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Policy Opportunities to Rectify Data Fragmentation in Health Care Supply Chain Financing

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Abstract

One in four people worldwide lack reliable access to essential medicines. This underperformance is not just the result of scarce resources; it also reflects fundamental weaknesses in how public health supply chains (SC) are designed, operated, monitored, and governed. In LMICs, complex ecosystems require strong coordination to function, yet information asymmetries and fragmentation of health, finance, and SC data leaves stakeholders out of sync. Data fragmentation drives cascading failures in health supply chain financing (HSCF) — a critical and underappreciated bottleneck. Our research into 311 unique digital systems across 47 LMICs quantifies the extent of this fragmentation. Only one country (Thailand) manages a functioning, interoperable bridge between finance and SC, despite many having the technological capacity to do so. Almost half of all systems are government-built or bespoke donor-projects, 34% have no documented standards, and six software model archetypes dominate. Most systems focus on SC delivery and monitoring, leaving upstream planning, budgeting, market-shaping, and prioritisation functions thinly covered. Persistent data fragmentation is not a technical hurdle, but rooted in political economy, stemming from historical verticalisation, misaligned incentives, vendor lock-in, and unresolved data sovereignty issues. Applying a use case-driven approach to HSCF can better align information system investments with health sector goals; we outline four that best represent country experience and feasible improvements. Further, we present six policy opportunities to strengthen governance, information infrastructure, and systems intelligence. These include specific actions to institutionalise and incentivise data exchange, finance sustainable architecture, and expand access to market intelligence.

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Acronyms

AI	Artificial intelligence
API	Application programming interface
CMS	Central medical store
DAH	Development assistance for health
DPI	Digital public infrastructure
DRM	Domestic resource mobilisation
EML	Essential Medicines List
ERP	Enterprise resource planning
GHI	Global health initiative
HF	Health financing
HIV	Human immunodeficiency virus
HMIS	Health management information system
HSCF	Health supply chain financing
ICD	International Classification of Diseases
ICT	Information and communication technology
IFMIS	Integrated financial management information system
ITU	International Telecommunication Union
KII	Key informant interview
LMIC	Low- and middle-income country
LMIS	Logistics management information system
MoF	Ministry of Finance
MoH	Ministry of Health
MOU	Memorandum of understanding
NGO	Non-governmental organisation
PBB	Programme-based budget
PEPFAR	US President's Emergency Plan for AIDS Relief
PFM	Public financial management
SC	Supply chain
TA	Technical assistance
TB	Tuberculosis

UN	United Nations
UNFPA	United Nations Population Fund
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
VMI	Vendor-managed inventory
WHO	World Health Organization
WMS	Warehouse management system

Executive summary

Despite decades of investment, one in four people worldwide lack reliable access to essential medicines, with the greatest gaps in low- and middle-income countries (LMICs) (Ozawa et al., 2019). This underperformance is not just the result of scarce resources; it also reflects fundamental weaknesses in how public health supply chains (SC) are designed, operated, monitored, and governed.

Among these weaknesses, health supply chain financing (HSCF) is a critical and underappreciated bottleneck. Baker and colleagues (2025) called attention to frequent challenges with HSCF, noting that "too often the financing is slow, unpredictable, fragmented, inflexible, dependent on donors, and inefficient, which contributes to limited and unreliable access to essential medicines and diagnostics." These failures are not incidental. LMIC supply chains are incredibly complex, involving multiple funders, procurers, distributors, government agencies or departments, and technical assistants working in administratively decentralised, low-infrastructure environments. Emerging infectious diseases, climate-driven events, and political instability frequently complicate plans, requiring urgent reassessment and programme pivots. In such contexts, effective system performance depends on strong coordination across actors, which concretely depends on shared, high-quality, and timely information.

However, in LMICs, information asymmetries and fragmentation of health, finance, and SC data systems routinely undermine coordination. Budget and account information arrive too late to drive product procurement cycles, delayed insurance claims adjudication and reimbursement compromises drug funds, and lack of price and expenditure visibility erodes purchasing power. Gathering intelligence to create procurement plans, manage stock, and develop policy is mostly manual, requiring piecemeal compilation of data from disparate systems and spreadsheets. This fragmentation compromises data integrity, drags down system efficiency, and ultimately undermines HSCF performance.

To shed light on the drivers of persistent information fragmentation, we conducted an evidence synthesis, interviewed experts and country representatives, and constructed a comprehensive inventory and analysis of the current state of data ecosystems for HSCF in LMICs.

We find extensive fragmentation and lack of interoperability

For 311 unique systems across 47 LMICs in sub-Saharan Africa and South and Southeast Asia, we find evidence of an operational bridge (integration that is routine, automatic, and at significant scale) in only one: Thailand. Notably, 8 countries have demonstrated bridges, where exchange is narrow, programme-specific, or degraded; 14 countries have potential bridges (high, untapped potential for routine interoperability); and 24 countries have nascent/fragmented systems that are undigitised or not well set up for routine integration (see Annex 5 for a description of the methods and typology rubric).

We find a small number of platform families dominate the landscape (led by DHIS2 and OpenLMIS), yet roughly 45 percent of all systems are government-built or bespoke donor-project builds, and public documentation is sparse or absent for a large share of them. When mapped to the Baker et al. (2025) HSCF framework, digital solutions cluster around delivery and monitoring

(over half of functional assignments), leaving upstream planning, budgeting, and market-shaping functions thinly covered. Indeed, we find no evidence of the prioritisation function being supported by any digital system. Interoperability layers are rare, despite widespread policy commitments.

Political economy is the primary constraint to integration

By and large, the data, technology, and infrastructure exist and integration is feasible, as evidenced by nearly half the countries we reviewed having the digital foundations for integration. The primary constraints are not technical, but structural, rooted in political economy and a web of interagent dynamics that tend to be ignored in formal policy and procurement arrangements. The root causes of system misalignment and information fragmentation include:

- **A history of piecemeal, vertical investments.** Global health initiatives (GHIs) built parallel, programme-specific digital tools optimised for donor accountability and reporting, not national integration.
- **Misaligned incentives.** Institutions often retain control over data because of accountability, governance, budgetary, and operational mandates that discourage sharing.
- **Vendor and partner lock-in.** Proprietