%
Facility Delivery	2029	extrapolation beyond evidence	100.0%	36.9% - 100.0%
Facility Delivery	2030	extrapolation beyond evidence	100.0%	30.2% - 100.0%
Stunting	2006	observed	37.4%	35.3% - 39.5%
Stunting	2011	observed	32.8%	31.5% - 34.1%
Stunting	2016	observed	28.2%	26.6% - 29.9%
Stunting	2017	nowcast	27.3%	25.5% - 29.2%
Stunting	2018	nowcast	26.4%	24.3% - 28.5%

Indicator	Year	Product	Estimate	95% interval
Stunting	2019	nowcast	25.5%	23.1% - 27.8%
Stunting	2020	nowcast	24.6%	22.0% - 27.1%
Stunting	2021	nowcast	23.6%	20.8% - 26.5%
Stunting	2022	forecast	22.7%	19.6% - 25.8%
Stunting	2023	forecast	21.8%	18.4% - 25.2%
Stunting	2024	forecast	20.9%	17.2% - 24.5%
Stunting	2025	forecast	20.0%	16.0% - 23.9%
Stunting	2026	forecast	19.0%	14.8% - 23.2%
Stunting	2027	extrapolation beyond evidence	18.1%	13.6% - 22.6%
Stunting	2028	extrapolation beyond evidence	17.2%	12.4% - 22.0%
Stunting	2029	extrapolation beyond evidence	16.3%	11.2% - 21.3%
Stunting	2030	extrapolation beyond evidence	15.4%	10.0% - 20.7%

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_trends.csv).

The engine's fit reproduces HealthModelling's forecast to within 1e-9 in every year, with identical product labels.

Stunting has fallen steadily: 37.3% in 2006, 33.2% in 2011 and 28.2% in 2016. The smoothed levels (37.4%, 32.8%, 28.2%) lie close to a straight line; the smoother pulls the 2011 value slightly towards the trend because its standard error is the largest of the three. The model projects the decline forward at a little under one point a year:

- **nowcast** for 2021: 23.6% (95% interval 20.8–26.5%);
- **forecast** for 2026, the plan's base year: 19.0% (14.8–23.2%);
- **beyond the evidence** for 2030: 15.4% (10.0–20.7%).

The interval for 2026 is about 8 points wide. It is informative: the model is confident that stunting in 2026 is well below 2016's 28.2%, and it gives a plausible range. But this is a forecast from three points ten years old. It holds only if the drivers of the 2006–2016 decline continued to work at the same pace.

Facility delivery has risen fast and unevenly: from 35.5% in 1995 to 36.8% in 2000, then 41.9% in 2006, 57.4% in 2011 and 73.4% in 2016. The model has picked up the acceleration after 2006 as a steep slope, of about 3.2 points a year at the end of the series, and projects it forward:

- **nowcast** for 2021: 89.4% (70.9–100.0%);
- **forecast** for 2024: 99.1% (65.8–100.0%);
- **forecast** for 2025 and 2026: 100.0%, with intervals of 61.3–100.0% and 55.5–100.0%;
- **beyond the evidence** from 2027: 100.0%, with the lower bound falling to 30.2% by 2030.

The central estimate for facility delivery must not be read. The projected level reaches the 100% bound in 2025 and is clamped there. A trend that ran on unchecked would pass 100%, which is impossible. The central value in 2026 is therefore an artefact of extending a straight line into a bounded quantity. The information is in the **interval**. By 2026 it runs from 55.5% to the upper bound. The data are consistent with facility delivery anywhere from slightly below the 2016 level to universal coverage. The model says the 2016 slope was steep and says nothing reliable about whether it continued, levelled off or reversed. The widening lower bound, falling to 30.2% by 2030, is the model's honest statement of how little it knows.

For planning, the facility-delivery trend is a reason to obtain a new survey estimate, not a substitute for one. The engine's HM-04 baseline for delivery uses the league-table deliveries in government and PNFP facilities, tier measured, not this projection.

16.4 The UCSN cross-check

16.4.1 What is compared

UCSN owns unit-cost estimation for the AICTEM system: salaries, workforce densities, bed stocks and coverage coefficients, each with a confidence rating and a range. The engine takes its prices from its own pinned price vintage (UGA-2026Q1) and its norms from its own norm version (UGA-2026-v1). *ucsn_crosscheck* sets five engine figures beside the UCSN coefficient for the same quantity:

Table 16.4 gives the values.

Table 16.4: The engine against the UCSN coefficients (a cross-check, never a rescale)

Item	Engine	UCSN (range)	Difference	Verdict
Medical officer, annual cost per FTE	48.6 m UGX	64.9 m UGX (64.9–64.9)	–25.1%	below UCSN range
Nurses and midwives per 1,000	1.600	1.529 (1.273–1.676)	+4.7%	within range
Physicians per 1,000	0.137	0.143 (0.098–0.172)	–4.0%	within range
Hospital beds per 1,000	0.466	0.450 (0.4–0.5)	+3.5%	within range
DPT3 coverage, baseline	79.6%	91.3% (89.5–93.0%)	–12.9%	below UCSN range

Figure 16.2 plots each engine value as a ratio to the UCSN central value, with the UCSN range as a grey band.

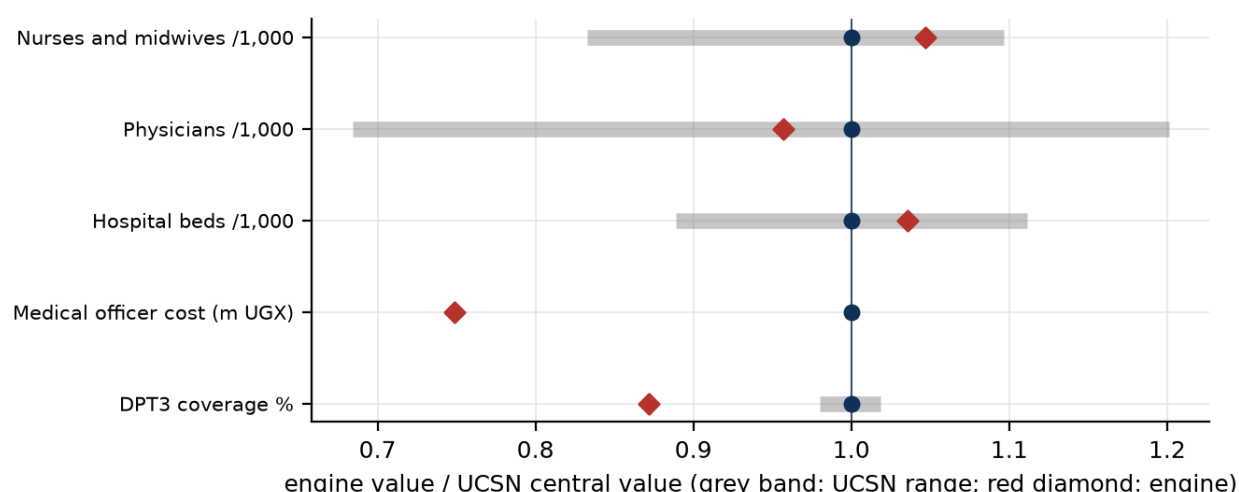


Figure 16.2: Engine against UCSN unit-cost coefficients (a cross-check, never a rescale)

Source: UCSN coefficients (vended); HPRAS

16.4.2 Reading the results

Three of the five agree. Nurse and midwife density, physician density and hospital beds all sit within the UCSN range, and within 5% of its central value. The engine's workforce in post and its bed stock, which it derives from the facility register and the bed standard for each level, are consistent with the international statistics UCSN draws on.

The medical officer's cost is 25% below UCSN. The engine's figure is its price per staff minute multiplied by the WISN available working time for the cadre, which gives the full annual employment cost of one full-time equivalent: 48.6 m UGX. UCSN's figure is the **gross salary** alone, at 64.9 m UGX. A full employment cost should never sit below the gross salary it includes. The disagreement therefore points to the engine's price for medical officers in the UGA-2026Q1 vintage. Establishing why it is low is for the owner of that price. If it is confirmed, medical officer time is under-costed throughout the requirement, in every service that uses it.

DPT3 coverage is 12.9% below UCSN. The engine's baseline is 79.6%, the population-weighted district coverage it uses in HM-04. It comes from the MoH district league table, calibrated down to the DHS 2016 survey level by a

factor of 0.8825, and it agrees with the survey figure of 79.7%. Uncalibrated, the administrative returns put pentavalent-3 coverage at 89.6% and exceeded 100% in 33 districts. UCSN's 91.3% is the WHO/UNICEF estimate. The two are different kinds of evidence: the survey observes children in a sample of households, while the WHO/UNICEF estimate draws on administrative returns as well as surveys. The engine deliberately plans immunisation on the survey level, not on administrative returns, and a test enforces this: no stored DPT3 value may claim the measured tier, and the calibration must be recorded in its source. The baseline matters for the plan because revealed capacity and the gap to target are both computed from it.

16.4.3 Never a rescale

The engine reports these comparisons. It never applies them. A test asserts that running the UCSN cross-check leaves every price in the database unchanged. A disagreement is a question for the **owner of the norm**, answered by a new, reviewed norm or price version that is recorded with its justification. The engine does not quietly adopt the outside figure. This is the same rule the calibration guidance applies to all norms (Chapter 17): a norm is a standard, and an observation that differs from it is a finding, not a calibration error.

16.5 External financing and the budget total

The last two cross-checks compare the budget side with HealthModelling's fiscal extract for FY2026/27.

The engine's budget parse agrees with HealthModelling's. Both read the same approved MoFPED budget, independently. The totals agree within 1.2% on every line (Table 16.5).

Table 16.5: Two independent parses of the FY2026/27 approved health budget

Line, FY2026/27	Engine (bn UGX)	HealthModelling (bn UGX)	Difference
Approved total	5,271	5,242	+0.5%
Wage	1,475	1,486	-0.7%
External	1,255	1,241	+1.1%
Domestic	4,016	4,002	+0.4%

External money is concentrated on a few lines. The Global Fund grant is 835 bn UGX, against a modelled requirement of 284 bn for antiretrovirals and 358 bn for all HIV, TB and malaria medicines. GAVI's 165 bn compares with 80 bn for vaccines. Ratios above 100% (294%, 233% and 205%) do not mean over-funding. The grants also pay for nets, diagnostics, campaigns, cold chain and programme costs that lie outside the modelled catalogue. They show how heavily these lines depend on a single external source. All external financing, 1,241 bn UGX, is 63% of the full modelled requirement of 1,966 bn; 241 bn of it is spread over projects with no funder named in the extract.

16.6 Data quality and limitations

- **The trends rest on few, old points.** Three rounds for stunting and five for facility delivery, the latest in 2016. Nowcasts and forecasts are conditional on the drivers behaving as they did, and the facility-delivery central estimate is clamped at 100%.
- **Only two indicators are trended.** The vendored rounds cover stunting and facility delivery. Other indicators would need their own rounds, with at least three for a projection.
- **The small-area variance is approximate.** The binomial variance with a design effect of 2.0 stands in for design-based standard errors, and the loader states this in every source string it writes.
- **UCSN coefficients carry their own status.** Some are marked APPROVED and others CANDIDATE in UCSN. The medical officer salary is a single observation with no range.

- **The vendored data are a snapshot.** They were copied from HealthModelling and are refreshed by copying again. A changed reference shows up as a failed test, which is the review step.

16.7 Implications for planning

- **Commission new survey evidence before relying on 2016 baselines.** The facility-delivery trend is consistent with anything from 55.5% to universal coverage in 2026. Only a new round, or routine data validated against one, can narrow that. The DHS 2022 results, already used for the mortality baseline, are the obvious next step for the trend rounds.
- **Refer the medical officer price to its owner.** An employment cost 25% below the UCSN gross salary suggests an outdated salary scale in the UGA-2026Q1 price vintage. The correction belongs in a new price vintage, reviewed and recorded, not in an automatic rescale.
- **Be explicit about which DPT3 figure is planned on.** The engine plans on the survey level (79.6%). The WHO/UNICEF estimate is 91.3%. Readers of the plan should know that the immunisation gap and the revealed capacity rest on the lower of the two.
- **Read the external-financing ratios as dependence, not sufficiency.** Global Fund money exceeds the modelled ARV requirement nearly threefold, and GAVI money twice the vaccine requirement. What the ratios measure is the exposure of these lines to a change in a single funder's commitment.

CHAPTER 17

17 Calibration and validation

A reader who has followed the plan this far will reasonably ask how much of it to believe. This chapter sets out the evidence. It explains what can and cannot be validated in a normative planning model, describes the automated tests that guard the engine, reports the known-answer checks and the reproductions of published figures, and states the plausibility checks the plan passes and the two it does not. It ends with the limits of validation: what no test can establish.

17.1 What validation means for a normative model

A normative planning model cannot be validated by prediction. It computes what *should* be delivered at target coverage and what that would cost, not what *will* happen. No future observation can show the requirement of 1,966 bn UGX for 2026 to be right or wrong, because it is conditional on targets that are policy choices.

The engine is validated instead in three other ways, each automated:

- **Internal consistency.** Every accounting identity holds exactly, every quantity sums from districts to the nation, and the same inputs give the same outputs.
- **Reproduction of the observed present.** Where the engine computes something that has also been measured or published, such as a survey indicator, a budget total or an area, it must reproduce it.
- **Expert plausibility.** Aggregate ratios, such as the wage share or the cost per person, must fall in ranges that informed readers expect. Where they do not, the difference must be explained.

A fourth element, expert review of the norms themselves, cannot be automated. It is discussed under the limits of validation.

17.1.1 Calibration without overwriting norms

Calibration in this engine follows one rule: **norms are not rescaled to match observation**. A norm is a standard of care. If observed drug use is 60% of the norm, that usually means patients are not receiving the standard treatment. It is a finding, not a calibration error, and rescaling it away would hide exactly the gap the engine exists to reveal. A norm is changed only where the evidence says the norm itself is wrong: a mis-specified time standard, an obsolete protocol or a unit error. Every change is recorded with its justification in a new norm version.

The same rule governs the cross-checks against outside evidence. When the UCSN medical officer salary disagrees with the engine's price by 25% (Chapter 16), the engine reports the disagreement and changes nothing. A test asserts that running the cross-check leaves every price unchanged.

Where the engine *does* calibrate, it says so in the data. The clearest case is immunisation. Administrative returns put pentavalent-3 coverage at 89.6% and above 100% in 33 districts, against 79.7% in the DHS 2016. The district returns are therefore scaled to the survey level, the calibration is written into each value's source string, and no calibrated value may claim the `measured` tier. A test enforces all three conditions.

17.2 The test suite

17.2.1 Five layers

The test suite in `test/runtests.jl` is organised in five layers, following the engine's validation specification, and followed by testsets for each module and for every external data source. At the time of this report, **776 tests** pass. They include regression tests for two defects found while the report was written: the modal binding constraint of the gap matrix, and a baseline of deaths that covered only funded cells. Both were corrected before the final run.

Table 17.1: The five layers of the test suite

Layer	What it asserts	Examples
1. Unit	Pure functions give known answers	WISN available working time; effective quantity with share of cases and wastage
2. Identity	The planning identity and every accounting relationship hold exactly	$Q = N \times C^* \times v$; unit cost equals the sum of its lines; recurrent plus capital equals total; two aggregation paths agree for all 100 service-level packages
3. Property	Monotonicity and sign properties hold for any input	Raising a coverage target never reduces volume or cost; doubling the population doubles every requirement; zero volume gives zero requirement
4. Gates	Failures are fatal, never silent	A missing norm or a missing price raises an error rather than costing at zero; pre-run gates pass; no column anywhere is a composite index or score
5. Plausibility	Magnitudes are of the right order	Unit costs of ANC, outpatient care, DPT3 and caesarean section within stated USD bands; hospital care costs more per unit than primary care; staff share of recurrent cost between 25% and 85%

Table 17.1 summarises the layers. **Identity tests** are the backbone. The planning identity, which gives required volume as need times target coverage times units per case, is tested directly, and so are the relationships built on it. **Gate tests** protect against the failure that most damages a planning model's credibility: silently costing a missing norm at zero, which produces a number that looks plausible and is wrong. A missing norm or price raises an error, and the pre-run gates (G1, a package with no bill of materials; G2, a resource with no price; and a check that each service's level mix sums to one) must pass before any run. The plan run for this report opens with "pre-run gates: pass".

Beyond the five layers, testsets cover each module chain and the principles. National totals must equal the sum of districts (principle P6). Two runs with identical pins must give identical numbers. The gap matrix must keep its four dimensions separate (principle P3). Deaths averted must always carry a range, and no scenario may be declared the winner (principle P8).

17.2.2 Golden regression

A regression testset pins the headline figures of a full test run inside deliberate bands. Any movement outside them is either a bug or a deliberate change, recorded with a reason in the test itself. Each widening so far is documented in the test alongside the catalogue change that caused it, such as the addition of HIV services, the rest of the immunisation schedule, or family planning.

Table 17.2: Golden regression bands and the plan run's values, 2026

Headline	Band asserted	Plan run
Population	40–55 million	47.4 million
Requirement	1,300–2,200 bn UGX	1,966 bn UGX
Workforce requirement (WISN)	20,000–40,000 FTE	32,775 FTE
Districts in the gap matrix	exactly 122	122
Requirement per person	3–12 USD	11.2 USD

Table 17.2 shows that the plan run sits inside every band. The requirement per person, 11.2 USD, is close to the top of its band. Any further addition to the catalogue will need the band reviewed.

The district count is a reminder of why such tests exist. It once read 123, because the league table's misspelling "KYAKWANZI" made Kyankwanzi a second district, planned for twice. The canonical district function now folds it, and the test holds the count at 122.

17.3 Known-answer checks

Several tests compute a result whose correct value is known independently, from a worked example in the engine's manual or from arithmetic.

WISN available working time. The manual's doctor example has 260 working days, 21 days of leave, 12 public holidays, 5 days of training, 8 days of absence, 8 hours a day and a 20% category allowance for non-service time. The available working time is

$$AWT = (260 - 21 - 12 - 5 - 8) \times 8 \times 60 \times (1 - 0.20) = 82,176 \quad (17.1)$$

minutes a year. The test asserts this value exactly. It also asserts that 600,000 doctor-minutes of workload convert to 7.30 FTE, and that this is more than 1.4 times the naive calculation of 10,000 hours divided by 2,080 hours a year, which gives 4.8. The difference is entirely leave, training and non-clinical time. The test exists to stop anyone "simplifying" the WISN calculation back to the naive one.

The immunisation worked example. For 1,000,000 eligible children at 95% target coverage and three doses each, the required volume is 2,850,000 doses. Expanding the DPT3 norm gives 3,135,000 vaccine doses (10% wastage) and 2,992,500 syringes (5% wastage). It also gives 14,250,000 enrolled-nurse minutes (5 minutes a dose) and 2,280,000 village health team minutes (2 minutes for 40% of doses). The test also asserts that the nurse minutes carry **no** vaccine wastage: wastage belongs to the commodity, not to the service volume.

Spatial statistics. On a synthetic chain of eight districts, values clustered at the two ends give a Moran's I above 0.5. Alternating values give an I below -0.9. The same inputs give the same permutation p-value, because the seed is fixed. A concentration index of supply that rises with need is above 0.1, and of supply that falls with need is below -0.1.

The quintile concentration index. Equal values in every quintile give 0; an indicator present only in the richest quintile gives +0.8; one present only in the poorest gives -0.8.

The three budget views. The programme, economic and administrative views of the budget are three different aggregations of the same cost cells, and they must reconcile. In the plan run they agree on 1,966 bn UGX, with a maximum difference of 0.0017 UGX.

17.4 External reproductions

The strongest evidence that the engine reads its data correctly is that it reproduces published or independently computed figures. Table 17.3 lists the reproductions.

Table 17.3: External reproductions: the engine against independent figures

What is reproduced	Engine	Reference	Agreement
FY2025/26 approved health budget, from the MoFPED files	4,614 bn UGX	4,591 bn UGX (UNICEF budget brief)	+0.5%; test tolerance 2%
FY2026/27 budget, four lines (total, wage, external, domestic)	5,271 bn total	5,242 bn total (HealthModelling fiscal extract)	all four lines within 1.2%

What is reproduced	Engine	Reference	Agreement
HIV prevalence, adult-weighted mean of UPHIA regions	5.7%	5.8% national (UPHIA 2020–21)	within the published interval 5.3–6.3%
Uganda's land area, sum of 122 districts	241,413 km ²	241,550 km ² (official)	–0.06%
DPT3, children 12–23 months, DHS 2016	79.7%	79.7% (published)	exact to one decimal
Measles first dose, DHS 2016	80.2%	80.2% (published)	exact to one decimal
ANC4, DHS 2016	60.2%	60% (published)	within rounding
Equity by wealth and residence, 32 cells	–	HealthModelling export	to 1e-6, identical case counts
Sub-regional ANC4 EBLUP, 15 sub-regions	–	HealthModelling Fay–Herriot	within 1.7 points (tolerance 3)
Trend forecasts, stunting and facility delivery	–	HealthModelling forecast	to 1e-9, identical product labels
Fay–Herriot, Python port	–	Julia original	to 1e-10

The budget. The engine reads the MoFPED approved budget files line by line and selects the health lines itself. Its FY2025/26 total, 4,614 bn UGX, is within 0.5% of the 4,591 bn published in the UNICEF Health Sector Budget Brief. The test also guards against a specific failure. Vote numbers were reassigned in FY2022/23, and none of the votes for sports, science and technology, embassies, retirement or free zones may be read as health.

HIV geography. The engine apportions its national ART need to districts by the UPHIA 2020–21 regional prevalence, around an unchanged national total. The adult-weighted mean of the regional prevalences is 5.7%, against the published national 5.8% (95% interval 5.3–6.3%). A test also asserts that the ratio of South Buganda to Karamoja need stays near the published ratio of 8.1% to 2.1%. A further test checks the national total: ART need must land between 1.0 and 1.15 times the UNAIDS 2024 figure of 1,527,238 people living with HIV, taking the adult share as 95%.

Hypertension and mortality. Hypertension need must reconcile to the STEPS 2014 prevalence of 26.4% among adults aged 18–69 (the test band is 22–28%). The mortality baseline must be the DHS 2022 figures: 189 maternal deaths per 100,000 live births, 52 under-five deaths per 1,000 and 22 neonatal deaths per 1,000.

Survey indicators. Two denominator errors in the DHS loader were found through these tests. Immunisation was first computed over all under-fives rather than children aged 12–23 months, which put DPT3 at 42%. Women with no recent birth were counted as "no ANC4". Both are fixed and now pinned to the published DHS 2016 values.

17.5 The optimiser and outcome gates

Two gates protect the optimisation and outcome modules.

The optimiser must match or beat every rule-based scenario on its own objective. If a simple rule could avert more deaths than the optimiser, the optimiser would be mis-specified. In the plan run the optimiser averts **20,053** deaths (range 13,381–26,299), against **15,010** (range 10,321–19,293) for scenario E, the best of the rules on the same objective. The gate passes. A companion test asserts that more money never buys fewer lives.

The linear and multiplicative forms of the outcome model must agree. HM-09 combines services acting on the same cause multiplicatively, so that deaths averted can never exceed the baseline. The optimiser needs a linear objective, and uses the linear approximation. If the two differ by more than 10%, the optimiser's objective is materially distorted. In the plan run they differ by **5.9%**, within tolerance.

The outcome tests also assert that deaths averted never exceed baseline deaths, that every result carries a real range, and that a scenario with no money averts exactly nothing.

17.6 Plausibility cross-checks

The last layer of checks is applied after the run and reported, never used as a method. A result outside its expected range is a prompt to examine the norms, not to override the result. Table 17.4 gives the plan run's values.

Table 17.4: Plausibility cross-checks on the plan run, 2026

Check	Plan run	Expected range	Result
Wage bill share of recurrent cost	45.7%	45–70%	within range
PHC share of total, by service tier	79.4%	35–60%	above
HC II–IV share, by facility level	70.0%	35–60%	above
Health requirement as % of government expenditure	2.7%	0–20%	within range
Requirement per person	11.2 USD	5–80 USD	within range

17.6.1 Why the wage share sits at the bottom of its range

At 45.7%, the wage share of the recurrent requirement is just inside its expected range. The requirement is heavy in commodities: antiretroviral therapy alone is 24.0% of the 2026 requirement, and 296 bn UGX of its 471.5 bn is medicines, against 116 bn for staff. Use of goods and services (982 bn UGX) exceeds compensation of employees (827 bn) in the economic classification. Whole-system wage shares are higher, because administration, supervision and services outside the catalogue are staff-intensive.

17.6.2 Why the PHC share is above its range, and why that follows from the catalogue

The primary health care share is **79.4%** by service tier and **70.0%** by facility level. Both are above the expected range of 35–60%. The result is expected, and it follows directly from what the engine models.

The requirement covers **28 modelled services**, not the whole health sector. Of these, 21 are primary-tier services: outpatient care, antenatal and postnatal care, normal delivery, the immunisation schedule, family planning, malaria, TB and HIV testing and treatment, SAM, NCD screening, hypertension and severe mental disorders. Only seven are hospital services: caesarean section, obstetric complications, severe childhood illness, sick newborn care, complicated SAM, major surgery and the general inpatient bed-day. Together those seven cost 405 bn UGX of the 1,966 bn requirement, 20.6%, which leaves 79.4% for the primary tier.

The benchmark range describes whole-system spending. In a real health budget, hospitals carry much that is outside the catalogue: specialist care, referral diagnostics, chronic hospital care, teaching and administration. The engine does not model these, so the hospital share of the modelled requirement is bound to be lower than the hospital share of a health budget. The largest single service, antiretroviral therapy at 471.5 bn, is classed as primary care. That alone moves the share by 24 points.

The facility-level measure is lower, 70.0%, because some primary-tier services are delivered in hospital outpatient departments under the normative level mix. It is still above the range, for the same reason.

The budget reconciliation shows the same pattern from the other side. The modelled requirement for primary health care (HC II–IV), 1,376 bn UGX, is 1.10 times the approved budget line for primary care, 1,248 bn. The requirement for hospitals, 590 bn, is 0.65 times their budget of 913 bn. These are ratios to read, not gaps to close: the budget funds what the system does now, including everything outside the catalogue, while the requirement costs the modelled services at target coverage.

The "above" flag should therefore be read as a statement about scope, not as an error. It would become a concern only if the catalogue were extended to cover hospital services comprehensively and the share stayed above the range.

17.7 Limits of validation

The tests and reproductions establish that the engine computes what it says it computes, reads its data correctly and reproduces what can be reproduced. They do not establish everything a reader might want.

- **The norms have not been clinically reviewed.** The norm version used here, UGA-2026-v1, is recorded in the database as a **draft**: "constructed from published standards. NOT APPROVED: requires clinical review service by service." The engine's specification requires a structured expert review before any norm set moves to approved status. Each service's full bill of materials, time norms, unit cost and required volume is printed as a norm card and reviewed with the relevant programme managers, and every challenge and resolution is recorded. No automated test can replace that review. It is the step that determines whether the Ministry believes the output.
- **The base-year reconciliation is incomplete.** The specification asks the engine to reproduce current resource use: implied staff time against HRIS, implied commodity use against LMIS, and modelled cost at current coverage against actual expenditure within 10%. No LMIS data is on hand, so commodity availability is unknown. The commodity gap is taken as the full requirement and flagged, never assumed to be met. The budget reconciliation compares objects that differ in scope and is a ratio to read, not a reconciliation to within 10%.
- **No sensitivity analysis is automated yet.** The specification calls for one-at-a-time variation of each major parameter class by $\pm 20\%$, and a tornado chart of the largest drivers of cost and deaths averted. It is not yet implemented. The deaths-averted ranges reflect uncertainty in the effectiveness parameters only, not in the norms, prices or need rates.
- **Plausibility ranges are broad.** A per-person cost between 5 and 80 USD, or a government-expenditure share below 20%, would catch a unit error but not a moderate mis-specification.
- **Reproduction is not validation of the source.** Reproducing the DHS, the UPHIA or the MoFPED figures shows that the engine reads them correctly. It does not make them current or correct: the DHS 2016 baselines are ten years old, and the access layer dates from 2020.
- **Tests cover the code that exists.** A service missing from the catalogue is invisible to every test. The requirement is the requirement of 28 modelled services, and nothing here validates the parts of the health sector it does not model.

17.8 Implications for planning

- **Rely on the arithmetic; review the norms.** The identities, gates and reproductions give strong assurance that the engine turns inputs into outputs correctly and reads its data as published. The main remaining uncertainty is in the norms themselves, which are an unreviewed draft. Clinical review of the norm cards, service by service, is the most valuable next validation step.
- **Read the PHC share as a statement about scope.** The PHC share of 79.4% is above the whole-system benchmark because the modelled catalogue is overwhelmingly primary care. It should not be read as a recommendation to shift spending towards primary care. Nor should it be "corrected" by rescaling.
- **Commission the missing reconciliations.** Access to LMIS stock data and HRIS staff records would allow the base-year reconciliation the specification calls for, and would replace the assumed commodity gap with a measured one.
- **Add a sensitivity analysis before the plan is used for allocation decisions.** Staff time norms and salary levels are expected to be the largest drivers of cost. The medical officer cost is already 25% below the UCSN salary. A tornado chart would show how far the requirement and the scenario comparison depend on such parameters.

CHAPTER 18

18 Integration with national systems, the interface and institutional use

A plan that stays inside a model changes nothing. For the analysis in this report to affect Uganda's health budget, three things are needed. It has to reach the systems that set the fiscal envelope and assemble the budget. The people who prepare the sector submission have to be able to use it. And the norms that drive it have to be governed by the institutions that own them. This chapter describes how HPRAS connects to the other EDIP models and to national systems, which of those connections are live today and which are stubs, how ministries interact with the engine through its web application, command line and workbooks, where the build stands against its plan, and how the norms are to be versioned and approved.

The chapter matters for one reason above all. Several figures in this report, notably the allocation scenarios, depend on a fiscal envelope that did not come from the macro-fiscal model. The rules below keep that fact visible, so that no reader mistakes a planning illustration for a fiscal projection.

18.1 HPRAS in the EDIP system

HPRAS is one module of a larger government planning system. It consumes prices, estimates and a fiscal envelope from other EDIP models, and it emits an expenditure requirement that feeds the macroeconomic and budget models. The division of labour is fixed in the engine's scope (`docs/00_SCOPE_AND_PRINCIPLES.md`, `docs/13_INTEGRATION.md`):

- **UnitCostModelling (UCSN)** owns unit-cost estimation. HPRAS takes a resolved price snapshot pinned to a price vintage and does not estimate prices itself.
- **HealthModelling** owns survey estimation, small-area estimation, forecasting and causal analysis. HPRAS consumes its estimates, not its methods.
- **FINEX** determines the fiscal envelope. HPRAS sends it the health expenditure requirement and receives the envelope back.
- **CDCGE** computes general-equilibrium effects. HPRAS sends it the health shock and deliberately computes no "return on investment" of its own. A partial-equilibrium multiplier computed in the health module would disagree with CDCGE's answer and be misused.
- **MTEF and budget models** receive the sector submission in the national chart of accounts and return ceilings by vote.
- **Monitoring, evaluation and learning (MEL)** receives the plan's targets and returns observed performance, which closes the loop for the next planning cycle.

18.1.1 Design rules

Every exchange follows five rules, enforced in `src/Integration.jl`:

Rule	Reason
Exchange files or tables, not in-process calls	the models run on different schedules and machines
Every exchange is versioned and dated	a run must be reproducible after the counterpart changes
Every exchange has a schema contract	silent column changes are the main failure mode
A missing counterpart yields a documented fallback, never a silent zero	a stub must never pass for a real exchange

Rule	Reason
Exchanges are idempotent	re-running produces the same result

The manual requires every interface to be built in the first phase, even against a stub. An integration added later means rewriting the modules that should have produced its inputs.

18.2 Exchange interfaces and their status

Table 18.1 lists the ten exchange interfaces and their status in the run behind this report, as printed by the engine's `integration_status` function at the end of every plan run. There are three kinds of status:

- **emitted:** the engine wrote the outbound file;
- **snapshot:** real data were copied from the counterpart and marked with a `SNAPSHOT` file, so that they are never reported as a live feed;
- **stub:** no counterpart file exists and a documented fallback is in use.

Table 18.1: Exchange interfaces and their status, run uga-unconstrained-2026

Interface	Direction	Counterpart	Content	Status
UCSN prices	inbound	UnitCostModelling	unit-cost coefficients	snapshot (1 file, vendored UCSN coefficients)
FINEX envelope	inbound	FINEX	fiscal envelope by year, cost class and financing source	stub, fallback in use
HealthModelling estimates	inbound	HealthModelling	small-area, equity, trend and fiscal aggregates	snapshot (2 files, vendored exports)
SDI travel-time access	inbound	Spatial data infrastructure	share of population within 30/60/120 minutes' drive and 60 minutes' walk	snapshot (1 file, vendored via HealthModelling)
MTEF ceilings	inbound	MTEF / budget model	ceilings by vote	stub, fallback in use
MEL actuals	inbound	MEL	observed performance	stub, fallback in use
FINEX requirement	outbound	FINEX	health expenditure requirement	emitted (3 files)
CDCGE shock	outbound	CDCGE	four macro channels	emitted (3 files)
MTEF submission	outbound	MTEF / budget model	sector MTEF in the chart of accounts	emitted (3 files)
MEL targets	outbound	MEL	plan targets by district, service and year	emitted (3 files)

The pattern is clear. All four outbound interfaces emit, because the engine controls its own outputs. Three of the six inbound interfaces are snapshots of real data. The other three — the FINEX envelope, the MTEF ceilings and MEL actuals — are stubs, because the counterparts are not yet producing files. For the SDI access table, the status line itself records that a live SDI export should replace the snapshot when one becomes available.

18.2.1 What the outbound files carry

Each outbound file is written to a dated directory under `data/exchange/outbound/`, named by counterpart, country and date, with the run identifier on every row. In this run they are `health_requirement_UGA_20260922.csv`, `health_shock_UGA_20260922.csv`, `health_mtef_UGA_20260922.csv` and `health_indicators_UGA_20260922.csv`.

- **To FINEX:** the requirement by year, cost class and economic (GFS) code, on a requirement basis. The **wage bill travels on its own channel**, because public wage bills usually face a separate hard constraint: a health plan can be affordable on total spending and infeasible on the wage bill. The import content of medicines, vaccines, diagnostics, consumables and equipment is also reported separately, because it matters for the balance of payments.
- **To CDCGE:** four separate channels rather than one spending number: government consumption (recurrent requirement), government investment (capital requirement), labour demand (FTE required) and human capital (DALYs averted). No multiplier is emitted.
- **To the MTEF:** the sector MTEF under the Ministry of Health vote code 014, built from the same medium-term framework that Chapter 13 reports, including induced recurrent cost and wage drift.
- **To MEL:** the required volume of every service by district and year, linked to the programme-budget output code and indicator, so that monitoring can compare delivery with the plan.

18.3 A fallback envelope is never presented as FINEX

The rule that governs all of Chapter 11 is short: **a number produced against a stubbed envelope must never be presentable as though it came from the macro model** (*docs/13_INTEGRATION.md*, §13.9). The engine enforces it in code. `fetch_envelope` reads the latest FINEX file for the country if one exists. If none does, it returns the fallback amount together with `source = "fallback"`, the note "none — FINEX not available" and a flag. Every caller prints that flag. The plan log of this run records:

```
envelope source: fallback (none — FINEX not available). WARNING: a fallback envelope is in use. No figure
derived from it may be presented as a FINEX result (§13.9).
```

The fallback used in this report is not an arbitrary number. It is the approved increase in the health budget between FY2025/26 and FY2026/27, 413 bn UGX, in the institutions that deliver the modelled services: local-government primary health care, KCCA, National Medical Stores and the referral hospitals. The whole health budget grew by 657 bn UGX over the same period. The increment is observed in the approved budget files, but it is not a macro-fiscal projection, and it says nothing about what FINEX would find affordable in the outer years. Where the budget files are not loaded, the web application falls back further, to an illustrative envelope of USD 100 m, and labels it "USD 100 m illustrative - budget files not loaded; not a FINEX result".

For readers of this report, the practical consequence is that the scenario comparisons in Chapter 11 and the outcomes in Chapter 12 show what a given increment would buy under each rule. They are not a forecast of the increment Uganda will have. When FINEX supplies an envelope, the same engine re-runs the allocation and the fallback flag disappears.

18.4 The web application

HPRAS includes a web application (`web/App.js`, started with `hpras serve` or `app.js`), built on the Genie framework. Its design follows one principle from the interface specification (*docs/14_INTERFACE.md*): the opening screen defines what the product is. An application that opens on a model-run screen teaches users that it is a research tool. One that opens on the planning questions teaches them it is a decision system. The six questions are therefore the navigation, held as a permanent left rail. The application is a thin JSON interface over the engine and computes nothing the engine does not. It serves plain JavaScript and inline SVG maps without any external content delivery network, so it works offline, as district offices often must.

Table 18.2 summarises what each question shows.

Table 18.2: The web application, organised by the six planning questions

Question	What the user sees	Interaction
1 What are the health needs?	population by group, trend and district; need, required volume, target and cost by service; every GIS layer with its value, local cluster and quality	a coverage-target slider for any service moves volume and cost live through $Q = N \times C^* \times v$
2 What do we currently have?	facilities by level, ownership and located share; staff required, established and in post by cadre; capacity by service with the binding constraint named	capacity rows show which constraint binds most often and in how many districts
3 Where are the gaps?	the district gap matrix in four separate columns, with induced recurrent cost beside capital to close and access alongside	a user-chosen ranking criterion (never a composite score); drill-down to a district's service gaps
4 What will it cost?	the MTEF with induced recurrent cost; cost by service and by resource class	capital always shown with its induced recurrent
5 Where should resources go?	all scenarios in a fixed order with coverage, districts above floor, FTE, deaths averted with range, spent and unallocated money and the reason; allocation maps	the equity slider γ re-computes scenario E and re-draws its map live
6 What will we achieve?	coverage before and after by scenario; deaths averted by outcome with ranges; equity by wealth, residence and geography; affordability, execution, external financing and cross-checks; survey trends by product	the impact chain from money to outcome for any district and service

Behind the six questions sits the **analysis workbench**, which carries every analysis of this report as a live screen. It holds 85 analyses grouped by the chapter they reproduce. Each one states its method, draws its chart and its district map, and offers its table sorted, filtered and downloadable as CSV. Where an analysis varies by something the reader might want to change, the screen offers the control: the year, the service, the district, the cadre, the scenario, the mapped layer, the sub-region, the survey or the cause of death.

Four screens do what a document cannot.

- **The scenario laboratory** allocates any envelope under any rule, at any equity weight γ and any absorption multiple, and reports what it buys: coverage gain, districts above the floor, money per person by district, services funded and deaths averted with their range. It calls the same functions the plan run calls, and writes nothing, so a preview is exactly what the plan would produce with those settings.
- **The layer explorer** puts any two of the 41 mapped indicators side by side, with their correlation across districts, the fitted line and the concentration curve and index of one against the other.
- **District and sub-region profiles** show one district against the national distribution, with its rank on every indicator, its service gaps and what each allocation would give it.
- **The formulas screen** renders the compendium in Annex A, so a figure on screen can be traced to the equation that produced it.

The workbench is declared in one file (`web/Analyses.jl`), and a test runs every analysis against the current database, so a screen cannot silently go blank after a change to the engine.

Four features carry the interface principles into practice.

- **The equity slider.** Moving γ between 0 and 3 calls the same allocation function that records scenario E in the plan run, so a preview is exactly what the scenario would fund at that γ , with absorptive capacity caps included. At $\gamma = 0$ the allocation follows population only; higher values concentrate money on the worst-served districts. Beside the map, the page states how much of the envelope is allocated, to how many districts, and why any money is left unallocated. This one interaction makes the trade-off between equity and aggregate gain visible without the application ever choosing a side.

- **The explain modal.** Every figure that can be decomposed is clickable. A click calls the engine's `explain` function for that district, service and year and opens its factor decomposition: population × need rate × coverage target × units per case, then the full bill of materials with each line's quantity, share, wastage, price, source and quality tier, together with the time taken.
- **Maps.** Every GIS layer (41 layers across the ten modules) can be mapped by district with its local Moran cluster, and the allocation maps re-render for each scenario.
- **Quality and neutrality.** Every table carries the quality tier of its figures, reduced in order of severity so that an aggregate never looks better evidenced than its inputs. Scenarios are always shown together in a fixed alphabetical order, with the note that none is recommended. The FINEX stub warning is printed on the allocation page.

The application also offers a run comparison (any two runs, service by service) and a list of every export of the current run. Because the database is opened in write-ahead-log mode, planners can keep using the application while the engine writes a new run into the same file.

18.5 The command line

The `hpras` command line (`bin/hpras.jl`) exposes the same engine for analysts and for scripted use. Every command maps onto an engine function or loader that already exists. A command the engine cannot yet honour says so and exits with an error rather than pretending.

Command	What it does
<code>hpras migrate</code>	rebuild the database schema and norms tier
<code>hpras seed --country UGA</code>	full rebuild: norms, observations, DHS, supply, budget and GIS base layers, in order
<code>hpras load --source <s></code>	re-run one loader (estate, dhs, supply, budget, nhfr, geo, geocode, piap)
<code>hpras norms cards --service <id></code>	print a service's bill of materials by facility level, for clinical review
<code>hpras validate --country UGA</code>	run the pre-run gates: missing norms, missing prices, level mixes
<code>hpras run --country UGA</code>	the full plan run, HM-01 to HM-10
<code>hpras explain --run <id> --cell <district>:<service>:<year></code>	the factor decomposition of one figure, with its timing
<code>hpras diff --run <a> --run </code>	compare two runs service by service
<code>hpras report --run <id> --type <t></code>	write a report: a ministry workbook, the six-question HTML report, a district profile or the atlas
<code>hpras gis --run <id></code>	evaluate every GIS layer, compute spatial statistics and render maps
<code>hpras serve</code>	start the web application

18.6 Ministry workbooks and reports

Ministries work in spreadsheets and documents, and a system whose output cannot leave it will not be used. Each plan run therefore writes six XLSX workbooks (`src/Exports.jl`), built only from result tables already in the database:

Workbook	Audience	Contents
Investment case	Cabinet, development partners	need, capacity, gaps, cost, what the money buys and what is not done
Workforce plan	human resources, training institutions	WISN requirement against staff in post, recruitment by cadre and year, by district

Workbook	Audience	Contents
Programme budget	Ministry of Finance	programme, economic and administrative views, the reconciliation check, output indicators and the MTEF with induced recurrent cost
Investment programme	infrastructure and procurement	sites by district, capital phasing and the induced recurrent cost of each year's capital
Scenario brief	Minister, senior policy	all scenarios side by side with outcome ranges, none marked recommended
Tables	analysts	every result table of the run, one sheet each

Each workbook opens with a cover sheet and a generated narrative. Every narrative sentence is computed from result cells and cites the table it came from, so no narrative can drift out of step with the numbers. Each workbook closes with the Sources sheet and a quality-tier legend. The workbooks enforce the report's principles mechanically:

- no capital figure without its induced recurrent cost beside it;
- no deaths-averted figure without its range;
- no scenario marked recommended, best or optimal;
- amounts in UGX, with a USD column at 3,700 UGX per USD where a reader expects one.

Alongside the workbooks, each run writes a self-contained HTML report of all six questions, with every figure's quality tier and a worked factor decomposition; a district health profile as CSV; and the GIS atlas as PDF maps for each module.

18.7 Build-plan status

The engine was built in the seven phases of the build plan (*docs/17_BUILD_PLAN.md*). Each phase ends in an acceptance gate. Table 18.3 summarises where the build stands, judged against the deliverables in the plan and the evidence in the code and in this run.

Table 18.3: Build-plan status against the phases of docs/17

Phase	Scope	Status in this build	Outstanding
0 Foundations	schema, migrations, provenance	built: five forward-only migrations; SQLite working copy; <code>explain()</code>	PostgreSQL deployment on the EDIP cluster
1 Norms database	service norms, bills of materials, catalogues, versioning	built for 28 services; resolver raises rather than defaults; gates G1 and G2 enforced	clinical review; norm-entry workbook for import and approval; the norm version is draft
2 Needs chain	HM-01 to HM-03	built and tested; identity holds for every service; <code>explain()</code> decomposes any cell	district population for post-2018 districts
3 Supply, gaps, cost	HM-04 to HM-06	built; capacity with binding constraint; four gap dimensions; induced recurrent beside capital	readiness survey, equipment inventory, LMIS and HRIS data
4 Allocation	HM-07, HM-08 scenarios A–F	built; six scenarios under the approved budget increment; recruitment feasibility; absorptive capacity	an investment programme listing what is actually built, from which induced recurrent cost is computed (the MTEF now derives it from the growth of the capital line)
5 Optimisation and outcomes	optimiser, HM-09	built as a linear programme in JuMP/HiGHS; the gate against the best rule passes; deaths averted with ranges	sensitivity analysis and tornado chart

Phase	Scope	Status in this build	Outstanding
6 Budget, MTEF, integration	HM-10, exchange interfaces	built; three views reconcile; all outbound files emitted; stubs flagged	live FINEX, MTEF and MEL counterparts; the determinant modifier table for cross-sector links
7 Interface and reports	web application, reports	built: six-question Genie application, γ slider, explain on every figure, run diff, six workbooks and HTML report	acceptance testing with Ministry users

The engine's test suite carries 776 tests across the five layers of the validation manual (Chapter 17). The final acceptance gate of the build plan is that a user who has not seen the system before gets a defensible answer to all six questions in under ten minutes and can trace any number to its sources. That gate is a test with users, not with code, and it remains to be run with Ministry staff.

18.8 Governance of norms

The norms are the most important and most contestable input to the plan. The build plan is explicit that the norms database is the critical path: every number the system produces inherits its weaknesses, and a ministry will find them. Governance therefore matters more than any further technical feature.

18.8.1 Versioning

Every norm belongs to a **norm version**, and every plan run pins one. A version carries a status: draft, proposed, approved, superseded or rejected. The schema enforces that a version cannot be marked approved without a named approver and an approval date. **Approved versions are immutable.** Any edit forks a new draft that records the version it was based on. A run pinned to an approved version therefore reproduces its results after the norms have moved on, and a published plan can be defended a year later. Coverage targets are held in a separate target set, because targets are political and norms technical, and they are revised on different cycles by different owners. Prices are held in a separate price vintage owned by UCSN.

18.8.2 Approval

The version behind this report, UGA-2026-v1, is a **draft**. Its norms come from published standards and first-pass encoding. The manual's review protocol (`docs/15_CALIBRATION_AND_VALIDATION.md`) sets out the path to approval:

1. Print the norm card for each service: its bill of materials, time norms, unit cost and required volume (hpras norms cards).
2. Review it with the relevant clinical programme managers, one service at a time.
3. Record every challenge and its resolution, with a justification, in an append-only change log.
4. Require sign-off per service category before the version is approved.

The specification defines that change log as an audit table on which no role, including the owner, holds update or delete rights. It belongs to the canonical schema to be created on the EDIP database cluster and is not yet part of the working copy used for this report. The manual is candid that this step cannot be shortened by better code. It is the step that determines whether the Ministry believes the output.

18.8.3 Institutional roles

The data model assigns write access by tier. Reference catalogues belong to a reference custodian. Norms, targets and effectiveness parameters belong to a norms custodian and are versioned and approved. Observations are written only by loaders. Results are written only by the engine. The audit tier is insert-only for everyone. In Uganda the natural owners are the Ministry of Health's clinical programmes and standards function for the norms, its

planning division for targets and the Ministry of Finance for the envelope and ceilings, with the National Planning Authority aligning targets to the NDP IV. The engine can hold these roles; it cannot assign them.

18.9 Implications for planning

The integration layer is built. What is missing are the counterparts. The four outbound files are ready to be consumed by FINEX, CDCGE, the MTEF process and MEL today. The single most consequential step is for FINEX to return an envelope. That would replace the approved-increment fallback, close the fiscal loop specified in the architecture, and allow the allocation and outcome results to be presented as fiscal results rather than illustrations. Until then, every allocation figure in this report should be quoted with its fallback flag.

The approval of a norm version is the institutional step on which the credibility of every figure depends. The Ministry of Health should designate a norms custodian, convene the service-by-service review, and approve a first version. Each later revision then becomes a traceable, reproducible change rather than a dispute over totals.

The web application, the command line and the ministry workbooks are designed so that the plan's users do not need to be modellers. The next step is to test them with the people who prepare the sector submission: the acceptance test of the build plan, run with Ministry staff on the six questions. What those users find hard to answer is the best guide to what the next build should improve.

CHAPTER 19

19 Conclusions, limitations and next steps

This chapter draws the findings of the eighteen preceding chapters together. It states plainly what the evidence can and cannot support, and sets out the steps that would most improve the next planning round. It does not recommend an allocation scenario. The report's principle is that the choice among scenarios is a political judgement. The analysis exists to make the consequences of each choice visible, not to take the choice away from the people accountable for it.

19.1 What the analysis shows

19.1.1 Need is regional, and it is concentrated where supply is thinnest

The strongest single finding of the atlas is that health need in Uganda is organised by region. Malaria need (Moran's $I = 0.87$), severe acute malnutrition (0.81), HIV (0.78) and hypertension (0.70) cluster at the scale of the sub-region. Neighbouring districts resemble each other far more than chance would allow.

The malaria belt runs through Lango, Acholi, Teso and Karamoja. HIV need is heaviest in South Buganda and lightest in Karamoja. The under-five mortality index is highest in Karamoja, Bunyoro and West Nile.

Supply does not follow this geography. Health workers and facilities are both slightly concentrated in districts where need is *lower*, with concentration indices of -0.042 and -0.049 against need. The northern sub-regions combine the highest malaria need with the weakest walking access:

- Karamoja: 69% of people within an hour's walk;
- Lango: 73%;
- Acholi: 73%.

Some district-level indicators show no clustering at all: TB ($I = 0.09$), outpatient demand per person (0.03) and bed capacity (-0.05). These are the places where decisions genuinely have to be made district by district. For the clustered needs, sub-regional programmes are the natural unit of planning.

19.1.2 The requirement is large but not unaffordable

Meeting the 28 modelled services at the illustrative targets requires UGX 1,966 bn in 2026, about USD 11 per person. It rises to UGX 3,084 bn in 2030.

Against a whole-sector envelope of UGX 4,614 bn (FY2025/26) and UGX 5,271 bn (FY2026/27), that is 43% of the budget, falling to 40% by 2030. The fall assumes the envelope keeps growing at its observed 13.4% a year, excluding the anomalous FY2022/23.

The requirement is therefore not beyond the country's means in aggregate. The binding problems are elsewhere:

- whether money reaches the levels that deliver the services;
- whether it is spent;
- whether the supply it buys exists where the need is.

19.1.3 Money is not reaching primary care in proportion to the work it does

The clearest fiscal signal is at the primary-care level. The requirement for services delivered at HC II to HC IV already exceeds the local-government and KCCA health budget: the ratio is 1.10. It exceeds that budget even though the whole requirement is less than half the sector envelope.

Two plausibility checks also flag this:

- the primary-care share of the requirement (79%) is above the expected range;
- the HC II–IV share by delivery level (70%) is above it too.

Both follow directly from a catalogue that is weighted to primary care. They are nonetheless a reminder that the modelled services are delivered predominantly at the lower levels, while the budget is weighted toward central institutions.

19.1.4 Execution matters as much as allocation

Budget execution was 88% in FY2021/22. FY2025/26 stands at 67% in the latest quarterly release. It varies from 31% at the Ministry of Health headquarters to 121% at National Medical Stores.

Execution is not an accounting detail. Every allocation scenario in this report is expressed in approved shillings, and what an allocation buys is what is spent. A UGX 413 bn increment executed at 67% buys about two-thirds of what the tables in Chapter 11 show.

19.1.5 Capacity, not money, binds many services

Capacity falls well short of requirement for:

- severe mental disorders (0.18);
- hypertension (0.20);
- outpatient care (0.46);
- the routine immunisations (about 0.68).

For these services, additional money that is not matched by rooms, staff time or readiness cannot be turned into services. The scenarios show a related limit: every rule-based scenario leaves part of the envelope unspent, from UGX 124 bn (D) to UGX 280 bn (F). The services each rule favours reach their need ceiling, leaving no remaining gap to fund, and a fixed rule does not move the money elsewhere. The optimiser allocates the whole envelope. Space is the binding constraint in 59% of district × service × level cells. In 19% of cells, observed delivery exceeds the normed throughput of the registered facilities, which suggests that the throughput norms are conservative.

19.1.6 Additional resources can buy very different things

The same UGX 413 bn envelope produces very different results depending on what it is allocated to value:

- a coverage gain from 5.6 to 23.4 percentage points;
- between 35 and 119 districts above the coverage floor;
- between 5,558 and 20,053 deaths averted.

The allocation that maximises lives saved on its stated objective averts 20,053 deaths (range 13,381–26,299). The geographic-equity rule averts 15,010 (10,321–19,293) and yields the largest coverage gain among the rules. The ranges overlap. The choice between them is a choice of values, and it belongs to those accountable for it.

19.1.7 Inequity by wealth is large for services that depend on the household

The wealth gradients are steepest for services that require the household to reach a facility: facility delivery, contraception and four antenatal visits. They are flat for DPT3, a service that is also delivered through outreach. The poorest quintile carries twice the stunting of the richest and nearly three times the severe wasting. The lesson for planning is that the delivery modality, not only the money, shapes who is reached.

19.2 Limitations

The findings must be read with the following limitations. Each is stated in the chapter where it bears on a result.

1. **Coverage targets are illustrative.** The target set UGA-NDP-ILLUSTRATIVE stands in for the approved targets of the national development plan. The requirement scales directly with the targets, so replacing them is the first step before any figure is used for a budget submission.
2. **The catalogue is partial.** The 28 services cover the main primary, maternal, child, communicable and hospital services, but not the whole sector. The requirement is therefore compared with the budget as a ratio, and the WISN workforce requirement is not the full establishment.
3. **Staff in post is derived.** It is minimum staffing × facilities × the league-table fill rate, not an HRIS extract. Workforce gaps by district rest on that derivation.
4. **No equipment inventory and no stock data.** The commodity and equipment gaps are gaps against the requirement, not against measured stock.
5. **Survey evidence is ageing.** The DHS 2016 remains the source of sub-regional coverage, nutrition and age structure. DHS 2022 rates are used where only national figures are needed. Small-area smoothing reduces noise; it does not make old data new.
6. **Travel time is modelled.** Access comes from the SDI's modelled travel times for 2020 and is used as a vendored snapshot, not a live feed.
7. **Some exchanges are stubs.** The FINEX envelope, the MTEF ceilings and the MEL actuals are stubs. No figure in this report is presented as a FINEX result.
8. **Unit costs need owner review.** The medical officer employment cost is 25% below the UCSN gross salary. Baseline DPT3 coverage from the district league tables is below the WHO/UNICEF estimate. Both are reported to the owners of the norms rather than corrected by the engine.

19.3 Next steps

Four groups of steps would most improve the next planning round.

Replace the illustrative with the approved.

- Load the approved NDP coverage targets and the approved norm version.
- Issue a new price vintage that incorporates the UCSN salary review.
- Re-run the plan. The engine reproduces every figure in this report from its inputs, so the effect of each change can be traced service by service with the run comparison tool.

Close the data gaps that most affect decisions.

In order of impact on the results:

- an HRIS extract of staff in post by facility and cadre;
- a facility equipment and readiness inventory;
- commodity stock data from National Medical Stores and district stores;
- sub-regional estimates from the DHS 2022 microdata when they become available;
- a live SDI travel-time export with current facility locations.

Connect the exchanges.

- Replace the FINEX, MTEF and MEL stubs with live exchanges, so that the envelope, the ceilings and the actuals come from their owners.
- Move the vendored snapshots (UCSN, SDI, HealthModelling) to scheduled refreshes.

Use the analysis in the budget cycle.

- **Budget framework paper.** Present the reconciliation, the affordability path and the MTEF with its induced recurrent cost at the budget framework paper stage.
- **Investment decisions.** Present the investment programme with each district's facility gap and physical access side by side.
- **Allocation.** Bring the scenario comparison to the political level as a set of legible trade-offs, not as a single recommended option.

ANNEX A

A Formula compendium

This annex collects the key formulas of the engine in one place, grouped by module from HM-01 to HM-10, followed by small-area estimation, survey trends, spatial statistics and equity. Each formula is written as it is implemented in the source code (`src/*.jl` and `scripts/*.py`), and the file that implements it is named. Throughout, *d* indexes districts, *t* years, *s* services, *l* facility levels, *r* resources, *c* cadres and *j* causes of death (outcomes). Parameter values quoted are the defaults in the code or the fiscal parameters of the plan run.

A.1 HM-01 Population and demography

Implemented in `src/NeedsChain.jl` (`compute_population!`).

Projection. The observed base population of each district is grown at the national rate:

$$P_{d,t} = P_{d,t_0} (1 + g)^{t - t_0} \quad (\text{A.1})$$

- $P_{\{d,t_0\}}$: the most recent observed population of district *d* (MoH league table), in year t_0 ;
- g : the national population growth rate (0.029 a year in the plan run).

Planning groups. Each group (under-1, under-5, women of reproductive age, adults 15+, and so on) is a share of the total:

$$P_{d,t,k} = P_{d,t} \pi_{k,r(d)} \quad (\text{A.2})$$

- $\pi_{\{k,r(d)\}}$: the share of group *k* in the DHS sub-region $r(d)$ of district *d*, where the DHS provides it (tier measured), otherwise the national share (tier imputed).

Births and pregnancies.

$$B_{d,t} = P_{d,t} b_{r(d)}, \quad \text{PREG}_{d,t} = B_{d,t} (1 + \ell) \quad (\text{A.3})$$

- $b_{\{r(d)\}}$: the crude birth rate, sub-regional where available;
- ℓ : the pregnancy-loss factor, so that antenatal need is not understated by counting live births only.

A.2 HM-02 Disease burden and need

Implemented in `src/NeedsChain.jl` (`compute_needs!`) and `scripts/derive_dhs_rates.py`.

Need. For every service with a population basis:

$$N_{s,d,t} = P_{d,t,k(s)} \rho_{s,d,t} \quad (\text{A.4})$$

- $P_{\{d,t,k(s)\}}$: the population group the service applies to;
- $\rho_{\{s,d,t\}}$: the need rate (prevalence, incidence or contact rate); a district rate wins over a national one, and a rate observed in an earlier year is reused with its own quality tier.

Malaria index. The national incidence is the anchor; the DHS supplies the shape:

$$\iota_r = \frac{f_r q_r}{\bar{f} \bar{q}}, \quad \rho_d^{\text{mal}} = \rho_{\text{nat}}^{\text{mal}} \iota_{r(d)} \quad (\text{A.5})$$

- f_r : two-week child fever prevalence in sub-region r (smoothed by Fay–Herriot);
- q_r : malaria test positivity in sub-region r ;
- the denominator is the population-weighted national mean of $f_r q_r$, so the national total is preserved.

HIV index. ART and PMTCT need is the national rate apportioned by UPHIA 2020–21 regional prevalence:

$$\rho_d^{\text{HIV}} = \rho_{\text{nat}}^{\text{HIV}} \frac{h_{r(d)}}{\bar{h}}, \quad \bar{h} = \frac{\sum_d h_{r(d)} P_d a_{r(d)}}{\sum_d P_d a_{r(d)}} \quad (\text{A.6})$$

- h_r : UPHIA adult prevalence of the region containing sub-region r ;
- a_r : the adult (15+) share of sub-region r ; P_d : district population.

SAM incidence from prevalence.

$$\rho_d^{\text{SAM}} = s_{r(d)} K, \quad K = 2.6 \quad (\text{A.7})$$

- s_r : severe-wasting prevalence (weight-for-height below –3 SD) in sub-region r , Fay–Herriot smoothed;
- K : the incidence-to-prevalence conversion factor used for SAM planning.

Annual episode rate from a two-week prevalence (reference only, an upper bound):

$$\lambda = -\ln(1 - p) \frac{365}{14} \quad (\text{A.8})$$

- p : the share of children with an episode in the two weeks before the survey.

A.3 HM-03 Service demand and resource requirement

Implemented in `src/HealthPlanning.jl` and `src/NeedsChain.jl` (`compute_demand!`).

The planning identity.

$$Q_{s,d,t} = N_{s,d,t} C_{s,t}^* \nu_s \quad (\text{A.9})$$

- $C_{s,t}$: target coverage, the share of people in need who receive the service completely ($0 \leq C \leq 1$);
- ν_s : service units per case (for example, four ANC visits per pregnancy).

Split by level. $Q_{s,d,t,l} = Q_{s,d,t} m_{s,l}$, where $m_{s,l}$ is the normative level mix, with the shares $m_{s,l}$ summing to one over l .

Referral services. Need for a referral service follows its parent's volume:

$$N_{s,d,t} = Q_{\text{par}(s),d,t} \kappa_s \quad (\text{A.10})$$

- κ_s : the referral rate (for example, caesarean sections per normal delivery);
- the volume then follows Equation (A.9).

Bill of materials. Each norm line has a quantity per unit, a share of cases and a wastage factor:

$$R_r = \sum_{s,l} Q_{s,l} q_{r,s,l} \phi_{r,s,l} (1 + \omega_{r,s,l}) \quad (\text{A.11})$$

- q : quantity per service unit (minutes for staff);
- ϕ : the share of cases that use the resource;

- ω : wastage. Wastage belongs on the commodity, never on the service volume.

WISN available working time and FTE.

$$AWT_c = (D_w - D_l - D_h - D_{tr} - D_a) h 60 (1 - \alpha_c) \quad (A.12)$$

$$FTE_c = \frac{M_c}{AWT_c} \quad (A.13)$$

- $D_w, D_l, D_h, D_{tr}, D_a$: working days, leave, public holidays, training and absence days a year;
- h : working hours a day; α_c : the category allowance for non-service time;
- M_c : required minutes of cadre c , from Equation (A.11).

A.4 HM-04 Supply and capacity

Implemented in `src/SupplyGaps.jl (compute_capacity!)`. Capacity is a throughput, not a ratio.

Space constraint.

$$K_{s,d,l}^{space} = F_{d,l} \pi_l D_l \sigma_{s,d,l} \theta_{s,l} \quad (A.14)$$

- $F_{\{d,l\}}$: facilities of level l in district d ; π_l : service points (rooms) per facility;
- D_l : operating days a year; $\theta_{\{s,l\}}$: throughput per service point per day;
- $\sigma_{\{s,d,l\}}$: the service's share of the room-days of its pool, so the room stock is allocated, not replicated.

Staff constraint.

$$K_{s,d,l}^{staff} = \min_c \frac{E_{c,d} AWT_c \psi_{c,s,d,l}}{\tau_{c,s,l}} \quad (A.15)$$

- $E_{\{c,d\}}$: staff of cadre c in post in district d ; ψ : the share of the cadre's time following the required time mix;
- $\tau_{\{c,s,l\}}$: effective minutes of cadre c per service unit. Cadres with no facility establishment (village health teams) are excluded.

Capacity and the binding constraint.

$$K_{s,d,l} = \min (K^{space}, K^{staff}) \chi_d \quad (A.16)$$

- χ_d : the district readiness index. The smaller of the two constraints is recorded as binding, and the slack ratio is the larger divided by the smaller.

Revealed capacity. Delivered volume is a proven lower bound on capacity:

$$K_{s,d,l}^{rev} = Q_{s,d,l} \frac{c_{s,d}^{raw}}{C_s^*} \quad (A.17)$$

- c^{raw} : observed coverage, uncapped, so that inflow from other districts counts;
- where facility data are measured, $K = \max(K, K^{rev})$; where they are not, K^{rev} replaces K .

Catchment population (descriptive only): $P_d / F_{\{d,l\}}$.

A.5 HM-05 Gaps (four dimensions, never combined)

Implemented in `src/SupplyGaps.jl (compute_gaps!, build_gap_matrix!)`.

Gap 1, service. Volume gap $V = Q - K$, positive for a shortfall and negative for a surplus. The capacity shortfall is $\max(0, Q - K)$, and the coverage gap is $C^* - C_0$ against current coverage C_0 .

Gap 2, workforce.

$$G_{c,d}^{\text{wf}} = \frac{M_{c,d}}{\text{AWT}_c} - E_{c,d} \quad (\text{A.18})$$

Gap 3, commodity. With no LMIS stock data, availability is unknown, so the commodity gap is the full commodity requirement, flagged assumed, and costed at price.

Gap 4, facility. Facility-equivalents needed to close the space-bound shortfall:

$$G_d^{\text{fac}} = \frac{\sum_{s \in \text{space}} \max(V_{s,d}, 0)}{\sum_{s \in \text{space}} K_{s,d}^{\text{space}}} \quad (\text{A.19})$$

- the sums run over the service-district cells where space is the binding constraint.

A.6 HM-06 Costing

Implemented in `src/HealthPlanning.jl` (`unit_cost`) and `src/SupplyGaps.jl` (`compute_costs!`).

Unit cost.

$$u_{s,l} = \sum_r q_{r,s,l} \phi_{r,s,l} (1 + \omega_{r,s,l}) p_r \quad (\text{A.20})$$

- p_r : the price of resource r in the pinned price vintage; staff are priced per minute. The unit cost splits into recurrent and capital lines.

Requirement and gap cost.

$$\text{Cost}_{d,t}^{\text{req}} = \sum_r R_{r,d,t} p_r, \quad \text{Cost}_{d,t}^{\text{gap}} = \sum_r \max(G_{r,d,t}, 0) \tilde{p}_r \quad (\text{A.21})$$

- $G_{\{r,d,t\}}$: the resource gap; for staff, the FTE gap is converted back to minutes by AWT before pricing ($\tilde{p} = \text{AWT} \times \text{price per minute}$). The gap basis is incremental on top of what is delivered and is never added to the requirement basis.

A.7 HM-07 Investment and workforce plan

Implemented in `src/Allocation.jl` (`recruitment_plan`) and `src/GIS.jl`.

Recruitment need.

$$\text{Rec}_{c,t} = \max(\text{FTE}_{c,t} - E_c, 0) + E_c a_c (t - t_0 + 1) \quad (\text{A.22})$$

- E_c : staff in post (whole establishment); a_c : annual attrition rate;
- only a positive workload gap is a real gap: the requirement covers the modelled services only.

Capital with its induced recurrent cost. Every capital figure carries a high bound:

$$\text{Cap}^{\text{high}} = \text{Cap} (1 + \rho_{\text{ind}}), \quad \rho_{\text{ind}} = 0.15 \quad (\text{A.23})$$

- ρ_{ind} : the induced recurrent share, the annual running cost (staff, utilities, maintenance) of an asset as a share of its capital cost.

A.8 HM-08 Resource allocation

Implemented in `src/Allocation.jl` and `src/Optimise.jl`.

Envelope. Baseline is the cost of what is delivered today; the financing gap is the requirement minus baseline. The incremental envelope Δ is split into donor-earmarked (share 0.35 by default) and flexible money.

Scenario weights. For each district-service cell with a shortfall $S = \max(Q - K, 0) > 0$, the six rules are:

Table A.1: The allocation rules (weights are normalised to sum to one)

Scenario	Weight $w_{\{d,s\}}$ before normalisation
A Current trajectory	$K_{\{d,s\}}$, what is delivered today
B Universal basic services	$S_{\{d,s\}}$ if s is in the basic package, else 0
C Primary healthcare emphasis	$S_{\{d,s\}} \times 0.70$ for community and primary services, $\times 0.30$ otherwise
D Hospital expansion	$S_{\{d,s\}} \times 0.70$ for secondary and tertiary services, $\times 0.30$ otherwise
E Geographic equity	$P_d \times (S_{\{d,s\}}/Q_{\{d,s\}})^\gamma$, with $\gamma = 1.5$
F Disease burden	$S_{\{d,s\}} \times \text{deaths}_d / \max(\text{completeness}_d, 0.2)$

Table A.1 gives the weights. In scenario F, deaths_d are HMIS facility deaths, and the completeness correction is floored at 0.2.

Allocation. Cells are funded in descending order of weight:

$$x_{d,s} = \min \left(\Delta w_{d,s}, S_{d,s} u_{d,s}, \bar{A}_d - \sum_{s'} x_{d,s'} \right) \quad (\text{A.24})$$

$$\bar{A}_d = 1.5 f_d \sum_s K_{d,s} u_{d,s} \quad (\text{A.25})$$

- $u_{\{d,s\}}$: unit cost, weighted by the level mix; $\bar{A}_d$: the absorptive ceiling;
- f_d : the establishment fill rate (0.7 where unknown); the multiple 1.5 is the default;
- the third term is the room left under district d 's absorptive ceiling.

Scenario metrics. Coverage after is $c_1 = (K + x/u)/Q$. The coverage gain in percentage points is $100 \times \Sigma(c_1 - c_0)$ divided by the number of cells. A district is above the floor if $c_1 \geq f_s$ for every basic-package service with a floor. The equity ratio is given in Equation (A.50).

Optimiser (linear programme).

$$\max_{x, \xi} \sum_i v_i x_i - M \sum_i \xi_i \quad (\text{A.26})$$

$$\sum_i u_i x_i \leq \Delta, \quad 0 \leq x_i \leq S_i, \quad \sum_{i \in d} u_i x_i \leq \bar{A}_d, \quad K_i + x_i + \xi_i \geq f_{s(i)} Q_i \quad (\text{A.27})$$

- i indexes district-service cells; x_i : extra units funded; $\xi_i \geq 0$: floor slack, penalised by $M = 10^6$ (floors are soft);
- v_i : value per unit. For the stated objective of maximising lives saved:

$$v_{d,s} = \sum_j \frac{B_{d,j} \text{AF}_{s,j} \epsilon_{s,j}}{Q_{d,s}} \quad (\text{A.28})$$

- $B_{\{d,j\}}$: baseline deaths from cause j ; AF: affected fraction; ϵ : efficacy. The equity-weighted objective multiplies v by $(1 - \min(c_0, 1) + 0.05)^\gamma$.

A.9 HM-09 Health outcomes

Implemented in `src/Outcomes.jl`.

Baseline deaths.

$$B_{d,j} = D_{d,j} m_j I_{d,j} \quad (\text{A.29})$$

- $D_{\{d,j\}}$: the denominator population (births or total population) of district d ;
- m_j : the national mortality rate for outcome j (DHS 2022);
- $I_{\{d,j\}}$: the district mortality index, with a population-weighted mean of 1 (1 where no index exists).

Deaths averted (multiplicative, Lives Saved Tool form).

$$A_{d,j} = B_{d,j} \left[1 - \prod_s (1 - AF_{s,j} \epsilon_{s,j} \Delta c_{d,s}) \right] \quad (\text{A.30})$$

- $\Delta c_{\{d,s\}}$: the coverage change bought by the scenario (never negative);
- the low and high bounds replace ϵ with the lower and upper limits of its published confidence interval.

DALYs averted. $A_{\{d,j\}} \times YLL_j$, the years of life lost per death (default 40).

Linearisation error between the multiplicative form and the linear form used by the optimiser:

$$e = \frac{\left| \sum B_{\min}(\sum_s AF_{s,j} \epsilon_{s,j} \Delta c_{d,s}, 0.8) - \sum A \right|}{\sum A} \quad (\text{A.31})$$

- a value above 0.10 means the optimiser's objective is materially distorted.

A.10 HM-10 Budget, MTEF and fiscal space

Implemented in `src/Budget.jl`.

MTEF composition.

$$T_t = R_t + \rho_{\text{ind}} \sum_{\tau < t} NC_{\tau} + W_t [(1 + \delta)^{t-t_0} - 1] + \text{Cap}_t \quad (\text{A.32})$$

$$NC_t = \max(\text{Cap}_t - \text{Cap}_{t-1}, 0) \quad (\text{A.33})$$

- R_t : recurrent requirement; Cap_t : capital requirement; W_t : the wage bill of the requirement;
- $\rho_{\text{ind}} = 0.15$: induced recurrent share; $\delta = 0.025$: salary drift a year;
- NC_t : new capital (zero in the first year), the year-on-year growth of the annualised capital line.

Affordability. Beyond the last approved year, the envelope is grown at the compound rate observed over the longest complete run of approved budgets (13.4% a year in the plan run):

$$\text{Env}_t = \text{Env}_{t_a} (1 + g_b)^{t-t_a}, \quad \text{share}_t = \frac{\text{Req}_t}{\text{Env}_t} \quad (\text{A.34})$$

- t_a : the last year with an approved budget; g_b : the observed compound growth rate.

Execution rate. Spent / approved, by financial year and institution.

Reconciliation ratio. Requirement / approved budget, line by line: a ratio to read, not a gap to close.

Sustainability. Total as a percentage of government expenditure and of GDP; wage share = wage bill / recurrent.

A.11 Small-area estimation

Implemented in `src/SmallArea.jl` and its Python port `scripts/small_area.py`.

Fay–Herriot EBLUP.

$$\hat{\theta}_i = x_i' \hat{\beta} + \gamma_i (y_i - x_i' \hat{\beta}), \quad \gamma_i = \frac{\sigma_u^2}{\sigma_u^2 + D_i} \quad (\text{A.35})$$

Estimation. Starting from $\sigma_u^2 = \max(\text{var}(y) - \text{mean}(D), 10^{-6})$, iterate 50 times:

$$\hat{\beta} = (X'V^{-1}X)^{-1}X'V^{-1}y, \quad V = \text{diag}(D_i + \sigma_u^2) \quad (\text{A.36})$$

$$\sigma_u^2 \leftarrow \max \left(\sigma_u^2 + \frac{\sum_i e_i^2 / (D_i + \sigma_u^2) - (m - p)}{\sum_i 1 / (D_i + \sigma_u^2)}, 10^{-8} \right) \quad (\text{A.37})$$

- y_i : direct estimate; D_i : sampling variance; X : auxiliary matrix (an intercept by default);
- $e_i = y_i - x_i' \hat{\beta}$; m : number of areas; p : number of columns of X .

Precision. $\text{MSE}_i \approx y_i D_i$; the 95% interval is $\hat{\theta}_i \pm 1.96 \sqrt{\text{MSE}_i}$.

Sampling variance of a DHS proportion.

$$D_i = 2.0 \frac{\bar{p}(1 - \bar{p})}{n_i}, \quad \bar{p} = \frac{\sum_i y_i n_i}{\sum_i n_i} \quad (\text{A.38})$$

- n_i : unweighted sample; the design effect is 2.0; $\bar{p}$ is the pooled proportion. Fewer than four areas are left unsmoothed.

A.12 Survey trends

Implemented in `src/Trends.jl`.

Local linear trend.

$$y_t = \mu_t + \varepsilon_t, \quad \mu_t = \mu_{t-1} + \beta_{t-1} + \eta_t, \quad \beta_t = \beta_{t-1} + \zeta_t \quad (\text{A.39})$$

- $\varepsilon_t \sim N(0, D_t)$, with D_t the known survey variance; $\eta_t \sim N(0, \sigma^2_\mu)$; $\zeta_t \sim N(0, \sigma^2_\beta)$.

Kalman filter, with state $a = (\mu, \beta)'$, $T = \begin{bmatrix} 1 & 1 \\ 0 & 1 \end{bmatrix}$, $Z = (1, 0)$, $Q = \text{diag}(\sigma^2_\mu, \sigma^2_\beta)$:

$$a_{t|t-1} = T a_{t-1}, \quad P_{t|t-1} = T P_{t-1} T' + Q, \quad F_t = Z P_{t|t-1} Z' + D_t \quad (\text{A.40})$$

$$K_t = P_{t|t-1} Z' / F_t, \quad a_t = a_{t|t-1} + K_t (y_t - Z a_{t|t-1}), \quad P_t = P_{t|t-1} - K_t Z P_{t|t-1} \quad (\text{A.41})$$

Likelihood and grid search. $\ell = \sum_t -\frac{1}{2} [\ln(2\pi F_t) + v_t^2 / F_t]$ over survey years; $\sigma^2_\mu \in \{10^{-6}, \dots, 10^{-2}\}$ and $\sigma^2_\beta \in \{0, 10^{-6}, \dots, 10^{-3}\}$.

Rauch–Tung–Striebel smoother.

$$J_t = P_t T' P_{t+1|t}^{-1}, \quad \tilde{a}_t = a_t + J_t (\tilde{a}_{t+1} - a_{t+1|t}), \quad \tilde{P}_t = P_t + J_t (\tilde{P}_{t+1} - P_{t+1|t}) J_t' \quad (\text{A.42})$$

Interval and products. The estimate is $\tilde{\mu}_t \pm 1.96 s_t$, clamped to $[0, 1]$, with $s_t = \sqrt{\tilde{p}_t[1,1]}$. The product is observed or interpolated inside the survey years, a nowcast for horizons $h \leq 5$, a forecast for $5 < h \leq 10$, and an extrapolation beyond evidence for $h > 10$. Fewer than three rounds: refused.

A.13 Spatial statistics

Implemented in `src/GIS.jl` and `scripts/build_geo.py`.

Weights. Queen contiguity with a 50 m tolerance; row-standardised, $w_{ij} = 1/|N(i)|$ for $j \in N(i)$, else 0.

Global Moran's I and inference.

$$I = \frac{\sum_i z_i \sum_j w_{ij} z_j}{\sum_i z_i^2}, \quad E[I] = -\frac{1}{n-1}, \quad z_I = \frac{I - \bar{I}^*}{sd(I^*)} \quad (\text{A.43})$$

$$p = \frac{1 + \#\{k : |I_k^* - E[I]|\geq |I - E[I]|\}}{1 + 999} \quad (\text{A.44})$$

- $z_i = x_i - \bar{x}$; I_k^* : Moran's I under the k-th of 999 random permutations (seed 20260921).

Local Moran (LISA).

$$I_i = \frac{z_i}{m_2} \sum_j w_{ij} z_j, \quad m_2 = \frac{1}{n} \sum_i z_i^2 \quad (\text{A.45})$$

- conditional permutation: z_i fixed, its k_i neighbours drawn 999 times without replacement from the other $n - 1$ values; $p_i = (1 + \#\{|I_k^*| \geq |I_i|\}) / 1,000$; classes HH, LL, HL, LH at $\alpha = 0.05$, otherwise not significant.

Referral distance (haversine).

$$d = 2R \arcsin \sqrt{\sin^2 \frac{\Delta\phi}{2} + \cos \phi_1 \cos \phi_2 \sin^2 \frac{\Delta\lambda}{2}}, \quad R = 6371 \text{ km} \quad (\text{A.46})$$

- summarised by district as the median, the 90th percentile and the share of health centres beyond 50 km.

A.14 Equity

Implemented in `scripts/load_dhs.py`, `src/CrossChecks.jl`, `src/GIS.jl` and `src/Allocation.jl`.

Survey-weighted proportion in group g (national, wealth quintile or residence; cells with fewer than 25 unweighted cases are not stored):

$$\hat{p}_g = \frac{\sum_{k \in g} v_k y_k}{\sum_{k \in g} v_k} \quad (\text{A.47})$$

- v_k : DHS sample weight / 10^6 ; y_k : the 0/1 outcome.

Concentration index over quintiles.

$$C = \frac{2}{\mu} \sum_{i=1}^5 w_i x_i R_i - 1, \quad w_i = 0.2, \quad R_i \in \{0.1, 0.3, 0.5, 0.7, 0.9\}, \quad \mu = \sum_i w_i x_i \quad (\text{A.48})$$

Concentration index of supply against need, districts sorted by need:

$$C_{geo} = \frac{2}{\mu} \sum_d w_d s_d \left(R_d - \frac{1}{2} \right), \quad w_d = \frac{P_d}{\sum_k P_k}, \quad R_d = \sum_{k < d} w_k + \frac{w_d}{2} \quad (\text{A.49})$$

- s_d : supply per person (workers in post, or public and PNFP facilities); $\mu = \sum w_d s_d$.

Equity ratio of an allocation scenario.

$$E = \frac{\bar{c}_{(n - \lfloor n/10 \rfloor)}}{\bar{c}_{(\lfloor n/10 \rfloor)}} \quad (\text{A.50})$$

- $\bar{c}_k$: the k-th smallest district mean coverage after allocation; $n = 122$ districts.

ANNEX B

B Reference catalogues

This annex reproduces the reference catalogues on which every figure in the report rests. They are the contents of norm version UGA-2026-v1 and price vintage UGA-2026Q1, as held in the planning database. A change to any entry is made by issuing a new norm or price version, never by editing a result.

B.1 Services

The 28 modelled services, with their category, tier, unit of output and the basis on which need is estimated (Table B.1). Referral services derive their volume from a parent service rather than from population.

Table B.1: The 28 modelled services

Service	Category	Tier	Unit	Need basis	Referral
Outpatient consultation	Primary care	Primary	visit	episodes	
Antenatal care visit	RMNCAH	Primary	visit	births	
Normal delivery	RMNCAH	Primary	delivery	births	
Caesarean section	RMNCAH	Secondary	procedure	referral	yes
Pentavalent immunisation (DTP-HepB-Hib)	Immunisation	Primary	dose	universal	
Tuberculosis treatment course	Communicable	Primary	patient	incidence	
Malaria diagnosis and treatment	Communicable	Primary	case	incidence	
BCG immunisation	Immunisation	Primary	dose	universal	
Polio immunisation	Immunisation	Primary	dose	universal	
Measles-rubella immunisation	Immunisation	Primary	dose	universal	
Pneumococcal immunisation	Immunisation	Primary	dose	universal	
Rotavirus immunisation	Immunisation	Primary	dose	universal	
HPV immunisation	Immunisation	Primary	dose	universal	
Family planning	RMNCAH	Primary	user-year	population rate	
Postnatal care contact	RMNCAH	Primary	visit	births	
Severe acute malnutrition treatment	Nutrition	Primary	case	incidence	
NCD screening (blood pressure, glucose)	NCD	Primary	screen	population rate	
Hypertension management	NCD	Primary	patient-year	prevalence	
Severe childhood illness, admission	Hospital	Secondary	bed-day	incidence	
Sick newborn care	RMNCAH	Secondary	bed-day	births	
Obstetric complications (non-surgical)	RMNCAH	Secondary	bed-day	births	
Complicated SAM, inpatient stabilisation	Nutrition	Secondary	bed-day	referral	yes
Major surgery (non-obstetric)	Hospital	Secondary	procedure	population rate	
Severe mental disorders and epilepsy care	NCD	Primary	patient-year	prevalence	
HIV testing and counselling	Communicable	Primary	test	population rate	
Antiretroviral therapy	Communicable	Primary	patient-year	prevalence	
Prevention of mother-to-child transmission	Communicable	Primary	patient	births	
Inpatient bed-day	Hospital	Secondary	bed-day	referral	yes

Service catalogue of norm version UGA-2026-v1. Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_services.csv).

B.2 Cadres and working time

Table B.2 lists each cadre, the basic monthly pay on the public service salary scale and the WISN available working time. Available working time is the time an FTE can give to services after leave, public holidays, training, absence and the category allowance for non-service work. It is the denominator of every FTE figure in the report.

Table B.2: Cadres, pay and WISN available working time

Cadre	Group	Training (yrs)	Scale	Basic pay UGX/month	Working days	Leave+hol.+train.+abs.	Hours/day	Allowance	AWT min/FTE-yr
Specialist / consultant	clinical	10.0	U2	5,000,000	261.0	49.0	8.0	25%	76,320
Medical officer	clinical	5.0	U4	3,000,000	261.0	49.0	8.0	25%	76,320
Clinical officer	clinical	3.0	U5	2,000,000	261.0	49.0	8.0	25%	76,320
Anaesthetic officer	clinical	3.0	U5	2,000,000	261.0	49.0	8.0	25%	76,320
Registered nurse	nursing	3.0	U5	2,000,000	261.0	49.0	8.0	25%	76,320
Enrolled nurse	nursing	2.0	U7	1,000,000	261.0	49.0	8.0	25%	76,320
Registered midwife	nursing	3.0	U5	2,000,000	261.0	49.0	8.0	25%	76,320
Enrolled midwife	nursing	2.0	U7	1,000,000	261.0	49.0	8.0	25%	76,320
Pharmacist	allied	4.0	U4	3,000,000	261.0	49.0	8.0	22%	79,373
Pharmacy technician	allied	2.0	U5	2,000,000	261.0	49.0	8.0	22%	79,373
Laboratory technologist	allied	3.0	U5	2,000,000	261.0	49.0	8.0	22%	79,373
Laboratory technician	allied	2.0	U7	1,000,000	261.0	49.0	8.0	22%	79,373
Radiographer	allied	3.0	U5	2,000,000	261.0	49.0	8.0	22%	79,373
Nutritionist	allied	3.0	U5	2,000,000	261.0	49.0	8.0	22%	79,373
Health records officer	support	2.0	U7	1,000,000	261.0	49.0	8.0	15%	86,496
Administrative officer	support	3.0	U5	2,000,000	261.0	49.0	8.0	15%	86,496
Support staff	support	0.0	U8	1,100,000	261.0	49.0	8.0	15%	86,496
Village health team member	community	0.2	VHT	50,000	261.0	49.0	8.0	30%	71,232

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_cadres.csv).

B.3 Staff time norms

Table B.3 gives the minutes of each cadre's time consumed by one unit of each service at each facility level. The time is weighted by the share of cases that need the cadre. The WISN workload in Chapter 6 is these minutes multiplied by volume and divided by available working time.

Table B.3: Annex: staff time norms, minutes per service unit by cadre and level

Service	Level	Anaesthetic officer	Village health team member	Clinical officer	Medical officer	Specialist / consultant	Laboratory technician	Laboratory technologist	Enr. midwife	Reg. midwife	Enr. nurse	Reg. nurse	Nutritionist	Pharmacy technician	Health records officer	Support staff
Caesarean section	General hospital	85.0			31.5	38.5				55.0		330.0				215.0
Caesarean section	HC IV	90.0			105.0					60.0		330.0				225.0
Caesarean section	Regional referral	80.0			9.8	55.2				50.0		330.0				210.0
Inpatient bed-day	General hospital				12.0	1.8						90.0				45.0
Inpatient bed-day	HC IV			14.0	3.6							85.0				45.0
Inpatient bed-day	Regional referral				14.0	5.6						95.0				48.0
Sick newborn care	General hospital				12.0					30.0		120.0				30.0
Sick newborn care	HC IV			12.0						30.0		120.0				30.0
Sick newborn care	Regional referral				12.0					30.0		120.0				30.0
Complicated SAM, inpatient stabilisation	General hospital				10.0							90.0	20.0			40.0
Complicated SAM, inpatient stabilisation	HC IV			10.0								90.0	20.0			40.0
Complicated SAM, inpatient stabilisation	Regional referral				10.0							90.0	20.0			40.0
Obstetric complications (non-surgical)	General hospital				20.0					90.0						45.0
Obstetric complications (non-surgical)	HC IV				20.0					90.0						45.0
Obstetric complications (non-surgical)	Regional referral					20.0				90.0						45.0
Severe childhood illness, admission	General hospital				15.0							90.0				45.0
Severe childhood illness, admission	HC IV			15.0								90.0				45.0
Severe childhood illness, admission	Regional referral				15.0							90.0				45.0
Major surgery (non-obstetric)	General hospital	100.0			36.0	54.0						150.0				90.0
Major surgery (non-obstetric)	HC IV	100.0			90.0							150.0				90.0
Major surgery (non-obstetric)	Regional referral	100.0				90.0						150.0				90.0
Antenatal care visit	General hospital				1.5					22.0		8.0				

Service	Level	Anaesthetic officer	Village health team member	Clinical officer	Medical officer	Specialist / consultant	Laboratory technician	Laboratory technologist	Enr. midwife	Reg. midwife	Enr. nurse	Reg. nurse	Nutritionist	Pharmacy technician	Health records officer	Support staff
Antenatal care visit	HC II								20.0		5.0					
Antenatal care visit	HC III									20.0	8.0					
Antenatal care visit	HC IV				0.8					22.0	8.0					
Normal delivery	General hospital				5.0					180.0		90.0				70.0
Normal delivery	HC III								180.0		90.0					60.0
Normal delivery	HC IV				2.4					180.0	90.0					60.0
Family planning	General hospital									29.0					5.0	
Family planning	HC II										25.0				5.0	
Family planning	HC III								27.0						5.0	
Family planning	HC IV									29.0					5.0	
Antiretroviral therapy	General hospital		48.0		75.0							90.0		30.0	20.0	
Antiretroviral therapy	HC III		48.0	60.0								90.0		30.0	20.0	
Antiretroviral therapy	HC IV		48.0	60.0								90.0		30.0	20.0	
Prevention of mother-to-child transmission	General hospital									90.0		45.0			15.0	
Prevention of mother-to-child transmission	HC III									90.0		45.0			15.0	
Prevention of mother-to-child transmission	HC IV									90.0		45.0			15.0	
HIV testing and counselling	General hospital											15.0			3.0	
HIV testing and counselling	HC II										15.0				3.0	
HIV testing and counselling	HC III										15.0				3.0	
HIV testing and counselling	HC IV											15.0			3.0	
BCG immunisation	General hospital										5.0					
BCG immunisation	HC II		1.1								5.0					
BCG immunisation	HC III		0.8								5.0					
BCG immunisation	HC IV		0.5								5.0					
Pentavalent immunisation (DTP-HepB-Hib)	General hospital										5.0					
Pentavalent immunisation (DTP-HepB-Hib)	HC II		1.1								5.0					
Pentavalent immunisation (DTP-HepB-Hib)	HC III		0.8								5.0					

Service	Level	Anaesthetic officer	Village health team member	Clinical officer	Medical officer	Specialist / consultant	Laboratory technician	Laboratory technologist	Enr. midwife	Reg. midwife	Enr. nurse	Reg. nurse	Nutritionist	Pharmacy technician	Health records officer	Support staff
Pentavalent immunisation (DTP-HepB-Hib)	HC IV		0.5								5.0					
HPV immunisation	General hospital										5.0					
HPV immunisation	HC II		1.1								5.0					
HPV immunisation	HC III		0.8								5.0					
HPV immunisation	HC IV		0.5								5.0					
Measles-rubella immunisation	General hospital										5.0					
Measles-rubella immunisation	HC II		1.1								5.0					
Measles-rubella immunisation	HC III		0.8								5.0					
Measles-rubella immunisation	HC IV		0.5								5.0					
Pneumococcal immunisation	General hospital										5.0					
Pneumococcal immunisation	HC II		1.1								5.0					
Pneumococcal immunisation	HC III		0.8								5.0					
Pneumococcal immunisation	HC IV		0.5								5.0					
Polio immunisation	General hospital										5.0					
Polio immunisation	HC II		1.1								5.0					
Polio immunisation	HC III		0.8								5.0					
Polio immunisation	HC IV		0.5								5.0					
Rotavirus immunisation	General hospital										5.0					
Rotavirus immunisation	HC II		1.1								5.0					
Rotavirus immunisation	HC III		0.8								5.0					
Rotavirus immunisation	HC IV		0.5								5.0					
Malaria diagnosis and treatment	General hospital			4.4	3.6			4.0				6.0				
Malaria diagnosis and treatment	HC II										10.0				2.0	
Malaria diagnosis and treatment	HC III			9.0			4.0				5.0				2.0	
Malaria diagnosis and treatment	HC IV			7.2	1.2			4.0			5.0					
Severe mental disorders and epilepsy care	General hospital			60.0								60.0		20.0	10.0	
Severe mental disorders and epilepsy care	HC III			60.0								60.0		20.0	10.0	

Service	Level	Anaesthetic officer	Village health team member	Clinical officer	Medical officer	Specialist / consultant	Laboratory technician	Laboratory technologist	Enr. midwife	Reg. midwife	Enr. nurse	Reg. nurse	Nutritionist	Pharmacy technician	Health records officer	Support staff
Severe mental disorders and epilepsy care	HC IV			60.0								60.0		20.0	10.0	
Severe mental disorders and epilepsy care	Regional referral			60.0								60.0		20.0	10.0	
Hypertension management	General hospital				60.0							40.0		20.0	10.0	
Hypertension management	HC III			60.0								40.0		20.0	10.0	
Hypertension management	HC IV			60.0								40.0		20.0	10.0	
NCD screening (blood pressure, glucose)	General hospital											10.0			2.0	
NCD screening (blood pressure, glucose)	HC II										10.0				2.0	
NCD screening (blood pressure, glucose)	HC III										10.0				2.0	
NCD screening (blood pressure, glucose)	HC IV											10.0			2.0	
Severe acute malnutrition treatment	General hospital		36.0									160.0	30.0		15.0	
Severe acute malnutrition treatment	HC II		36.0								160.0				15.0	
Severe acute malnutrition treatment	HC III		36.0								160.0		6.0		15.0	
Severe acute malnutrition treatment	HC IV		36.0									160.0	18.0		15.0	
Outpatient consultation	General hospital			4.0	4.4							4.0			2.0	
Outpatient consultation	HC II										10.0				2.0	
Outpatient consultation	HC III			10.0							3.0				2.0	
Outpatient consultation	HC IV			7.0	1.2						3.0				2.0	
Postnatal care contact	General hospital									22.0					3.0	
Postnatal care contact	HC II		12.0						20.0						3.0	
Postnatal care contact	HC III		9.0						20.0						3.0	
Postnatal care contact	HC IV		4.5							22.0					3.0	
Tuberculosis treatment course	General hospital		108.0	120.0	33.0							120.0				
Tuberculosis treatment course	HC III		210.0	160.0							120.0					
Tuberculosis treatment course	HC IV		180.0	140.0	14.0							120.0				

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/a_time_norms.csv).

B.4 Unit costs

Table B.4 is the unit cost catalogue by service and facility level. It also shows the shares of staff, medicine and capital in each unit cost, and the number of norm lines behind it.

Table B.4: Unit cost catalogue by service and facility level (price vintage UGA-2026Q1)

Service	Level	Unit	Unit cost UGX	USD	Staff	Medicines	Capital	Lines
Antenatal care visit	General hospital	visit	25,313	6.84	54%	6%	14%	16
Antenatal care visit	HC II	visit	13,532	3.66	39%	12%	9%	17
Antenatal care visit	HC III	visit	19,266	5.21	53%	9%	8%	17
Antenatal care visit	HC IV	visit	21,808	5.89	53%	8%	11%	18
Antiretroviral therapy	General hospital	patient-year	369,849	99.96	28%	59%	3%	16
Antiretroviral therapy	HC III	patient-year	341,062	92.18	24%	64%	2%	16
Antiretroviral therapy	HC IV	patient-year	344,312	93.06	23%	64%	3%	16
BCG immunisation	General hospital	dose	2,542	0.69	42%	43%	0%	5
BCG immunisation	HC II	dose	2,816	0.76	38%	39%	0%	7
BCG immunisation	HC III	dose	2,666	0.72	40%	41%	0%	7
BCG immunisation	HC IV	dose	2,596	0.70	41%	43%	0%	7
Caesarean section	General hospital	procedure	473,955	128.10	64%	5%	4%	27
Caesarean section	HC IV	procedure	494,987	133.78	64%	5%	6%	26
Caesarean section	Regional referral	procedure	466,914	126.19	65%	6%	4%	26
Complicated SAM, inpatient stabilisation	General hospital	bed-day	90,554	24.47	67%	9%	8%	15
Complicated SAM, inpatient stabilisation	HC IV	bed-day	88,432	23.90	67%	9%	9%	15
Complicated SAM, inpatient stabilisation	Regional referral	bed-day	90,554	24.47	67%	9%	8%	15
Family planning	General hospital	user-year	31,254	8.45	42%	28%	12%	14
Family planning	HC II	user-year	20,575	5.56	30%	43%	6%	14
Family planning	HC III	user-year	21,734	5.87	31%	41%	8%	14
Family planning	HC IV	user-year	29,539	7.98	45%	30%	9%	14
HIV testing and counselling	General hospital	test	16,407	4.43	42%	0%	21%	9
HIV testing and counselling	HC II	test	9,548	2.58	39%	0%	12%	9
HIV testing and counselling	HC III	test	10,283	2.78	36%	0%	16%	9
HIV testing and counselling	HC IV	test	14,692	3.97	47%	0%	16%	9
HPV immunisation	General hospital	dose	20,231	5.47	5%	93%	0%	5
HPV immunisation	HC II	dose	20,505	5.54	5%	92%	0%	7
HPV immunisation	HC III	dose	20,354	5.50	5%	92%	0%	7
HPV immunisation	HC IV	dose	20,284	5.48	5%	93%	0%	7
Hypertension management	General hospital	patient-year	89,370	24.15	73%	15%	6%	13
Hypertension management	HC III	patient-year	73,204	19.78	72%	19%	4%	13

Service	Level	Unit	Unit cost UGX	USD	Staff	Medicines	Capital	Lines
Hypertension management	HC IV	patient-year	74,674	20.18	70%	18%	6%	13
Inpatient bed-day	General hospital	bed-day	101,702	27.49	56%	15%	9%	15
Inpatient bed-day	HC IV	bed-day	95,514	25.81	56%	15%	8%	15
Inpatient bed-day	Regional referral	bed-day	119,470	32.29	54%	16%	9%	15
Major surgery (non-obstetric)	General hospital	procedure	478,712	129.38	43%	12%	5%	24
Major surgery (non-obstetric)	HC IV	procedure	455,788	123.19	40%	13%	5%	24
Major surgery (non-obstetric)	Regional referral	procedure	493,995	133.51	45%	12%	5%	24
Malaria diagnosis and treatment	General hospital	case	24,107	6.52	35%	33%	15%	17
Malaria diagnosis and treatment	HC II	case	11,454	3.10	22%	36%	10%	14
Malaria diagnosis and treatment	HC III	case	16,507	4.46	37%	28%	10%	17
Malaria diagnosis and treatment	HC IV	case	17,942	4.85	36%	31%	13%	17
Measles-rubella immunisation	General hospital	dose	3,958	1.07	27%	64%	0%	5
Measles-rubella immunisation	HC II	dose	4,232	1.14	25%	60%	0%	7
Measles-rubella immunisation	HC III	dose	4,081	1.10	26%	62%	0%	7
Measles-rubella immunisation	HC IV	dose	4,012	1.08	27%	63%	0%	7
NCD screening (blood pressure, glucose)	General hospital	screen	7,459	2.02	62%	0%	19%	8
NCD screening (blood pressure, glucose)	HC II	screen	3,866	1.04	65%	0%	12%	8
NCD screening (blood pressure, glucose)	HC III	screen	4,111	1.11	61%	0%	16%	8
NCD screening (blood pressure, glucose)	HC IV	screen	6,724	1.82	69%	0%	14%	8
Normal delivery	General hospital	delivery	187,974	50.80	70%	1%	10%	19
Normal delivery	HC III	delivery	113,078	30.56	62%	2%	10%	18
Normal delivery	HC IV	delivery	158,698	42.89	69%	2%	9%	19
Obstetric complications (non-surgical)	General hospital	bed-day	125,310	33.87	48%	31%	7%	20
Obstetric complications (non-surgical)	HC IV	bed-day	124,510	33.65	48%	32%	7%	20
Obstetric complications (non-surgical)	Regional referral	bed-day	135,826	36.71	51%	29%	8%	20
Outpatient consultation	General hospital	visit	17,983	4.86	37%	21%	20%	16
Outpatient consultation	HC II	visit	8,379	2.26	30%	39%	13%	12
Outpatient consultation	HC III	visit	12,152	3.28	43%	28%	13%	14
Outpatient consultation	HC IV	visit	12,900	3.49	37%	25%	19%	15
Pentavalent immunisation (DTP-HepB-Hib)	General hospital	dose	4,648	1.26	23%	69%	0%	5
Pentavalent immunisation (DTP-HepB-Hib)	HC II	dose	5,074	1.37	21%	66%	0%	7
Pentavalent immunisation (DTP-HepB-Hib)	HC III	dose	4,862	1.31	22%	68%	0%	7
Pentavalent immunisation (DTP-HepB-Hib)	HC IV	dose	4,732	1.28	23%	68%	0%	7
Pneumococcal immunisation	General hospital	dose	9,359	2.53	11%	85%	0%	5
Pneumococcal immunisation	HC II	dose	9,633	2.60	11%	82%	0%	7
Pneumococcal immunisation	HC III	dose	9,482	2.56	11%	84%	0%	7
Pneumococcal immunisation	HC IV	dose	9,412	2.54	11%	84%	0%	7
Polio immunisation	General hospital	dose	2,036	0.55	52%	29%	0%	5
Polio immunisation	HC II	dose	2,310	0.62	46%	26%	0%	7

Service	Level	Unit	Unit cost UGX	USD	Staff	Medicines	Capital	Lines
Polio immunisation	HC III	dose	2,159	0.58	50%	28%	0%	7
Polio immunisation	HC IV	dose	2,089	0.56	51%	29%	0%	7
Postnatal care contact	General hospital	visit	15,963	4.31	62%	2%	19%	10
Postnatal care contact	HC II	visit	9,340	2.52	53%	3%	10%	12
Postnatal care contact	HC III	visit	9,661	2.61	51%	3%	15%	12
Postnatal care contact	HC IV	visit	15,114	4.08	66%	2%	14%	12
Prevention of mother-to-child transmission	General hospital	patient	172,269	46.56	35%	5%	5%	11
Prevention of mother-to-child transmission	HC III	patient	167,369	45.23	36%	5%	3%	11
Prevention of mother-to-child transmission	HC IV	patient	169,819	45.90	35%	5%	4%	11
Rotavirus immunisation	General hospital	dose	7,756	2.10	14%	81%	0%	5
Rotavirus immunisation	HC II	dose	8,029	2.17	13%	79%	0%	7
Rotavirus immunisation	HC III	dose	7,879	2.13	14%	80%	0%	7
Rotavirus immunisation	HC IV	dose	7,809	2.11	14%	81%	0%	7
Severe acute malnutrition treatment	General hospital	case	283,438	76.60	29%	63%	4%	14
Severe acute malnutrition treatment	HC II	case	227,429	61.47	16%	78%	2%	13
Severe acute malnutrition treatment	HC III	case	232,328	62.79	17%	76%	3%	14
Severe acute malnutrition treatment	HC IV	case	274,864	74.29	29%	65%	3%	14
Severe childhood illness, admission	General hospital	bed-day	94,454	25.53	60%	12%	10%	19
Severe childhood illness, admission	HC IV	bed-day	89,245	24.12	60%	13%	9%	19
Severe childhood illness, admission	Regional referral	bed-day	96,479	26.08	59%	12%	11%	19
Severe mental disorders and epilepsy care	General hospital	patient-year	132,735	35.87	46%	44%	3%	11
Severe mental disorders and epilepsy care	HC III	patient-year	130,285	35.21	47%	45%	2%	11
Severe mental disorders and epilepsy care	HC IV	patient-year	131,510	35.54	46%	44%	2%	11
Severe mental disorders and epilepsy care	Regional referral	patient-year	133,960	36.21	46%	44%	4%	11
Sick newborn care	General hospital	bed-day	115,046	31.09	67%	8%	10%	18
Sick newborn care	HC IV	bed-day	110,474	29.86	68%	8%	9%	18
Sick newborn care	Regional referral	bed-day	117,071	31.64	66%	8%	11%	18
Tuberculosis treatment course	General hospital	patient	396,098	107.05	31%	43%	5%	16
Tuberculosis treatment course	HC III	patient	356,073	96.24	27%	48%	4%	15
Tuberculosis treatment course	HC IV	patient	388,478	104.99	31%	44%	4%	16

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_unit_costs.csv).

B.5 Prices

Table B.5 is the full price list, with the source and quality tier of each price.

Table B.5: Price list (price vintage UGA-2026Q1)

Resource	Class	Unit	Price UGX	Source	Quality
ANC card and register entry	consumable	unit	700	AICTEM-NORM	assumed
Auto-disable syringe	consumable	unit	330	UNICEF-SD	normed
Bedding and linen service	consumable	bed-day	2,200	AICTEM-NORM	assumed
Caesarean section surgical pack	consumable	pack	48,000	AICTEM-NORM	assumed
Clean delivery kit	consumable	kit	12,000	AICTEM-NORM	assumed
Condoms, user-year	consumable	user-year	13,300	UNICEF-SD	assumed
Examination gloves, pair	consumable	pair	400	AICTEM-NORM	assumed
Gauze and dressing set	consumable	set	1,800	AICTEM-NORM	assumed
General surgical pack and drapes, per procedure	consumable	procedure	148,000	AICTEM-NORM	assumed
IV giving set	consumable	set	1,600	AICTEM-NORM	assumed
MUAC tape	consumable	each	220	UNICEF-SD	assumed
Sharps safety box	consumable	unit	2,800	UNICEF-SD	normed
Sputum container	consumable	unit	450	AICTEM-NORM	assumed
Standard syringe and needle	consumable	unit	300	AICTEM-NORM	assumed
Sterile gloves, pair	consumable	pair	1,500	AICTEM-NORM	assumed
Suture pack	consumable	pack	6,500	AICTEM-NORM	assumed
Urinary catheter	consumable	unit	3,400	AICTEM-NORM	assumed
Blood glucose test	diagnostic	test	900	AICTEM-NORM	assumed
Blood grouping and cross-match	diagnostic	test	9,000	AICTEM-NORM	assumed
Chest radiograph	diagnostic	examination	14,000	AICTEM-NORM	assumed
Early infant diagnosis PCR	diagnostic	test	44,400	GF-PPM	assumed
GeneXpert MTB/RIF cartridge	diagnostic	test	29,600	STOPTB-GDF	normed
HIV rapid test kit	diagnostic	test	3,000	GF-PPM	normed
HIV viral load test	diagnostic	test	29,600	GF-PPM	normed
Haemoglobin test	diagnostic	test	1,500	AICTEM-NORM	assumed
Inpatient diagnostics basket	diagnostic	bed-day-equivalent	6,500	AICTEM-NORM	assumed
Malaria rapid diagnostic test	diagnostic	test	1,300	GF-PPM	normed
Sputum smear microscopy	diagnostic	test	2,200	AICTEM-NORM	assumed

Resource	Class	Unit	Price UGX	Source	Quality
Syphilis rapid test	diagnostic	test	2,500	AICTEM-NORM	assumed
Urinalysis strip	diagnostic	test	800	AICTEM-NORM	assumed
Clinical equipment, annualised allocation	equipment	service-unit-equivalent	600	AICTEM-NORM	assumed
Cold chain capacity, litre-year	equipment	litre-year	4,200	AICTEM-NORM	assumed
Theatre equipment, annualised allocation	equipment	service-unit-equivalent	9,500	AICTEM-NORM	assumed
Facility space, annualised allocation	infrastructure	service-unit-equivalent	1,000	AICTEM-NORM	assumed
Albendazole tablet	medicine	tablet	180	AICTEM-NORM	assumed
Amlodipine 5-10 mg, patient-year	medicine	patient-year	8,100	AICTEM-NORM	assumed
Amoxicillin capsule	medicine	capsule	120	AICTEM-NORM	assumed
Ampicillin + gentamicin, neonatal 7-day course	medicine	course	11,100	AICTEM-NORM	assumed
Antiretrovirals, adult first-line TLD	medicine	patient-year	166,500	GF-ARV	normed
Antiretrovirals, paediatric	medicine	patient-year	222,000	GF-ARV	assumed
Antiretrovirals, second-line	medicine	patient-year	666,000	GF-ARV	assumed
Artemether-lumefantrine, adult course	medicine	course	5,300	GF-PPM	normed
Artemether-lumefantrine, paediatric course	medicine	course	1,800	GF-PPM	normed
Artesunate injection, severe malaria course	medicine	course	26,000	GF-PPM	assumed
Bupivacaine spinal ampoule	medicine	ampoule	3,200	AICTEM-NORM	assumed
Ceftriaxone 1g vial	medicine	vial	2,400	AICTEM-NORM	assumed
Chlorhexidine cord gel	medicine	tube	1,100	AICTEM-NORM	assumed
Contraceptive implant, annualised	medicine	user-year	6,300	UNICEF-SD	normed
Cotrimoxazole prophylaxis	medicine	patient-year	18,500	AICTEM-NORM	assumed
Diclofenac ampoule	medicine	ampoule	700	AICTEM-NORM	assumed
Hydrochlorothiazide 25 mg, patient-year	medicine	patient-year	5,400	AICTEM-NORM	assumed
Infant nevirapine prophylaxis course	medicine	course	7,400	AICTEM-NORM	assumed
Injectable contraceptive, user-year	medicine	user-year	12,600	UNICEF-SD	normed
Inpatient medicines basket	medicine	bed-day-equivalent	11,000	AICTEM-NORM	assumed
Intrauterine device, annualised	medicine	user-year	2,200	UNICEF-SD	assumed
Intravenous fluid 500 ml bag	medicine	bag	3,200	AICTEM-NORM	assumed
Iron and folic acid tablet	medicine	tablet	22.00	AICTEM-NORM	assumed
Ketamine vial	medicine	vial	4,500	AICTEM-NORM	assumed
Lignocaine 2% vial	medicine	vial	900	AICTEM-NORM	assumed
Losartan 50 mg, patient-year	medicine	patient-year	20,300	AICTEM-NORM	assumed
Magnesium sulphate vial	medicine	vial	1,600	AICTEM-NORM	assumed
Medical oxygen, patient-day	medicine	patient-day	18,500	AICTEM-NORM	assumed

Resource	Class	Unit	Price UGX	Source	Quality
Misoprostol 200 mcg tablet	medicine	tablet	700	AICTEM-NORM	assumed
ORS sachet with zinc course	medicine	course	1,400	AICTEM-NORM	assumed
Oral contraceptive, user-year	medicine	user-year	14,400	UNICEF-SD	assumed
Oxytocin 10 IU ampoule	medicine	ampoule	950	AICTEM-NORM	assumed
Paracetamol tablet	medicine	tablet	35.00	AICTEM-NORM	assumed
Psychotropic and antiepileptic basket, patient-year	medicine	patient-year	55,500	AICTEM-NORM	assumed
Ready-to-use therapeutic food, sachet	medicine	sachet	1,110	UNICEF-SD	normed
Residual OPD medicines basket	medicine	visit-equivalent	2,600	AICTEM-NORM	assumed
Sulfadoxine-pyrimethamine, IPTp dose	medicine	dose	900	GF-PPM	assumed
TB first-line FDC, 6-month adult course	medicine	course	166,500	STOPTB-GDF	normed
Therapeutic milk F-75/F-100, child-day	medicine	child-day	3,700	UNICEF-SD	assumed
Whole blood / packed cells, unit transfused	medicine	unit	166,500	AICTEM-NORM	assumed
Inpatient meals	other	bed-day	4,500	AICTEM-NORM	assumed
TB patient transport and adherence support	other	patient	42,000	AICTEM-NORM	assumed
Administrative officer	staff	minute	375	MoPS-CSI-2022	normed
Anaesthetic officer	staff	minute	425	MoPS-CSI-2022	normed
Clinical officer	staff	minute	425	MoPS-CSI-2022	normed
Enrolled midwife	staff	minute	212	MoPS-CSI-2022	normed
Enrolled nurse	staff	minute	212	MoPS-CSI-2022	normed
Health records officer	staff	minute	187	MoPS-CSI-2022	normed
Laboratory technician	staff	minute	204	MoPS-CSI-2022	normed
Laboratory technologist	staff	minute	408	MoPS-CSI-2022	normed
Medical officer	staff	minute	637	MoPS-CSI-2022	normed
Nutritionist	staff	minute	408	MoPS-CSI-2022	normed
Pharmacist	staff	minute	612	MoPS-CSI-2022	normed
Pharmacy technician	staff	minute	408	MoPS-CSI-2022	normed
Radiographer	staff	minute	408	MoPS-CSI-2022	normed
Registered midwife	staff	minute	425	MoPS-CSI-2022	normed
Registered nurse	staff	minute	425	MoPS-CSI-2022	normed
Specialist / consultant	staff	minute	1,061	MoPS-CSI-2022	normed
Support staff	staff	minute	206	MoPS-CSI-2022	normed
Village health team member	staff	minute	11.37	MoPS-CSI-2022	normed
Supportive supervision allocation	supervision	service-unit-equivalent	320	AICTEM-NORM	assumed
Outreach transport, kilometre	transport	km	1,900	AICTEM-NORM	assumed

Resource	Class	Unit	Price UGX	Source	Quality
Referral transport, trip	transport	trip	65,000	AICTEM-NORM	assumed
Utilities, cleaning and waste management	utility	service-unit-equivalent	850	AICTEM-NORM	assumed
BCG vaccine	vaccine	dose	850	UNICEF-SD	normed
HPV vaccine	vaccine	dose	17,400	UNICEF-SD	normed
Inactivated polio vaccine	vaccine	dose	6,700	UNICEF-SD	normed
Measles-rubella vaccine	vaccine	dose	2,100	UNICEF-SD	normed
Oral polio vaccine	vaccine	dose	520	UNICEF-SD	normed
Pentavalent DTP-HepB-Hib vaccine	vaccine	dose	3,000	UNICEF-SD	normed
Pneumococcal conjugate vaccine	vaccine	dose	7,400	UNICEF-SD	normed
Rotavirus vaccine	vaccine	dose	5,900	UNICEF-SD	normed
Tetanus-diphtheria (Td) vaccine	vaccine	dose	400	UNICEF-SD	normed

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/t_prices.csv).

ANNEX C

C District statistical tables

This annex gives the district-level values behind every map in the report, for all 122 plan districts, grouped by DHS sub-region. The values are those stored in the GIS layers of run uga-unconstrained-2026 for 2026, so each table matches the map of the same layer. Districts follow the 2018 district set: districts and cities created since then are folded into their parent district.

A dash marks a value that is not defined for a district. For example, a capacity ratio is not defined where the district has no requirement for the service.

C.1 Population and demography

Table C.1: Annex: population and demography by district, 2026

District	Sub-region	Population	Area km2	Density /km2	Under five %	Births /1,000
Gulu	Acholi	374,827	1,968	190	17.2	38.5
Agago	Acholi	299,660	3,489	86	17.2	38.5
Kitgum	Acholi	267,608	3,960	68	17.2	38.5
Amuru	Acholi	251,770	3,634	69	17.2	38.5
Pader	Acholi	234,675	3,370	70	17.2	38.5
Omoro	Acholi	222,357	1,486	150	17.2	38.5
Nwoya	Acholi	220,849	4,758	46	17.2	38.5
Lamwo	Acholi	174,215	5,591	31	17.2	38.5
Isingiro	Ankole	673,607	2,669	252	17.5	41.9
Ntungamo	Ankole	640,675	2,028	316	17.5	41.9
Mbarara	Ankole	629,865	1,820	346	17.5	41.9
Kiruhura	Ankole	455,021	4,599	99	17.5	41.9
Ibanda	Ankole	329,576	962	343	17.5	41.9
Bushenyi	Ankole	302,426	943	321	17.5	41.9
Sheema	Ankole	268,111	705	380	17.5	41.9
Mitooma	Ankole	236,686	546	434	17.5	41.9
Rubirizi	Ankole	170,947	1,291	132	17.5	41.9
Buhweju	Ankole	165,039	803	206	17.5	41.9
Mbale	Bugisu	669,962	519	1,292	17.0	39.5
Sironko	Bugisu	322,914	403	800	17.0	39.5
Namisindwa	Bugisu	298,780	298	1,003	17.0	39.5
Bududa	Bugisu	298,403	316	946	17.0	39.5
Bulambuli	Bugisu	250,764	699	359	17.0	39.5
Manafwa	Bugisu	176,981	237	748	17.0	39.5
Kapchorwa	Bugisu	142,917	355	403	17.0	39.5
Bukwo	Bugisu	128,965	515	250	17.0	39.5
Kween	Bugisu	126,702	863	147	17.0	39.5
Tororo	Bukedi	695,856	1,209	575	18.5	39.5
Busia	Bukedi	441,195	762	579	18.5	39.5
Butaleja	Bukedi	338,752	646	524	18.5	39.5
Pallisa	Bukedi	332,341	860	386	18.5	39.5
Budaka	Bukedi	286,839	418	687	18.5	39.5
Kibuku	Bukedi	281,309	489	576	18.5	39.5
Butebo	Bukedi	201,240	238	846	18.5	39.5
Hoima	Bunyoro	808,982	5,645	143	18.9	46.2

District	Sub-region	Population	Area km2	Density /km2	Under five %	Births /1,000
Kagadi	Bunyoro	486,194	1,566	310	18.9	46.2
Kakumiro	Bunyoro	464,197	1,675	277	18.9	46.2
Masindi	Bunyoro	394,184	2,582	153	18.9	46.2
Kiryandongo	Bunyoro	361,629	3,623	100	18.9	46.2
Kibaale	Bunyoro	208,656	1,147	182	18.9	46.2
Buliisa	Bunyoro	162,400	3,370	48	18.9	46.2
Iganga	Busoga	685,046	1,017	673	18.4	41.1
Kamuli	Busoga	652,490	1,556	419	18.4	41.1
Mayuge	Busoga	647,085	3,430	189	18.4	41.1
Jinja	Busoga	617,170	732	843	18.4	41.1
Bugiri	Busoga	536,347	1,054	509	18.4	41.1
Buyende	Busoga	457,535	1,880	243	18.4	41.1
Namutumba	Busoga	348,053	813	428	18.4	41.1
Kaliro	Busoga	326,559	868	376	18.4	41.1
Luuka	Busoga	315,749	650	485	18.4	41.1
Namayingo	Busoga	283,068	4,666	61	18.4	41.1
Kampala	Kampala	1,993,294	195	10,201	15.4	34.5
Kotido	Karamoja	248,376	3,608	69	19.5	48.2
Kaabong	Karamoja	225,877	7,308	31	19.5	48.2
Nakapiripirit	Karamoja	222,985	4,197	53	19.5	48.2
Napak	Karamoja	187,916	4,976	38	19.5	48.2
Abim	Karamoja	160,640	2,352	68	19.5	48.2
Amudat	Karamoja	149,327	1,616	92	19.5	48.2
Moroto	Karamoja	138,643	3,543	39	19.5	48.2
Rukungiri	Kigezi	406,125	1,517	268	15.6	32.4
Kisoro	Kigezi	373,318	730	511	15.6	32.4
Kanungu	Kigezi	331,336	1,299	255	15.6	32.4
Kabale	Kigezi	300,037	620	484	15.6	32.4
Rubanda	Kigezi	253,907	691	367	15.6	32.4
Rukiga	Kigezi	129,090	440	294	15.6	32.4
Lira	Lango	553,064	1,321	419	16.4	34.8
Oyam	Lango	522,269	2,178	240	16.4	34.8
Apac	Lango	505,677	3,191	158	16.4	34.8
Kole	Lango	326,434	1,077	303	16.4	34.8
Alebtong	Lango	307,956	1,551	199	16.4	34.8
Dokolo	Lango	248,628	1,079	230	16.4	34.8
Amolatar	Lango	203,503	1,796	113	16.4	34.8
Otuke	Lango	147,442	1,548	95	16.4	34.8
Mubende	North Buganda	959,190	4,625	207	17.5	40.6
Mukono	North Buganda	809,737	4,076	199	17.5	40.6
Luwero	North Buganda	612,519	2,216	276	17.5	40.6
Buikwe	North Buganda	560,732	1,460	384	17.5	40.6
Kayunga	North Buganda	485,314	1,703	285	17.5	40.6
Mityana	North Buganda	432,647	1,579	274	17.5	40.6
Kyankwanzi	North Buganda	307,831	2,455	125	17.5	40.6
Nakaseke	North Buganda	269,242	3,475	77	17.5	40.6
Nakasongola	North Buganda	247,496	3,509	71	17.5	40.6
Kiboga	North Buganda	199,480	1,586	126	17.5	40.6
Buvuma	North Buganda	134,370	9,569	14	17.5	40.6
Wakiso	South Buganda	3,011,310	2,816	1,069	18.2	42.6
Masaka	South Buganda	395,315	2,258	175	18.2	42.6
Kyotera	South Buganda	366,154	2,448	150	18.2	42.6
Lwengo	South Buganda	354,338	993	357	18.2	42.6
Sembabule	South Buganda	342,271	2,301	149	18.2	42.6

District	Sub-region	Population	Area km2	Density /km2	Under five %	Births /1,000
Mpigi	South Buganda	335,484	1,525	220	18.2	42.6
Rakai	South Buganda	318,138	1,607	198	18.2	42.6
Kalungu	South Buganda	236,309	822	288	18.2	42.6
Gomba	South Buganda	208,907	1,689	124	18.2	42.6
Bukomansimbi	South Buganda	193,070	599	322	18.2	42.6
Butambala	South Buganda	130,724	405	323	18.2	42.6
Lyantonde	South Buganda	127,456	888	143	18.2	42.6
Kalangala	South Buganda	75,544	7,764	10	18.2	42.6
Soroti	Teso	410,902	1,415	290	18.3	51.1
Serere	Teso	400,846	1,949	206	18.3	51.1
Amuria	Teso	373,318	2,598	144	18.3	51.1
Kumi	Teso	326,559	1,074	304	18.3	51.1
Kaberaimaido	Teso	302,174	1,625	186	18.3	51.1
Bukedea	Teso	287,216	1,057	272	18.3	51.1
Katakwi	Teso	225,122	2,428	93	18.3	51.1
Ngora	Teso	192,064	716	268	18.3	51.1
Kasese	Tooro	929,651	3,371	276	18.7	39.1
Kyenjojo	Tooro	589,139	2,346	251	18.7	39.1
Kamwenge	Tooro	576,947	2,416	239	18.7	39.1
Kyegegwa	Tooro	439,435	1,751	251	18.7	39.1
Kabarole	Tooro	397,955	1,313	303	18.7	39.1
Bundibugyo	Tooro	304,562	827	368	18.7	39.1
Bunyangabu	Tooro	228,139	503	453	18.7	39.1
Ntoroko	Tooro	89,370	1,400	64	18.7	39.1
Arua	West Nile	1,058,867	4,341	244	17.8	41.0
Yumbe	West Nile	708,425	2,328	304	17.8	41.0
Zombo	West Nile	326,308	899	363	17.8	41.0
Nebbi	West Nile	325,428	991	328	17.8	41.0
Adjumani	West Nile	288,976	3,081	94	17.8	41.0
Koboko	West Nile	288,599	752	384	17.8	41.0
Maracha	West Nile	246,742	449	549	17.8	41.0
Pakwach	West Nile	220,220	1,032	213	17.8	41.0
Moyo	West Nile	185,905	1,829	102	17.8	41.0

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/a_pop.csv).

C.2 Need

Table C.2: Annex: need by district, 2026

District	Sub-region	Malaria /1,000	HIV ART /1,000	SAM /1,000	Hypertension /1,000	TB /100,000
Gulu	Acholi	455	40.0	4.75	108.7	198
Agago	Acholi	455	40.0	4.75	108.7	198
Kitgum	Acholi	455	40.0	4.75	108.7	198
Amuru	Acholi	455	40.0	4.75	108.7	198
Pader	Acholi	455	40.0	4.75	108.7	198
Omoro	Acholi	455	40.0	4.75	108.7	198
Nwoya	Acholi	455	40.0	4.75	108.7	198
Lamwo	Acholi	455	40.0	4.75	108.7	198
Isingiro	Ankole	110	34.5	3.60	113.1	198
Ntungamo	Ankole	110	34.5	3.60	113.1	198
Mbarara	Ankole	110	34.5	3.60	113.1	198
Kiruhura	Ankole	110	34.5	3.60	113.1	198
Ibanda	Ankole	110	34.5	3.60	113.1	198
Bushenyi	Ankole	110	34.5	3.60	113.1	198
Sheema	Ankole	110	34.5	3.60	113.1	198

District	Sub-region	Malaria /1,000	HIV ART /1,000	SAM /1,000	Hypertension /1,000	TB /100,000
Mitooma	Ankole	110	34.5	3.60	113.1	198
Rubirizi	Ankole	110	34.5	3.60	113.1	198
Buhweju	Ankole	110	34.5	3.60	113.1	198
Mbale	Bugisu	287	23.0	7.57	113.3	198
Sironko	Bugisu	287	23.0	7.57	113.3	198
Namisindwa	Bugisu	287	23.0	7.57	113.3	198
Bududa	Bugisu	287	23.0	7.57	113.3	198
Bulambuli	Bugisu	287	23.0	7.57	113.3	198
Manafwa	Bugisu	287	23.0	7.57	113.3	198
Kapchorwa	Bugisu	287	23.0	7.57	113.3	198
Bukwo	Bugisu	287	23.0	7.57	113.3	198
Kween	Bugisu	287	23.0	7.57	113.3	198
Tororo	Bukedi	423	22.1	4.08	108.6	198
Busia	Bukedi	423	22.1	4.08	108.6	198
Butaleja	Bukedi	423	22.1	4.08	108.6	198
Pallisa	Bukedi	423	22.1	4.08	108.6	198
Budaka	Bukedi	423	22.1	4.08	108.6	198
Kibuku	Bukedi	423	22.1	4.08	108.6	198
Butebo	Bukedi	423	22.1	4.08	108.6	198
Hoima	Bunyoro	297	30.1	2.56	113.0	198
Kagadi	Bunyoro	297	30.1	2.56	113.0	198
Kakumiro	Bunyoro	297	30.1	2.56	113.0	198
Masindi	Bunyoro	297	30.1	2.56	113.0	198
Kiryandongo	Bunyoro	297	30.1	2.56	113.0	198
Kibaale	Bunyoro	297	30.1	2.56	113.0	198
Buliisa	Bunyoro	297	30.1	2.56	113.0	198
Iganga	Busoga	391	23.0	3.58	105.4	198
Kamuli	Busoga	391	23.0	3.58	105.4	198
Mayuge	Busoga	391	23.0	3.58	105.4	198
Jinja	Busoga	391	23.0	3.58	105.4	198
Bugiri	Busoga	391	23.0	3.58	105.4	198
Buyende	Busoga	391	23.0	3.58	105.4	198
Namutumba	Busoga	391	23.0	3.58	105.4	198
Kaliro	Busoga	391	23.0	3.58	105.4	198
Luuka	Busoga	391	23.0	3.58	105.4	198
Namayingo	Busoga	391	23.0	3.58	105.4	198
Kampala	Kampala	171	42.0	4.48	144.6	198
Kotido	Karamoja	371	10.8	8.97	105.8	198
Kaabong	Karamoja	371	10.8	8.97	105.8	198
Nakapiripirit	Karamoja	371	10.8	8.97	105.8	198
Napak	Karamoja	371	10.8	8.97	105.8	198
Abim	Karamoja	371	10.8	8.97	105.8	198
Amudat	Karamoja	371	10.8	8.97	105.8	198
Moroto	Karamoja	371	10.8	8.97	105.8	198
Rukungiri	Kigezi	105	37.1	3.83	121.5	198
Kisoro	Kigezi	105	37.1	3.83	121.5	198
Kanungu	Kigezi	105	37.1	3.83	121.5	198
Kabale	Kigezi	105	37.1	3.83	121.5	198
Rubanda	Kigezi	105	37.1	3.83	121.5	198
Rukiga	Kigezi	105	37.1	3.83	121.5	198
Lira	Lango	601	41.6	5.83	112.9	198
Oyam	Lango	601	41.6	5.83	112.9	198
Apac	Lango	601	41.6	5.83	112.9	198
Kole	Lango	601	41.6	5.83	112.9	198

District	Sub-region	Malaria /1,000	HIV ART /1,000	SAM /1,000	Hypertension /1,000	TB /100,000
Alebtong	Lango	601	41.6	5.83	112.9	198
Dokolo	Lango	601	41.6	5.83	112.9	198
Amolatar	Lango	601	41.6	5.83	112.9	198
Otuke	Lango	601	41.6	5.83	112.9	198
Mubende	North Buganda	295	34.9	4.01	116.0	198
Mukono	North Buganda	295	34.9	4.01	116.0	198
Luwero	North Buganda	295	34.9	4.01	116.0	198
Buikwe	North Buganda	295	34.9	4.01	116.0	198
Kayunga	North Buganda	295	34.9	4.01	116.0	198
Mityana	North Buganda	295	34.9	4.01	116.0	198
Kyankwanzi	North Buganda	295	34.9	4.01	116.0	198
Nakaseke	North Buganda	295	34.9	4.01	116.0	198
Nakasongola	North Buganda	295	34.9	4.01	116.0	198
Kiboga	North Buganda	295	34.9	4.01	116.0	198
Buvuma	North Buganda	295	34.9	4.01	116.0	198
Wakiso	South Buganda	190	48.8	2.02	124.3	198
Masaka	South Buganda	190	48.8	2.02	124.3	198
Kyotera	South Buganda	190	48.8	2.02	124.3	198
Lwengo	South Buganda	190	48.8	2.02	124.3	198
Sembabule	South Buganda	190	48.8	2.02	124.3	198
Mpigi	South Buganda	190	48.8	2.02	124.3	198
Rakai	South Buganda	190	48.8	2.02	124.3	198
Kalungu	South Buganda	190	48.8	2.02	124.3	198
Gomba	South Buganda	190	48.8	2.02	124.3	198
Bukomansimbi	South Buganda	190	48.8	2.02	124.3	198
Butambala	South Buganda	190	48.8	2.02	124.3	198
Lyantonde	South Buganda	190	48.8	2.02	124.3	198
Kalangala	South Buganda	190	48.8	2.02	124.3	198
Soroti	Teso	542	23.0	2.59	112.8	198
Serere	Teso	542	23.0	2.59	112.8	198
Amuria	Teso	542	23.0	2.59	112.8	198
Kumi	Teso	542	23.0	2.59	112.8	198
Kaberamaido	Teso	542	23.0	2.59	112.8	198
Bukedea	Teso	542	23.0	2.59	112.8	198
Katakwi	Teso	542	23.0	2.59	112.8	198
Ngora	Teso	542	23.0	2.59	112.8	198
Kasese	Tooro	147	30.1	5.55	113.0	198
Kyenjojo	Tooro	147	30.1	5.55	113.0	198
Kamwenge	Tooro	147	30.1	5.55	113.0	198
Kyegegwa	Tooro	147	30.1	5.55	113.0	198
Kabarole	Tooro	147	30.1	5.55	113.0	198
Bundibugyo	Tooro	147	30.1	5.55	113.0	198
Bunyangabu	Tooro	147	30.1	5.55	113.0	198
Ntoroko	Tooro	147	30.1	5.55	113.0	198
Arua	West Nile	301	14.8	13.82	109.4	198
Yumbe	West Nile	301	14.8	13.82	109.4	198
Zombo	West Nile	301	14.8	13.82	109.4	198
Nebbi	West Nile	301	14.8	13.82	109.4	198
Adjumani	West Nile	301	14.8	13.82	109.4	198
Koboko	West Nile	301	14.8	13.82	109.4	198
Maracha	West Nile	301	14.8	13.82	109.4	198
Pakwach	West Nile	301	14.8	13.82	109.4	198
Moyo	West Nile	301	14.8	13.82	109.4	198

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/a_need.csv).

C.3 Demand and workforce requirement

Table C.3: Annex: demand and workforce requirement by district, 2026

District	Sub-region	OPD visits /person	Deliveries /1,000	Bed-days /1,000	FTE /10,000
Gulu	Acholi	0.48	28.5	45	7.5
Agago	Acholi	0.41	28.5	39	7.2
Kitgum	Acholi	0.42	28.5	39	7.2
Amuru	Acholi	0.40	28.5	37	7.2
Pader	Acholi	0.40	28.5	37	7.2
Omoro	Acholi	0.40	28.5	37	7.2
Nwoya	Acholi	0.40	28.5	37	7.2
Lamwo	Acholi	0.43	28.5	40	7.3
Isingiro	Ankole	0.40	31.0	37	6.7
Ntungamo	Ankole	0.40	31.0	37	6.7
Mbarara	Ankole	0.40	31.0	37	6.7
Kiruhura	Ankole	0.40	31.0	37	6.7
Ibanda	Ankole	0.40	31.0	37	6.7
Bushenyi	Ankole	0.40	31.0	37	6.7
Sheema	Ankole	0.40	31.0	37	6.7
Mitooma	Ankole	0.40	31.0	37	6.7
Rubirizi	Ankole	0.40	31.0	37	6.7
Buhweju	Ankole	0.40	31.0	37	6.7
Mbale	Bugisu	0.40	29.2	37	6.5
Sironko	Bugisu	0.40	29.2	37	6.5
Namisindwa	Bugisu	0.40	29.2	37	6.5
Bududa	Bugisu	0.40	29.2	37	6.5
Bulambuli	Bugisu	0.40	29.2	37	6.5
Manafwa	Bugisu	0.40	29.2	37	6.5
Kapchorwa	Bugisu	0.40	29.2	37	6.5
Bukwo	Bugisu	0.40	29.2	37	6.5
Kween	Bugisu	0.40	29.2	37	6.5
Tororo	Bukedi	0.40	29.2	37	6.7
Busia	Bukedi	0.40	29.2	37	6.7
Butaleja	Bukedi	0.52	29.2	49	7.1
Pallisa	Bukedi	0.48	29.2	45	6.9
Budaka	Bukedi	0.43	29.2	40	6.8
Kibuku	Bukedi	0.40	29.2	37	6.7
Butebo	Bukedi	0.40	29.2	37	6.7
Hoima	Bunyoro	0.41	34.2	39	7.2
Kagadi	Bunyoro	0.40	34.2	37	7.1
Kakumiro	Bunyoro	0.40	34.2	37	7.1
Masindi	Bunyoro	0.40	34.2	37	7.1
Kiryandongo	Bunyoro	0.46	34.2	43	7.4
Kibaale	Bunyoro	0.40	34.2	37	7.1
Buliisa	Bunyoro	0.40	34.2	37	7.1
Iganga	Busoga	0.40	30.4	37	6.7
Kamuli	Busoga	0.50	30.4	47	7.1
Mayuge	Busoga	0.40	30.4	37	6.7
Jinja	Busoga	0.40	30.4	37	6.7
Bugiri	Busoga	0.41	30.4	38	6.7
Buyende	Busoga	0.40	30.4	37	6.7
Namutumba	Busoga	0.40	30.4	37	6.7
Kaliro	Busoga	0.40	30.4	37	6.7

District	Sub-region	OPD visits /person	Deliveries /1,000	Bed-days /1,000	FTE /10,000
Luuka	Busoga	0.40	30.4	37	6.7
Namayingo	Busoga	0.43	30.4	40	6.8
Kampala	Kampala	0.40	25.6	37	6.8
Kotido	Karamoja	0.43	35.7	41	6.9
Kaabong	Karamoja	0.40	35.7	37	6.8
Nakapiripirit	Karamoja	0.40	35.7	37	6.8
Napak	Karamoja	0.40	35.7	38	6.8
Abim	Karamoja	0.40	35.7	37	6.8
Amudat	Karamoja	0.40	35.7	37	6.8
Moroto	Karamoja	0.40	35.7	37	6.8
Rukungiri	Kigezi	0.40	24.0	37	6.2
Kisoro	Kigezi	0.40	24.0	37	6.2
Kanungu	Kigezi	0.40	24.0	37	6.2
Kabale	Kigezi	0.40	24.0	37	6.2
Rubanda	Kigezi	0.40	24.0	37	6.2
Rukiga	Kigezi	0.40	24.0	37	6.2
Lira	Lango	0.40	25.7	37	7.2
Oyam	Lango	0.40	25.7	37	7.2
Apac	Lango	0.40	25.7	37	7.2
Kole	Lango	0.40	25.7	37	7.2
Alebtong	Lango	0.40	25.7	37	7.2
Dokolo	Lango	0.51	25.7	48	7.6
Amolatar	Lango	0.40	25.7	37	7.2
Otuke	Lango	0.40	25.7	37	7.2
Mubende	North Buganda	0.40	30.1	37	6.9
Mukono	North Buganda	0.40	30.1	37	6.9
Luwero	North Buganda	0.40	30.1	37	6.9
Buikwe	North Buganda	0.40	30.1	37	6.9
Kayunga	North Buganda	0.40	30.1	37	6.9
Mityana	North Buganda	0.40	30.1	37	6.9
Kyankwanzi	North Buganda	0.40	30.1	37	6.9
Nakaseke	North Buganda	0.43	30.1	40	7.0
Nakasongola	North Buganda	0.40	30.1	37	6.9
Kiboga	North Buganda	0.52	30.1	49	7.4
Buvuma	North Buganda	0.40	30.1	37	6.9
Wakiso	South Buganda	0.40	31.6	37	7.4
Masaka	South Buganda	0.40	31.6	37	7.4
Kyotera	South Buganda	0.40	31.6	37	7.4
Lwengo	South Buganda	0.40	31.6	37	7.4
Sembabule	South Buganda	0.40	31.6	37	7.4
Mpigi	South Buganda	0.44	31.6	41	7.5
Rakai	South Buganda	0.40	31.6	37	7.4
Kalungu	South Buganda	0.40	31.6	37	7.4
Gomba	South Buganda	0.40	31.6	37	7.4
Bukomansimbi	South Buganda	0.40	31.6	37	7.4
Butambala	South Buganda	0.42	31.6	39	7.4
Lyantonde	South Buganda	0.43	31.6	40	7.5
Kalangala	South Buganda	0.40	31.6	37	7.4
Soroti	Teso	0.45	37.8	42	7.8
Serere	Teso	0.48	37.8	45	7.9
Amuria	Teso	0.47	37.8	44	7.8
Kumi	Teso	0.40	37.8	37	7.6

District	Sub-region	OPD visits /person	Deliveries /1,000	Bed-days /1,000	FTE /10,000
Kaberamaido	Teso	0.40	37.8	37	7.6
Bukedea	Teso	0.40	37.8	37	7.6
Katakwi	Teso	0.43	37.8	40	7.7
Ngora	Teso	0.43	37.8	40	7.7
Kasese	Tooro	0.40	28.9	37	6.5
Kyenjojo	Tooro	0.40	28.9	37	6.5
Kamwenge	Tooro	0.40	28.9	37	6.5
Kyegegwa	Tooro	0.40	28.9	37	6.5
Kabarole	Tooro	0.40	28.9	37	6.5
Bundibugyo	Tooro	0.40	28.9	37	6.5
Bunyangabu	Tooro	0.40	28.9	37	6.5
Ntoroko	Tooro	0.40	28.9	37	6.5
Arua	West Nile	0.40	30.4	37	6.5
Yumbe	West Nile	0.40	30.4	37	6.5
Zombo	West Nile	0.40	30.4	37	6.5
Nebbi	West Nile	0.42	30.4	40	6.5
Adjumani	West Nile	0.40	30.4	37	6.5
Koboko	West Nile	0.40	30.4	37	6.5
Maracha	West Nile	0.42	30.4	39	6.5
Pakwach	West Nile	0.40	30.4	37	6.5
Moyo	West Nile	0.40	30.4	37	6.5

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/a_demand.csv).

C.4 Supply and access

Table C.4: Annex: supply and access by district

District	Sub-region	Facilities /10,000	Hospitals /100,000	Workers /10,000	OPD cap./req.	Bed cap./req.	60 min drive %	60 min walk %
Gulu	Acholi	1.36	0.80	63.0	0.58	4.07	100	90
Agago	Acholi	1.43	0.33	25.0	0.69	1.33	99	73
Kitgum	Acholi	1.27	1.12	47.0	0.58	3.87	99	70
Amuru	Acholi	1.47	0.40	28.2	0.60	1.39	96	72
Pader	Acholi	1.79	0.00	21.3	0.73	0.06	100	68
Omoro	Acholi	1.30	0.00	21.2	0.50	0.03	99	87
Nwoya	Acholi	1.00	0.45	17.1	0.33	0.95	96	56
Lamwo	Acholi	1.78	0.00	18.5	0.75	0.10	99	54
Isingiro	Ankole	1.04	0.00	10.7	0.44	0.03	100	92
Ntungamo	Ankole	0.73	0.16	17.6	0.46	0.78	100	91
Mbarara	Ankole	1.03	0.48	20.7	0.47	2.12	100	96
Kiruhura	Ankole	1.05	0.22	15.9	0.53	0.77	98	57
Ibanda	Ankole	1.40	0.30	16.5	0.74	0.99	100	100
Bushenyi	Ankole	1.42	0.66	37.8	0.75	2.34	100	99
Sheema	Ankole	1.45	0.37	23.9	0.78	1.35	100	87
Mitooma	Ankole	0.93	0.42	25.8	0.50	1.46	100	100
Rubirizi	Ankole	1.17	0.00	16.2	0.47	0.04	100	98
Buhweju	Ankole	1.09	0.61	26.3	0.50	1.62	100	88
Mbale	Bugisu	0.88	0.45	43.2	0.60	2.86	100	99
Sironko	Bugisu	1.05	0.00	18.5	0.46	0.05	100	100
Namisindwa	Bugisu	0.67	0.00	11.1	0.28	0.03	100	100
Bududa	Bugisu	0.64	0.34	17.1	0.31	1.12	99	100
Bulambuli	Bugisu	1.08	0.00	24.6	0.53	0.04	95	95
Manafwa	Bugisu	0.68	0.00	12.8	0.38	0.08	100	100
Kapchorwa	Bugisu	1.82	0.70	49.4	0.95	3.01	100	100
Bukwo	Bugisu	1.78	0.00	24.0	0.81	0.11	99	98
Kween	Bugisu	2.05	0.00	26.3	1.01	0.07	99	97
Tororo	Bukedi	1.08	0.57	21.3	0.49	1.72	100	100
Busia	Bukedi	0.79	0.45	15.9	0.34	1.26	100	99
Butaleja	Bukedi	0.80	0.59	22.7	0.34	1.80	100	99
Pallisa	Bukedi	0.75	0.30	22.5	0.26	0.93	100	99
Budaka	Bukedi	0.70	0.00	16.5	0.26	0.03	100	100
Kibuku	Bukedi	0.64	0.00	16.5	0.32	0.04	100	99
Butebo	Bukedi	0.70	0.50	24.9	0.35	1.93	100	100

District	Sub-region	Facilities /10,000	Hospitals /100,000	Workers /10,000	OPD cap./req.	Bed cap./req.	60 min drive %	60 min walk %
Hoima	Bunyoro	0.87	0.12	19.3	0.36	0.49	99	75
Kagadi	Bunyoro	0.56	0.21	13.7	0.23	0.65	100	82
Kakumiro	Bunyoro	0.56	0.00	9.0	0.18	0.03	100	61
Masindi	Bunyoro	1.09	0.51	31.3	0.57	2.10	99	83
Kiryandongo	Bunyoro	0.69	0.55	19.5	0.28	1.41	100	78
Kibaale	Bunyoro	0.86	0.00	16.9	0.40	0.04	100	56
Buliisa	Bunyoro	0.99	0.62	22.3	0.37	1.45	100	75
Iganga	Busoga	0.96	0.15	14.8	0.41	0.60	100	98
Kamuli	Busoga	0.90	0.31	18.3	0.40	1.10	98	97
Mayuge	Busoga	0.77	0.15	13.2	0.38	0.71	98	92
Jinja	Busoga	1.46	0.81	51.5	0.80	5.10	100	100
Bugiri	Busoga	0.86	0.19	9.4	0.36	0.54	100	99
Buyende	Busoga	0.63	0.00	6.2	0.27	0.03	97	60
Namutumba	Busoga	1.06	0.00	8.5	0.50	0.04	99	98
Kaliro	Busoga	0.64	0.00	12.5	0.30	0.03	100	88
Luuka	Busoga	1.20	0.00	10.1	0.38	0.02	100	99
Namayingo	Busoga	1.06	0.00	8.6	0.43	0.02	100	96
Kampala	Kampala	0.46	1.00	60.3	0.13	3.05	100	94
Kotido	Karamoja	0.89	0.40	22.5	0.46	1.62	95	88
Kaabong	Karamoja	1.95	0.44	30.5	0.81	1.54	95	74
Nakapiripirit	Karamoja	0.99	0.00	17.4	0.53	0.11	73	71
Napak	Karamoja	1.01	0.53	30.2	0.53	2.23	70	48
Abim	Karamoja	1.37	0.62	28.1	0.41	1.45	94	85
Amudat	Karamoja	0.74	0.67	14.8	0.26	1.31	80	36
Moroto	Karamoja	1.37	0.72	50.5	0.51	1.97	90	74
Rukungiri	Kigezi	2.27	0.49	34.4	1.25	2.04	100	98
Kisoro	Kigezi	1.21	0.54	34.5	0.77	2.38	100	100
Kanungu	Kigezi	1.78	0.60	31.8	0.95	2.11	100	100
Kabale	Kigezi	1.97	1.00	58.3	1.07	5.32	100	96
Rubanda	Kigezi	1.58	0.39	21.2	0.81	1.23	100	97
Rukiga	Kigezi	2.48	0.00	25.5	1.35	0.14	100	100
Lira	Lango	0.71	0.54	45.8	0.40	3.45	100	88
Oyam	Lango	0.75	0.19	22.7	0.34	0.91	100	69
Apac	Lango	0.81	0.20	20.2	0.38	0.94	98	67
Kole	Lango	0.55	0.00	13.9	0.20	0.02	100	72
Alebtong	Lango	0.62	0.00	9.8	0.23	0.04	100	76
Dokolo	Lango	0.80	0.00	15.9	0.30	0.03	100	68
Amolatar	Lango	0.74	0.49	32.1	0.34	1.87	99	71
Otuke	Lango	1.15	0.00	24.1	0.44	0.05	98	54

District	Sub-region	Facilities /10,000	Hospitals /100,000	Workers /10,000	OPD cap./req.	Bed cap./req.	60 min drive %	60 min walk %
Mubende	North Buganda	0.87	0.10	11.6	0.30	0.27	99	80
Mukono	North Buganda	0.80	0.37	22.6	0.45	1.58	99	92
Luwero	North Buganda	1.19	0.49	34.9	0.68	2.27	100	94
Buikwe	North Buganda	1.03	0.89	34.7	0.49	2.75	100	94
Kayunga	North Buganda	0.72	0.21	24.7	0.33	0.80	100	89
Mityana	North Buganda	1.43	0.23	23.4	0.63	0.99	100	99
Kyankwanzi	North Buganda	0.81	0.00	10.1	0.33	0.02	97	63
Nakaseke	North Buganda	1.26	0.74	46.2	0.70	3.11	98	81
Nakasongola	North Buganda	1.66	0.40	34.1	0.87	1.88	96	76
Kiboga	North Buganda	1.30	0.50	25.0	0.53	1.40	99	88
Buvuma	North Buganda	1.12	0.00	19.6	0.50	0.06	68	36
Wakiso	South Buganda	0.38	0.27	14.0	0.19	1.37	100	99
Masaka	South Buganda	1.32	0.51	41.7	0.73	2.61	100	95
Kyotera	South Buganda	1.61	0.55	32.7	0.82	1.83	100	91
Lwengo	South Buganda	0.96	0.00	11.3	0.44	0.05	100	88
Sembabule	South Buganda	0.96	0.00	8.7	0.39	0.04	99	73
Mpigi	South Buganda	1.04	0.89	30.6	0.36	1.74	100	91
Rakai	South Buganda	1.41	0.31	23.6	0.66	1.04	100	93
Kalungu	South Buganda	1.27	0.42	28.5	0.63	1.51	99	94
Gomba	South Buganda	1.10	0.00	12.3	0.41	0.02	98	75
Bukomansimbi	South Buganda	1.09	0.00	15.9	0.42	0.03	100	93
Butambala	South Buganda	1.61	0.76	33.3	0.61	1.70	100	98
Lyantonde	South Buganda	1.73	0.78	44.6	0.69	2.19	98	92
Kalangala	South Buganda	2.78	0.00	41.6	1.34	0.19	66	42
Soroti	Teso	0.88	0.49	30.0	0.33	1.96	99	85
Serere	Teso	0.52	0.00	8.8	0.19	0.03	98	79
Amuria	Teso	1.07	0.27	23.9	0.47	1.11	100	79
Kumi	Teso	0.70	0.61	17.9	0.27	1.57	99	86
Kaberaido	Teso	0.76	0.66	33.5	0.35	2.50	99	76
Bukedea	Teso	0.84	0.35	24.7	0.41	1.50	99	64
Katakwi	Teso	1.42	0.44	25.0	0.55	1.45	98	71
Ngora	Teso	0.68	0.52	20.2	0.25	1.40	100	92
Kasese	Tooro	1.26	0.65	27.8	0.61	1.86	100	96
Kyenjojo	Tooro	0.53	0.34	20.3	0.31	1.38	100	68
Kamwenge	Tooro	0.85	1.04	44.8	0.52	4.05	100	84
Kyegegwa	Tooro	0.48	0.23	18.0	0.29	0.92	100	65
Kabarole	Tooro	1.18	0.75	60.9	0.80	4.42	100	100
Bundibugyo	Tooro	0.99	0.33	33.4	0.70	1.55	99	100
Bunyangabu	Tooro	1.01	0.00	23.3	0.42	0.03	100	100

District	Sub-region	Facilities /10,000	Hospitals /100,000	Workers /10,000	OPD cap./req.	Bed cap./req.	60 min drive %	60 min walk %
Ntoroko	Tooro	0.90	0.00	24.8	0.58	0.17	98	70
Arua	West Nile	0.83	0.28	22.1	0.47	1.69	100	87
Yumbe	West Nile	0.72	0.14	21.2	0.36	0.67	100	85
Zombo	West Nile	0.64	0.31	23.0	0.40	1.41	100	96
Nebbi	West Nile	0.74	0.61	21.9	0.32	1.76	100	94
Adjumani	West Nile	1.59	0.35	32.0	0.92	1.80	98	83
Koboko	West Nile	0.73	0.35	25.6	0.32	1.23	100	91
Maracha	West Nile	0.77	0.41	38.9	0.54	1.84	100	99
Pakwach	West Nile	0.91	0.00	10.0	0.39	0.03	97	94
Moyo	West Nile	2.58	0.54	53.5	1.60	2.80	99	96

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/a_supply.csv).

C.5 Gaps

The four gap dimensions are shown side by side and never added together. The last column is physical access: the number of people living beyond 60 minutes' walk of a facility.

Table C.5: Annex: the four gap dimensions and access by district, 2026 (never combined)

District	Sub-region	Gap 1 units /1,000	Gap 2 FTE /10,000	Gap 3 UGX /person	Gap 4 fac.-eq. /100,000	Beyond 60 min walk ('000)
Gulu	Acholi	310	0.97	21,023	0.17	36.4
Agago	Acholi	169	1.02	20,599	0.11	80.6
Kitgum	Acholi	205	1.06	20,611	0.09	79.5
Amuru	Acholi	298	1.01	20,481	0.21	69.7
Pader	Acholi	226	1.13	20,481	0.16	75.8
Omoro	Acholi	476	1.67	20,481	0.83	28.9
Nwoya	Acholi	508	1.22	20,481	1.00	97.4
Lamwo	Acholi	191	0.98	20,683	0.18	80.7
Isingiro	Ankole	557	2.14	17,749	0.34	52.5
Ntungamo	Ankole	511	0.73	17,749	0.33	58.9
Mbarara	Ankole	354	0.92	17,749	0.13	22.4
Kiruhura	Ankole	302	0.83	17,749	0.15	197.7
Ibanda	Ankole	124	0.88	17,749	0.03	1.6
Bushenyi	Ankole	112	0.62	17,749	0.03	3.3
Sheema	Ankole	102	0.69	17,749	0.03	34.6
Mitooma	Ankole	371	0.74	17,749	0.41	0.0
Rubirizi	Ankole	439	1.74	17,749	0.85	4.3
Buhweju	Ankole	248	0.75	17,749	0.24	20.3
Mbale	Bugisu	328	0.43	16,097	0.16	5.4
Sironko	Bugisu	573	0.98	16,097	0.71	0.0
Namisindwa	Bugisu	857	2.06	16,097	2.02	0.9
Bududa	Bugisu	590	0.82	16,097	0.93	1.2
Bulambuli	Bugisu	487	0.95	16,097	0.70	13.0
Manafwa	Bugisu	732	0.74	16,097	2.43	0.9
Kapchorwa	Bugisu	33	0.32	16,097	0.02	0.6
Bukwo	Bugisu	172	0.42	16,097	0.20	2.3
Kween	Bugisu	84	0.52	16,097	0.08	4.1
Tororo	Bukedi	282	0.87	16,298	0.11	0.0

District	Sub-region	Gap 1 units /1,000	Gap 2 FTE /10,000	Gap 3 UGX /person	Gap 4 fac.-eq. /100,000	Beyond 60 min walk ('000)
Busia	Bukedi	492	0.95	16,298	0.52	3.1
Butaleja	Bukedi	677	0.95	17,174	0.60	2.0
Pallisa	Bukedi	846	0.82	16,840	1.16	4.0
Budaka	Bukedi	949	1.83	16,515	1.97	0.0
Kibuku	Bukedi	753	1.58	16,298	2.00	1.7
Butebo	Bukedi	559	0.81	16,298	1.10	0.0
Hoima	Bunyoro	660	0.85	18,105	0.44	199.0
Kagadi	Bunyoro	756	1.12	18,001	1.18	85.6
Kakumiro	Bunyoro	858	2.30	18,001	1.68	182.0
Masindi	Bunyoro	327	0.73	18,001	0.19	65.8
Kiryandongo	Bunyoro	677	1.07	18,435	1.02	78.1
Kibaale	Bunyoro	676	1.56	18,001	1.69	91.6
Buliisa	Bunyoro	451	0.82	18,001	0.66	40.3
Iganga	Busoga	599	0.86	16,363	0.36	14.2
Kamuli	Busoga	548	0.91	17,078	0.32	19.6
Mayuge	Busoga	656	0.87	16,363	0.44	51.1
Jinja	Busoga	113	0.58	16,363	0.01	0.0
Bugiri	Busoga	630	1.06	16,431	0.52	5.4
Buyende	Busoga	789	2.38	16,363	1.45	183.9
Namutumba	Busoga	579	2.08	16,363	0.59	5.6
Kaliro	Busoga	767	2.02	16,363	1.78	40.5
Luuka	Busoga	687	2.57	16,363	0.86	4.4
Namayingo	Busoga	598	2.69	16,566	0.94	11.9
Kampala	Kampala	838	1.17	19,367	0.17	111.6
Kotido	Karamoja	510	0.66	14,721	0.65	30.1
Kaabong	Karamoja	93	0.36	14,461	0.02	57.8
Nakapiripirit	Karamoja	553	0.44	14,461	1.11	65.7
Napak	Karamoja	381	0.55	14,498	0.53	98.3
Abim	Karamoja	499	0.68	14,461	0.79	24.6
Amudat	Karamoja	649	0.80	14,461	1.98	95.3
Moroto	Karamoja	388	0.52	14,461	0.96	36.2
Rukungiri	Kigezi	12	0.57	17,501	0.00	7.3
Kisoro	Kigezi	106	0.59	17,501	0.02	1.1
Kanungu	Kigezi	35	0.66	17,501	0.00	1.7
Kabale	Kigezi	11	0.60	17,501	0.00	11.7
Rubanda	Kigezi	94	0.90	17,501	0.02	7.6

District	Sub-region	Gap 1 units /1,000	Gap 2 FTE /10,000	Gap 3 UGX /person	Gap 4 fac.-eq. /100,000	Beyond 60 min walk ('000)
Rukiga	Kigezi	68	0.38	17,501	0.06	0.5
Lira	Lango	572	1.00	21,108	0.33	69.1
Oyam	Lango	570	1.07	21,108	0.68	161.9
Apac	Lango	623	1.09	21,108	0.54	164.4
Kole	Lango	804	2.40	21,108	2.42	91.1
Alebtong	Lango	801	2.17	21,108	2.39	73.9
Dokolo	Lango	767	2.28	21,875	2.33	80.8
Amolatar	Lango	467	0.96	21,108	0.95	59.0
Otuke	Lango	451	1.09	21,108	1.26	68.4
Mubende	North Buganda	715	1.09	18,588	0.44	196.3
Mukono	North Buganda	446	0.97	18,588	0.25	64.0
Luwero	North Buganda	161	0.59	18,602	0.03	38.6
Buikwe	North Buganda	300	0.95	18,588	0.12	32.0
Kayunga	North Buganda	663	0.95	18,588	0.96	51.4
Mityana	North Buganda	208	0.71	18,588	0.08	3.0
Kyankwanzi	North Buganda	666	2.76	18,588	1.30	114.5
Nakaseke	North Buganda	165	0.55	18,794	0.04	52.0
Nakasongola	North Buganda	60	0.59	18,588	0.01	60.4
Kiboga	North Buganda	323	1.00	19,426	0.28	23.1
Buvuma	North Buganda	484	1.02	18,588	1.41	86.1
Wakiso	South Buganda	819	1.24	21,423	0.22	24.1
Masaka	South Buganda	128	0.86	21,423	0.03	19.8
Kyotera	South Buganda	90	0.94	21,423	0.02	31.9
Lwengo	South Buganda	571	2.04	21,423	0.73	42.5
Sembabule	South Buganda	671	2.26	21,423	0.93	91.0
Mpigi	South Buganda	465	1.16	21,731	0.48	31.2
Rakai	South Buganda	225	1.04	21,423	0.15	21.3
Kalungu	South Buganda	202	0.90	21,423	0.13	13.0
Gomba	South Buganda	584	2.77	21,423	1.15	51.6
Bukomansimbi	South Buganda	587	2.25	21,423	1.27	14.3
Butambala	South Buganda	185	1.05	21,555	0.24	2.1
Lyantonde	South Buganda	154	0.96	21,646	0.16	10.2
Kalangala	South Buganda	64	0.42	21,423	0.08	44.2
Soroti	Teso	785	0.98	18,320	0.68	61.6
Serere	Teso	1,217	2.58	18,556	2.46	83.4
Amuria	Teso	548	0.79	18,499	0.47	76.9

District	Sub-region	Gap 1 units /1,000	Gap 2 FTE /10,000	Gap 3 UGX /person	Gap 4 fac.-eq. /100,000	Beyond 60 min walk ('000)
Kumi	Teso	684	1.08	17,988	1.25	45.4
Kaberamaido	Teso	735	0.85	17,988	0.92	73.8
Bukedea	Teso	602	0.75	17,988	0.79	102.5
Katakwi	Teso	313	0.79	18,181	0.25	66.2
Ngora	Teso	749	0.98	18,190	1.89	15.4
Kasese	Tooro	172	0.78	16,815	0.02	32.5
Kyenjojo	Tooro	531	0.82	16,815	0.65	189.7
Kamwenge	Tooro	253	0.68	16,815	0.11	90.6
Kyegegwa	Tooro	651	0.80	16,815	0.83	154.7
Kabarole	Tooro	92	0.38	16,815	0.02	2.0
Bundibugyo	Tooro	230	0.38	16,815	0.15	0.6
Bunyangabu	Tooro	564	1.00	16,815	1.17	0.0
Ntoroko	Tooro	367	0.31	16,815	1.52	27.1
Arua	West Nile	450	0.65	14,767	0.17	134.7
Yumbe	West Nile	637	0.63	14,767	0.67	106.3
Zombo	West Nile	536	0.63	14,767	0.81	14.0
Nebbi	West Nile	534	0.79	14,957	0.87	19.5
Adjumani	West Nile	47	0.43	14,767	0.02	48.0
Koboko	West Nile	545	0.57	14,767	1.08	26.6
Maracha	West Nile	368	0.28	14,924	0.50	1.5
Pakwach	West Nile	615	1.95	14,767	1.59	12.8
Moyo	West Nile	5	0.23	14,767	0.00	7.2

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/a_gaps.csv).

C.6 Cost and investment

Table C.6: Annex: cost, investment and budget layers by district, 2026 (USD per person unless stated)

District	Sub-region	Requirement	Staff share %	Capital to close	Recurrent to close	Wage bill	Growth 2026-30 %
Gulu	Acholi	12.59	41	1.00	7.04	5.10	54
Agago	Acholi	12.23	40	0.96	6.93	4.94	54
Kitgum	Acholi	12.24	40	0.96	6.97	4.94	54
Amuru	Acholi	12.13	40	0.94	6.88	4.89	54
Pader	Acholi	12.13	40	0.94	7.09	4.89	54
Omoro	Acholi	12.13	40	0.94	7.59	4.89	54
Nwoya	Acholi	12.13	40	0.94	7.07	4.89	54
Lamwo	Acholi	12.30	40	0.96	7.01	4.97	54
Isingiro	Ankole	10.84	42	0.83	7.16	4.57	56
Ntungamo	Ankole	10.84	42	0.83	5.80	4.57	56
Mbarara	Ankole	10.84	42	0.83	5.97	4.57	56
Kiruhura	Ankole	10.84	42	0.83	5.89	4.57	56
Ibanda	Ankole	10.84	42	0.83	5.93	4.57	56
Bushenyi	Ankole	10.84	42	0.83	5.71	4.57	56
Sheema	Ankole	10.84	42	0.83	5.76	4.57	56
Mitooma	Ankole	10.84	42	0.83	5.80	4.57	56
Rubirizi	Ankole	10.84	42	0.83	6.81	4.57	56
Buhweju	Ankole	10.84	42	0.83	5.82	4.57	56
Mbale	Bugisu	10.32	43	0.85	5.19	4.43	60
Sironko	Bugisu	10.32	43	0.85	5.78	4.43	60
Namisindwa	Bugisu	10.32	43	0.85	6.74	4.43	60
Bududa	Bugisu	10.32	43	0.85	5.53	4.43	60
Bulambuli	Bugisu	10.32	43	0.85	5.76	4.43	60
Manafwa	Bugisu	10.32	43	0.85	5.53	4.43	60
Kapchorwa	Bugisu	10.32	43	0.85	5.10	4.43	60
Bukwo	Bugisu	10.32	43	0.85	5.25	4.43	60
Kween	Bugisu	10.32	43	0.85	5.36	4.43	60
Tororo	Bukedi	10.56	43	0.90	5.70	4.53	59
Busia	Bukedi	10.56	43	0.90	5.76	4.53	59
Butaleja	Bukedi	11.30	43	0.99	6.07	4.87	60
Pallisa	Bukedi	11.02	43	0.95	5.84	4.74	60

District	Sub-region	Requirement	Staff share %	Capital to close	Recurrent to close	Wage bill	Growth 2026-30 %
Budaka	Bukedi	10.75	43	0.92	6.74	4.62	59
Kibuku	Bukedi	10.56	43	0.90	6.43	4.53	59
Butebo	Bukedi	10.56	43	0.90	5.64	4.53	59
Hoima	Bunyoro	11.44	43	0.92	6.11	4.89	57
Kagadi	Bunyoro	11.35	43	0.91	6.31	4.85	57
Kakumiro	Bunyoro	11.35	43	0.91	7.48	4.85	57
Masindi	Bunyoro	11.35	43	0.91	5.97	4.85	57
Kiryandongo	Bunyoro	11.72	43	0.96	6.42	5.02	57
Kibaale	Bunyoro	11.35	43	0.91	6.82	4.85	57
Buliisa	Bunyoro	11.35	43	0.91	6.06	4.85	57
Iganga	Busoga	10.59	43	0.89	5.68	4.56	59
Kamuli	Busoga	11.20	43	0.97	5.99	4.83	59
Mayuge	Busoga	10.59	43	0.89	5.70	4.56	59
Jinja	Busoga	10.59	43	0.89	5.44	4.56	59
Bugiri	Busoga	10.65	43	0.90	5.88	4.58	59
Buyende	Busoga	10.59	43	0.89	7.15	4.56	59
Namutumba	Busoga	10.59	43	0.89	6.87	4.56	59
Kaliro	Busoga	10.59	43	0.89	6.83	4.56	59
Luuka	Busoga	10.59	43	0.89	7.32	4.56	59
Namayingo	Busoga	10.76	43	0.91	7.50	4.64	59
Kampala	Kampala	11.39	41	0.86	6.62	4.64	54
Kotido	Karamoja	10.35	45	0.93	5.14	4.69	65
Kaabong	Karamoja	10.13	45	0.90	4.79	4.59	64
Nakapiripirit	Karamoja	10.13	45	0.90	4.92	4.59	64
Napak	Karamoja	10.17	45	0.91	4.97	4.61	64
Abim	Karamoja	10.13	45	0.90	5.08	4.59	64
Amudat	Karamoja	10.13	45	0.90	5.18	4.59	64
Moroto	Karamoja	10.13	45	0.90	4.93	4.59	64
Rukungiri	Kigezi	10.39	41	0.79	5.56	4.27	56
Kisoro	Kigezi	10.39	41	0.79	5.57	4.27	56
Kanungu	Kigezi	10.39	41	0.79	5.64	4.27	56
Kabale	Kigezi	10.39	41	0.79	5.58	4.27	56
Rubanda	Kigezi	10.39	41	0.79	5.85	4.27	56
Rukiga	Kigezi	10.39	41	0.79	5.42	4.27	56
Lira	Lango	12.41	40	0.98	7.09	4.93	53
Oyam	Lango	12.41	40	0.98	7.14	4.93	53

District	Sub-region	Requirement	Staff share %	Capital to close	Recurrent to close	Wage bill	Growth 2026-30 %
Apac	Lango	12.41	40	0.98	7.17	4.93	53
Kole	Lango	12.41	40	0.98	8.46	4.93	53
Alebtong	Lango	12.41	40	0.98	8.24	4.93	53
Dokolo	Lango	13.06	40	1.06	8.63	5.22	54
Amolatar	Lango	12.41	40	0.98	7.05	4.93	53
Otuke	Lango	12.41	40	0.98	7.29	4.93	53
Mubende	North Buganda	11.35	42	0.89	6.41	4.73	56
Mukono	North Buganda	11.35	42	0.89	6.31	4.73	56
Luwero	North Buganda	11.36	42	0.90	5.98	4.73	56
Buikwe	North Buganda	11.35	42	0.89	6.29	4.73	56
Kayunga	North Buganda	11.35	42	0.89	6.29	4.73	56
Mityana	North Buganda	11.35	42	0.89	6.08	4.73	56
Kyankwanzi	North Buganda	11.35	42	0.89	8.02	4.73	56
Nakaseke	North Buganda	11.52	42	0.92	6.01	4.81	56
Nakasongola	North Buganda	11.35	42	0.89	5.97	4.73	56
Kiboga	North Buganda	12.05	42	0.98	6.63	5.05	57
Buvuma	North Buganda	11.35	42	0.89	6.46	4.73	56
Wakiso	South Buganda	12.44	41	0.91	7.23	5.05	52
Masaka	South Buganda	12.44	41	0.91	6.90	5.05	52
Kyotera	South Buganda	12.44	41	0.91	6.96	5.05	52
Lwengo	South Buganda	12.44	41	0.91	8.06	5.05	52
Sembabule	South Buganda	12.44	41	0.91	8.26	5.05	52
Mpigi	South Buganda	12.70	41	0.95	7.26	5.17	53
Rakai	South Buganda	12.44	41	0.91	7.06	5.05	52
Kalungu	South Buganda	12.44	41	0.91	6.93	5.05	52
Gomba	South Buganda	12.44	41	0.91	8.72	5.05	52
Bukomansimbi	South Buganda	12.44	41	0.91	8.26	5.05	52
Butambala	South Buganda	12.56	41	0.93	7.11	5.10	53
Lyantonde	South Buganda	12.63	41	0.94	7.06	5.13	53
Kalangala	South Buganda	12.44	41	0.91	6.54	5.05	52
Soroti	Teso	12.09	43	1.04	6.44	5.25	59
Serere	Teso	12.29	43	1.07	8.06	5.34	59
Amuria	Teso	12.24	43	1.06	6.34	5.32	59
Kumi	Teso	11.81	43	1.01	6.41	5.12	58
Kaberamaido	Teso	11.81	43	1.01	6.21	5.12	58
Bukedea	Teso	11.81	43	1.01	6.12	5.12	58

District	Sub-region	Requirement	Staff share %	Capital to close	Recurrent to close	Wage bill	Growth 2026-30 %
Katakwi	Teso	11.97	43	1.03	6.22	5.20	59
Ngora	Teso	11.98	43	1.03	6.40	5.20	59
Kasese	Tooro	10.44	43	0.82	5.62	4.44	58
Kyenjojo	Tooro	10.44	43	0.82	5.65	4.44	58
Kamwenge	Tooro	10.44	43	0.82	5.53	4.44	58
Kyegegwa	Tooro	10.44	43	0.82	5.63	4.44	58
Kabarole	Tooro	10.44	43	0.82	5.26	4.44	58
Bundibugyo	Tooro	10.44	43	0.82	5.27	4.44	58
Bunyangabu	Tooro	10.44	43	0.82	5.93	4.44	58
Ntoroko	Tooro	10.44	43	0.82	5.24	4.44	58
Arua	West Nile	9.89	44	0.85	5.06	4.37	64
Yumbe	West Nile	9.89	44	0.85	5.05	4.37	64
Zombo	West Nile	9.89	44	0.85	5.05	4.37	64
Nebbi	West Nile	10.06	44	0.87	5.25	4.44	64
Adjumani	West Nile	9.89	44	0.85	4.87	4.37	64
Koboko	West Nile	9.89	44	0.85	4.99	4.37	64
Maracha	West Nile	10.03	44	0.87	4.79	4.43	64
Pakwach	West Nile	9.89	44	0.85	6.32	4.37	64
Moyo	West Nile	9.89	44	0.85	4.70	4.37	64

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/a_cost.csv).

C.7 Allocation by scenario

No scenario is recommended; the columns are shown together so that they can be compared.

Table C.7: Annex: allocation per person by scenario, 2026 (USD per person)

District	Sub-region	A	B	C	D	E	F	OPT
Gulu	Acholi	0.92	0.95	0.96	0.95	0.61	1.00	0.58
Agago	Acholi	0.63	0.56	0.56	0.56	0.47	0.10	0.88
Kitgum	Acholi	0.61	0.66	0.67	0.66	0.43	0.47	0.37
Amuru	Acholi	1.10	0.92	0.94	0.92	0.69	0.03	1.60
Pader	Acholi	0.61	0.86	0.70	1.24	1.60	0.11	2.95
Omoro	Acholi	1.35	1.57	1.42	1.96	2.10	0.13	3.68
Nwoya	Acholi	1.43	1.56	1.56	1.62	1.29	0.22	2.33
Lamwo	Acholi	0.43	0.73	0.56	1.11	1.38	0.15	2.23
Isingiro	Ankole	1.51	1.81	1.65	2.21	2.33	0.39	4.12
Ntungamo	Ankole	1.74	1.52	1.50	1.61	1.09	0.31	2.29
Mbarara	Ankole	1.05	1.06	1.07	1.06	0.66	1.10	1.27
Kiruhura	Ankole	1.12	0.97	0.93	1.06	0.75	0.06	1.66
Ibanda	Ankole	0.45	0.43	0.42	0.44	0.38	0.12	0.75
Bushenyi	Ankole	0.33	0.38	0.38	0.37	0.31	0.20	0.59
Sheema	Ankole	0.30	0.35	0.35	0.34	0.31	0.05	0.57
Mitooma	Ankole	1.24	1.11	1.13	1.11	0.71	0.06	1.49
Rubirizi	Ankole	1.21	1.47	1.30	1.86	2.04	0.06	3.56
Buhweju	Ankole	0.82	0.79	0.80	0.79	0.50	0.00	1.50
Mbale	Bugisu	0.97	0.91	0.93	0.92	0.53	0.99	1.04
Sironko	Bugisu	1.72	1.91	1.76	2.29	2.13	0.32	3.95
Namisindwa	Bugisu	1.54	2.72	2.59	3.12	3.13	0.49	4.75
Bududa	Bugisu	1.44	1.73	1.76	1.73	1.24	0.35	2.39
Bulambuli	Bugisu	1.54	1.68	1.53	2.05	2.03	0.06	3.84
Manafwa	Bugisu	1.74	2.33	2.19	2.70	2.50	0.21	4.57
Kapchorwa	Bugisu	0.15	0.13	0.13	0.13	0.23	0.03	0.58
Bukwo	Bugisu	0.44	0.69	0.53	1.03	1.23	0.05	2.35
Kween	Bugisu	0.22	0.40	0.23	0.75	1.38	0.01	2.79
Tororo	Bukedi	0.81	0.85	0.86	0.85	0.53	0.80	1.05
Busia	Bukedi	1.15	1.45	1.47	1.45	0.99	0.60	1.66
Butaleja	Bukedi	1.80	2.16	2.18	2.16	0.92	0.34	1.72
Pallisa	Bukedi	2.13	2.71	2.72	2.80	1.73	0.82	2.86
Budaka	Bukedi	1.86	3.18	3.03	3.60	2.85	0.16	5.14

District	Sub-region	A	B	C	D	E	F	OPT
Kibuku	Bukedi	1.85	2.42	2.28	2.82	2.50	0.17	4.62
Butebo	Bukedi	1.46	1.70	1.72	1.70	0.97	0.07	1.90
Hoima	Bunyoro	1.81	2.00	1.92	2.22	1.80	1.69	3.66
Kagadi	Bunyoro	1.56	2.27	2.21	2.45	2.16	0.65	3.92
Kakumiro	Bunyoro	1.38	2.62	2.46	3.03	2.98	0.24	4.46
Masindi	Bunyoro	0.98	0.98	0.98	0.97	0.51	0.44	1.19
Kiryandongo	Bunyoro	1.30	1.93	1.96	1.93	1.25	0.93	2.30
Kibaale	Bunyoro	1.64	2.12	1.96	2.52	2.54	0.06	4.68
Buliisa	Bunyoro	1.09	1.32	1.33	1.32	0.70	0.12	1.56
Iganga	Busoga	1.75	1.80	1.76	1.98	1.64	1.66	2.92
Kamuli	Busoga	1.46	1.58	1.61	1.59	0.95	1.14	1.17
Mayuge	Busoga	1.89	2.01	1.99	2.13	1.53	0.61	3.37
Jinja	Busoga	0.40	0.40	0.40	0.40	0.19	0.39	0.54
Bugiri	Busoga	1.69	1.92	1.86	2.14	1.85	1.12	3.44
Buyende	Busoga	1.32	2.41	2.26	2.83	2.94	0.13	5.03
Namutumba	Busoga	1.61	1.94	1.78	2.34	2.40	0.08	4.50
Kaliro	Busoga	1.41	2.37	2.23	2.78	2.86	0.47	5.09
Luuka	Busoga	1.45	2.23	2.07	2.64	2.90	0.07	4.05
Namayingo	Busoga	1.56	1.96	1.80	2.39	2.48	0.12	4.52
Kampala	Kampala	0.94	2.50	2.53	2.50	1.70	3.08	2.32
Kotido	Karamoja	1.57	1.54	1.56	1.54	0.83	0.23	1.83
Kaabong	Karamoja	0.32	0.32	0.32	0.32	0.29	0.18	0.77
Nakapiripirit	Karamoja	1.59	1.78	1.62	2.16	2.11	0.16	4.23
Napak	Karamoja	1.15	1.12	1.13	1.12	0.68	0.99	1.68
Abim	Karamoja	1.53	1.54	1.56	1.56	1.18	0.30	2.19
Amudat	Karamoja	1.42	1.84	1.88	1.85	1.31	0.09	2.47
Moroto	Karamoja	1.25	1.16	1.18	1.16	0.75	0.37	1.69
Rukungiri	Kigezi	0.03	0.06	0.06	0.05	0.19	0.03	0.24
Kisoro	Kigezi	0.43	0.36	0.36	0.36	0.28	0.18	0.45
Kanungu	Kigezi	0.10	0.13	0.13	0.13	0.22	0.02	0.26
Kabale	Kigezi	0.03	0.05	0.05	0.05	0.18	0.02	0.23
Rubanda	Kigezi	0.31	0.33	0.33	0.33	0.38	0.01	0.42
Rukiga	Kigezi	0.18	0.32	0.17	0.64	1.05	0.01	1.93
Lira	Lango	1.82	1.83	1.85	1.83	0.96	1.87	1.79
Oyam	Lango	1.61	1.68	1.70	1.74	1.32	0.82	1.79
Apac	Lango	2.00	1.98	2.00	2.01	1.29	0.37	2.50
Kole	Lango	1.13	2.52	2.39	2.91	2.99	0.07	4.99
Alebtong	Lango	1.42	2.59	2.45	2.97	2.86	0.26	5.70
Dokolo	Lango	1.53	2.42	2.26	2.87	2.57	0.14	4.59

District	Sub-region	A	B	C	D	E	F	OPT
Amolatar	Lango	1.18	1.39	1.41	1.39	0.94	0.20	1.75
Otuke	Lango	1.25	1.48	1.33	1.84	1.89	0.08	2.91
Mubende	North Buganda	1.41	2.21	2.11	2.53	2.39	1.33	4.23
Mukono	North Buganda	1.42	1.34	1.36	1.33	0.91	0.59	1.66
Luwero	North Buganda	0.49	0.49	0.49	0.49	0.23	0.26	0.62
Buikwe	North Buganda	0.86	0.91	0.92	0.91	0.58	0.55	1.14
Kayunga	North Buganda	1.60	1.98	1.98	2.09	1.60	0.42	2.88
Mityana	North Buganda	0.77	0.67	0.67	0.68	0.45	0.47	1.03
Kyankwanzi	North Buganda	1.37	2.15	2.00	2.55	2.63	0.05	4.63
Nakaseke	North Buganda	0.56	0.57	0.57	0.57	0.24	0.33	0.73
Nakasongola	North Buganda	0.20	0.21	0.21	0.20	0.17	0.03	0.35
Kiboga	North Buganda	1.07	1.00	1.01	1.00	0.53	0.26	0.68
Buvuma	North Buganda	1.35	1.60	1.45	1.98	2.05	0.02	3.85
Wakiso	South Buganda	1.26	2.45	2.49	2.44	1.74	2.27	3.21
Masaka	South Buganda	0.54	0.43	0.43	0.43	0.31	0.42	0.91
Kyotera	South Buganda	0.25	0.32	0.32	0.31	0.34	0.17	0.58
Lwengo	South Buganda	1.53	1.88	1.71	2.27	2.33	0.02	4.33
Sembabule	South Buganda	1.54	2.18	2.02	2.58	2.66	0.36	4.86
Mpigi	South Buganda	1.06	1.37	1.38	1.37	0.87	0.51	1.59
Rakai	South Buganda	0.82	0.74	0.75	0.75	0.56	0.11	1.16
Kalungu	South Buganda	0.60	0.64	0.64	0.64	0.40	0.16	0.87
Gomba	South Buganda	1.50	1.95	1.78	2.35	2.42	0.06	4.38
Bukomansimbi	South Buganda	1.56	1.92	1.76	2.32	2.37	0.09	4.31
Butambala	South Buganda	0.53	0.62	0.62	0.62	0.52	0.18	0.97
Lyantonde	South Buganda	0.43	0.52	0.52	0.52	0.47	0.07	0.84
Kalangala	South Buganda	0.12	0.30	0.16	0.62	1.02	0.01	1.82
Soroti	Teso	1.97	2.40	2.43	2.40	1.29	2.07	2.77
Serere	Teso	1.95	3.96	3.78	4.42	3.34	0.58	5.43
Amuria	Teso	1.82	1.62	1.64	1.62	0.95	0.23	2.36
Kumi	Teso	1.34	1.92	1.95	1.93	1.25	0.89	2.28
Kaberamaido	Teso	2.11	2.37	2.39	2.36	1.11	0.41	2.69
Bukedea	Teso	1.79	1.79	1.82	1.78	0.98	0.04	2.28
Katakwi	Teso	0.97	0.97	0.98	0.97	0.47	1.00	1.21
Ngora	Teso	1.59	2.18	2.21	2.17	1.28	0.37	2.62
Kasese	Tooro	0.51	0.58	0.58	0.57	0.41	0.59	0.82
Kyenjojo	Tooro	1.05	1.49	1.52	1.50	1.09	0.51	1.71
Kamwenge	Tooro	0.72	0.75	0.75	0.74	0.41	0.23	0.93
Kyegegwa	Tooro	1.45	1.82	1.84	1.88	1.39	0.64	2.44
Kabarole	Tooro	0.29	0.31	0.31	0.31	0.24	0.32	0.49

District	Sub-region	A	B	C	D	E	F	OPT
Bundibugyo	Tooro	0.71	0.69	0.70	0.69	0.37	0.17	0.83
Bunyangabu	Tooro	1.47	1.79	1.63	2.19	2.24	0.01	3.89
Ntoroko	Tooro	1.11	1.18	1.02	1.50	1.33	0.14	2.79
Arua	West Nile	1.42	1.32	1.34	1.32	0.88	1.44	1.61
Yumbe	West Nile	1.70	1.89	1.86	2.04	1.66	1.31	3.14
Zombo	West Nile	1.42	1.51	1.54	1.52	1.12	0.39	1.95
Nebbi	West Nile	1.09	1.49	1.52	1.50	1.06	1.51	1.75
Adjumani	West Nile	0.13	0.17	0.17	0.17	0.26	0.15	0.37
Koboko	West Nile	1.17	1.55	1.57	1.58	1.35	0.67	2.04
Maracha	West Nile	1.05	1.03	1.04	1.03	0.67	0.52	1.23
Pakwach	West Nile	1.46	1.91	1.75	2.32	2.47	0.64	4.08
Moyo	West Nile	0.10	0.02	0.02	0.02	0.05	0.01	0.20

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/a_alloc.csv).

C.8 Outcomes

Each value of deaths averted is a point estimate. The range of every scenario total is given in Chapter 12.

Table C.8: Annex: baseline deaths and deaths averted per 100,000, 2026

District	Sub-region	Baseline deaths	Averted C	Averted F	Averted OPT
Gulu	Acholi	468	9.2	9.7	15.8
Agago	Acholi	468	3.7	0.7	15.8
Kitgum	Acholi	468	3.8	2.7	6.9
Amuru	Acholi	468	11.0	0.4	26.8
Pader	Acholi	468	6.7	1.1	49.2
Omoro	Acholi	468	18.4	2.1	61.4
Nwoya	Acholi	468	18.7	3.5	37.6
Lamwo	Acholi	468	4.8	1.4	42.3
Isingiro	Ankole	453	23.4	7.2	73.8
Ntungamo	Ankole	453	23.4	6.6	43.3
Mbarara	Ankole	453	13.1	13.4	18.9
Kiruhura	Ankole	453	9.7	0.9	26.6
Ibanda	Ankole	453	2.4	0.7	9.9
Bushenyi	Ankole	453	1.9	0.9	5.2
Sheema	Ankole	453	1.8	0.2	5.2
Mitooma	Ankole	453	14.9	1.1	22.1
Rubirizi	Ankole	453	16.2	1.0	71.9
Buhweju	Ankole	453	5.8	0.0	15.6
Mbale	Bugisu	428	12.5	13.2	18.4
Sironko	Bugisu	428	22.7	5.2	63.8
Namisindwa	Bugisu	428	35.7	9.0	88.9
Bududa	Bugisu	428	21.8	6.2	35.6
Bulambuli	Bugisu	428	18.6	0.9	63.5
Manafwa	Bugisu	428	30.9	3.9	75.0
Kapchorwa	Bugisu	428	1.1	0.2	7.2
Bukwo	Bugisu	428	5.7	0.5	37.8
Kween	Bugisu	428	4.0	0.1	46.3
Tororo	Bukedi	461	7.8	7.4	12.1
Busia	Bukedi	461	18.2	10.1	26.6
Butaleja	Bukedi	461	26.9	5.4	32.4
Pallisa	Bukedi	461	37.3	14.7	56.8
Budaka	Bukedi	461	45.1	3.0	95.4
Kibuku	Bukedi	461	33.5	3.3	79.3
Butebo	Bukedi	461	23.9	1.4	33.7
Hoima	Bunyoro	542	34.1	32.4	81.1
Kagadi	Bunyoro	542	39.0	16.2	79.6
Kakumiro	Bunyoro	542	44.0	6.1	104.7
Masindi	Bunyoro	542	15.9	9.1	20.5
Kiryandongo	Bunyoro	542	32.2	20.3	44.0
Kibaale	Bunyoro	542	35.6	1.5	94.4
Buliisa	Bunyoro	542	20.8	2.6	25.9
Iganga	Busoga	489	29.5	28.8	61.1
Kamuli	Busoga	489	22.0	18.5	32.4
Mayuge	Busoga	489	33.7	14.5	66.3
Jinja	Busoga	489	3.3	3.1	6.0
Bugiri	Busoga	489	29.3	21.7	67.2

District	Sub-region	Baseline deaths	Averted C	Averted F	Averted OPT
Buyende	Busoga	489	38.0	3.0	96.0
Namutumba	Busoga	489	27.6	1.7	84.8
Kaliro	Busoga	489	37.0	10.8	94.2
Luuka	Busoga	489	32.4	1.6	92.1
Namayingo	Busoga	489	26.0	2.4	84.0
Kampala	Kampala	404	33.8	43.2	43.2
Kotido	Karamoja	558	26.2	5.3	36.6
Kaabong	Karamoja	558	2.5	1.2	15.4
Nakapiripirit	Karamoja	558	30.8	4.2	98.5
Napak	Karamoja	558	19.9	18.2	35.3
Abim	Karamoja	558	25.3	6.8	51.2
Amudat	Karamoja	558	35.7	2.6	56.2
Moroto	Karamoja	558	17.7	7.9	30.8
Rukungiri	Kigezi	374	0.8	0.3	3.4
Kisoro	Kigezi	374	1.6	0.7	5.8
Kanungu	Kigezi	374	1.0	0.1	3.6
Kabale	Kigezi	374	0.7	0.3	3.2
Rubanda	Kigezi	374	1.8	0.1	6.2
Rukiga	Kigezi	374	2.8	0.1	31.0
Lira	Lango	453	25.3	25.5	34.7
Oyam	Lango	453	22.1	13.9	36.4
Apac	Lango	453	28.1	7.0	47.0
Kole	Lango	453	31.8	1.3	80.8
Alebtong	Lango	453	33.0	4.6	89.7
Dokolo	Lango	453	26.6	2.3	71.2
Amolatar	Lango	453	16.2	3.3	32.9
Otuke	Lango	453	14.5	1.2	50.0
Mubende	North Buganda	470	31.1	24.0	76.9
Mukono	North Buganda	470	18.4	10.6	27.1
Luwero	North Buganda	470	4.3	2.9	6.3
Buikwe	North Buganda	470	9.4	6.9	14.0
Kayunga	North Buganda	470	29.5	8.7	55.5
Mityana	North Buganda	470	6.1	4.6	19.4
Kyankwanzi	North Buganda	470	27.9	0.9	80.4
Nakaseke	North Buganda	470	3.8	2.0	6.3
Nakasongola	North Buganda	470	1.1	0.1	3.4
Kiboga	North Buganda	470	7.9	2.8	12.5
Buvuma	North Buganda	470	19.7	0.3	66.3
Wakiso	South Buganda	466	36.0	33.5	55.7
Masaka	South Buganda	466	2.6	2.3	11.5
Kyotera	South Buganda	466	1.7	0.8	5.4
Lwengo	South Buganda	466	22.6	0.3	72.7
Sembabule	South Buganda	466	28.1	6.6	82.6
Mpigi	South Buganda	466	14.2	7.4	21.5
Rakai	South Buganda	466	7.0	1.3	16.9
Kalungu	South Buganda	466	5.4	1.7	9.1
Gomba	South Buganda	466	22.7	0.9	73.1
Bukomansimbi	South Buganda	466	24.2	1.6	72.8
Butambala	South Buganda	466	2.9	0.7	11.9
Lyantonde	South Buganda	466	2.4	0.3	6.7
Kalangala	South Buganda	466	2.8	0.1	33.0
Soroti	Teso	502	33.5	29.0	43.9

District	Sub-region	Baseline deaths	Averted C	Averted F	Averted OPT
Serere	Teso	502	53.7	10.5	104.2
Amuria	Teso	502	20.2	3.8	34.8
Kumi	Teso	502	27.2	16.1	37.4
Kaberamaido	Teso	502	34.7	7.3	42.6
Bukedea	Teso	502	25.5	0.8	35.5
Katakwi	Teso	502	10.1	10.4	17.7
Ngora	Teso	502	29.6	6.7	40.0
Kasese	Tooro	456	2.7	2.9	6.4
Kyenjojo	Tooro	456	21.9	10.8	30.1
Kamwenge	Tooro	456	8.1	3.6	11.2
Kyegegwa	Tooro	456	30.2	15.2	49.5
Kabarole	Tooro	456	1.6	1.7	4.3
Bundibugyo	Tooro	456	10.4	3.6	14.3
Bunyangabu	Tooro	456	24.1	0.3	70.8
Ntoroko	Tooro	456	15.4	2.8	52.2
Arua	West Nile	467	20.3	21.5	28.8
Yumbe	West Nile	467	29.7	25.2	61.4
Zombo	West Nile	467	25.0	9.3	37.4
Nebbi	West Nile	467	21.9	21.8	32.0
Adjumani	West Nile	467	1.3	1.0	4.4
Koboko	West Nile	467	23.0	13.6	36.5
Maracha	West Nile	467	15.7	10.5	23.3
Pakwach	West Nile	467	27.3	13.7	78.2
Moyo	West Nile	467	0.3	0.1	2.7

Source: HPRAS database, run uga-unconstrained-2026 (report/build/data/a_outcomes.csv).

ANNEX D

D Glossary and abbreviations

This annex lists the abbreviations used in the report (Table D.1) and then defines the technical terms that carry a specific meaning in the engine. Terms are defined as the engine uses them, which is sometimes narrower than general usage.

D.1 Abbreviations

Table D.1: Abbreviations

Abbreviation	Meaning
ACT	Artemisinin-based combination therapy (first-line malaria treatment)
AF	Affected fraction: the share of deaths from a cause that an intervention can act on
ANC, ANC4	Antenatal care; four or more antenatal visits
ART	Antiretroviral therapy
AWT	Available working time: minutes a full-time worker can give to services in a year (WISN)
BCG	Bacillus Calmette–Guérin (tuberculosis vaccine)
CDCGE	The AICTEM general equilibrium model, to which the engine emits a health shock
DALY	Disability-adjusted life year
DHIS2	District Health Information Software 2, the platform of the national HMIS
DHS	Demographic and Health Survey (Uganda DHS 2016 is the survey used for most baselines)
DPT3	Third dose of diphtheria–pertussis–tetanus vaccine (in Uganda, pentavalent-3)
EBLUP	Empirical best linear unbiased predictor (the Fay–Herriot small-area estimate)
EPI	Expanded Programme on Immunisation
FH	Fay–Herriot, the area-level small-area estimation model
FINEX	The AICTEM fiscal model (MacroModelling), which supplies the fiscal envelope
FTE	Full-time equivalent
FY	Financial year; FY2025/26 ends in 2026 and is the plan year "2026"
GAVI	Gavi, the Vaccine Alliance
GDP	Gross domestic product
GFS	Government Finance Statistics (the economic classification of the budget)
GoU	Government of Uganda
HC II, HC III, HC IV	Health centre levels II, III and IV
HH, LL, HL, LH	LISA cluster classes: hot spot, cold spot, and the two kinds of spatial outlier
HIV	Human immunodeficiency virus
HMIS	Health Management Information System
HPRAS	Health Planning and Resource Allocation System, the engine behind this report
HPV	Human papillomavirus (vaccine)
HRIS	Human Resource Information System
HM-01 ... HM-10	The ten modules of the engine, from population (HM-01) to budget and MTEF (HM-10)
IPTp	Intermittent preventive treatment of malaria in pregnancy
KCCA	Kampala Capital City Authority
LG	Local government
LISA	Local indicator of spatial association (local Moran's I)

Abbreviation	Meaning
LMIS	Logistics Management Information System
LP	Linear programme (the form of the HM-08 optimiser)
MEL	Monitoring, Evaluation and Learning, which receives the plan's targets and returns actuals
MIS	Malaria Indicator Survey (Uganda MIS 2018–19 and 2024–25)
MoFPED	Ministry of Finance, Planning and Economic Development
MoH	Ministry of Health
MTEF	Medium-Term Expenditure Framework
NCD	Non-communicable disease
NDP	National Development Plan (NDP IV)
NHFR	National Health Facility Registry
NMS	National Medical Stores
NPA	National Planning Authority
ODbL	Open Database Licence (OpenStreetMap)
OPD	Outpatient department (outpatient consultation)
OPT	The optimiser's allocation: the allocation that maximises lives saved on its stated objective
OSM	OpenStreetMap
PCV	Pneumococcal conjugate vaccine
PHC	Primary health care
PIAP	Programme Implementation Action Plan (the NDP IV Human Capital Development PIAP)
PMTCT	Prevention of mother-to-child transmission of HIV
PNC	Postnatal care
PNFP	Private not-for-profit (facility ownership)
RRH	Regional referral hospital
RTS	Rauch–Tung–Striebel (the smoother used in the trend model)
SAE	Small-area estimation
SAM	Severe acute malnutrition
SD	Standard deviation (in anthropometric z-scores)
SDI	Spatial Data Infrastructure, which owns routing and travel-time access
STEPS	WHO STEPwise survey of NCD risk factors (Uganda 2014)
TB	Tuberculosis
UCSN	The AICTEM unit-cost system (UnitCostModelling), which owns prices and unit-cost coefficients
UGX	Uganda shilling; converted at the plan rate of 3,700 UGX per USD
UNAIDS	Joint United Nations Programme on HIV/AIDS
UNICEF	United Nations Children's Fund
UPHIA	Uganda Population-based HIV Impact Assessment (2020–21)
USD	United States dollar
VHT	Village health team (community health worker)
WHO	World Health Organization
WISN	Workload Indicators of Staffing Need (the WHO method for converting workload to staff)
WRA	Women of reproductive age (15–49)
YLL	Years of life lost

D.2 Glossary of terms

Absorptive capacity. The most a district can usefully spend in one year. HM-08 approximates it as 1.5 times what the district already spends on the modelled services, scaled by its establishment fill rate. A district that cannot fill its posts will not spend a much larger budget.

Allocation scenario. One of six single, statable rules (A to F) for distributing the incremental envelope, or the optimiser (OPT). Each reports what it buys: coverage gained, districts above the floor, workers added, deaths averted with a range. No scenario is called recommended, best, preferred or optimal.

Available working time (AWT). The minutes a full-time worker has for services in a year, after leave, holidays, training, absence and the category allowance for non-service work. It converts required minutes into full-time equivalents under WISN.

Baseline. The cost of what the system delivers today, valued at the engine's unit costs. It is set against the requirement to give the financing gap.

Binding constraint. Whichever of space (rooms and throughput) or staff (workers in post and their time) limits a service's capacity in a district. Where observed delivery exceeds both, capacity is **revealed** instead. The binding constraint tells a planner whether a district needs buildings, staff or supplies.

Bill of materials. The list of resources one unit of a service consumes at a given facility level: staff minutes, medicines, consumables, diagnostics, equipment and infrastructure, each with a quantity, a share of cases and a wastage factor.

Concentration index. A measure, between -1 and +1, of whether an indicator is concentrated among the richer or the poorer (by wealth quintile), or whether supply is concentrated where need is high or low (by district). For coverage, positive means the richer are better served; for burden, negative means the poorer carry more; for supply against need, negative means supply sits where need is low.

Coverage floor. The minimum coverage of a basic-package service that every district should reach. A district is "above the floor" when every such service meets it. In the optimiser the floors are soft constraints with a large penalty.

Deaths averted. Deaths from the modelled causes prevented by the coverage change a scenario buys, computed in the multiplicative Lives Saved Tool form. Always reported with a range from the confidence intervals on the effectiveness parameters, never as a point estimate.

Equity ratio. For an allocation scenario, the ratio between the district at the boundary of the best-served decile and the district at the boundary of the worst-served decile, ranked by mean coverage after allocation. A ratio of 1 means equal coverage.

Explain. The engine function that decomposes any figure into its factors: this population, times this need rate, times this coverage target, times this norm, times this price, with the source and year of each.

Facility-equivalent. The unit of the facility gap (Gap 4): the space-bound shortfall in service units divided by the space capacity of the district's existing facilities.

Financing gap. The requirement at target minus the baseline. It is not the same as the incremental envelope, which is the money that actually exists to allocate.

Four gap dimensions. Service (units that cannot be delivered), workforce (FTE short), commodity (commodities short, valued in UGX) and facility (facility-equivalents short). They are reported separately and never combined into a composite index. Physical access is shown beside them as geography, not as a fifth dimension.

Gate. A pre-run check that stops a run rather than produce a misleading number: for example, a service with no bill of materials, a resource with no price, or a level mix that does not sum to one.

Incremental envelope. The additional money allocated among the scenarios: 413 bn UGX, the approved increase from FY2025/26 to FY2026/27 in the institutions that deliver the modelled services.

Induced recurrent cost. The permanent annual running cost (staff, utilities, maintenance and consumables) that a capital asset creates once built. The engine sets it at 15% of the capital cost a year, and every capital figure carries it beside it. It is the obligation that outlives the capital programme.

Level mix. The normative share of a service's volume delivered at each facility level (community, HC II, HC III, HC IV, general hospital, referral hospital). The shares sum to one.

Linearisation error. The relative difference between the multiplicative outcome model and the linear approximation the optimiser uses. Above 10%, the optimiser's objective is materially distorted; in the plan run it is 5.9%.

Modelled services. The 28 services in the engine's catalogue: 21 primary and 7 hospital services. The requirement covers these services only, not the whole health sector, while the budget covers everything. The ratio of the two is read, not closed.

Moran's I. A statistic of global spatial autocorrelation. Positive values mean neighbouring districts resemble each other; values near its expectation, $-1/(n - 1)$, mean no spatial pattern.

Mortality index. A district factor, with a population-weighted mean of 1, that gives baseline deaths the same geography as need (HIV by UPHIA regional prevalence, malaria by the DHS fever index, under-five deaths by HealthModelling's small-area estimate). It moves deaths between districts without changing the national total.

Norm. A standard of care expressed as data: the bill of materials, time norms, throughput and referral rate of a service at a facility level. Norms are never rescaled to match observed practice; a difference between norm and practice is a finding. Norms are grouped into a **norm version** (UGA-2026-v1 in this report, a draft awaiting clinical review).

Nowcast, forecast, extrapolation beyond evidence. The products of the trend model after the last survey: a nowcast up to 5 years after, a forecast up to 10 years, and beyond that an extrapolation that is never presented as a projection. Observed and interpolated years lie within the survey period. Products are drawn apart, never joined into one line.

Planning identity. The core equation of HM-03: required volume equals need times target coverage times units per case ($Q = N \times C^* \times v$). Coverage means complete receipt of the service; partial coverage is a lower C^* , never a lower v .

Plan run. One execution of the engine with fixed pins: country, geography version, norm version, price vintage, target set and scenario. Two runs with identical pins give identical numbers. The run behind this report is uga-unconstrained-2026.

Price vintage. A pinned snapshot of resource prices (UGA-2026Q1 in this report), resolved from UCSN. Prices are data, not code.

Quality tier. The evidence grade attached to every datum and result, in order of increasing weakness: **measured** (an administrative or survey observation for this district and year), **normed** (a standard or guideline value), **imputed** (derived from a related observation, such as another year or a similar district) and **assumed** (planner judgement with no empirical basis). A result inherits the worst tier among its inputs.

Readiness index. A factor between 0 and 1 that scales throughput capacity for how ready facilities are to deliver: a weighted geometric mean of the service-readiness domains (staff present, basic amenities, essential equipment, diagnostic capacity, essential medicines), so that a facility with no water is not compensated by good equipment. Where no readiness survey exists it is set to 1 and flagged, never invented.

Reconciliation ratio. The modelled requirement divided by the corresponding approved budget line. It is a ratio to read, never a gap to close, because the two differ in scope.

Referral service. A service whose need follows the volume of a parent service by a referral rate, such as caesarean sections from deliveries or inpatient bed-days from outpatient visits.

Requirement. The cost of delivering the modelled services at target coverage in every district. It is unconstrained by the budget and is computed before any money is considered (principle P1).

Revealed capacity. Capacity inferred from what a district demonstrably delivers: the delivered volume is a proven lower bound. Where facility data are measured, it acts as a floor on the throughput estimate; where they are not, it replaces it.

Shrinkage weight. In the Fay–Herriot estimator, the weight (between 0 and 1) given to an area's own survey estimate against the model prediction. A precise estimate keeps most of its own value; a noisy one is pulled towards the model.

Snapshot, stub and fallback. The status of an integration interface. A snapshot is vendored data used in place of a live feed. A stub is an interface whose counterpart does not yet exist. A fallback is the value used when a stub is in place, which may not be presented as that system's result.

Spatial lag. The average value of a layer among a district's neighbours, using row-standardised queen-contiguity weights.

Target set. The coverage targets and floors a run plans to (UGA-NDP-ILLUSTRATIVE in this report).

Three budget views. The programme view (vote, programme and output), the economic view (GFS class and line item) and the administrative view (vote and district) of the same cost cells. They must reconcile exactly, and an automated test asserts it.

Throughput capacity. The number of service units a district's facilities and staff can deliver in a year. It is computed from rooms, operating days, throughput per room and staff time, never from people-per-facility ratios (principle P4).

Units per case (v). The number of service units one case needs for complete coverage, such as four ANC visits per pregnancy or three doses per child.

Wastage. The share of a commodity lost in delivery, such as opened vaccine vials. It is applied to the commodity line, never to the service volume or to staff time.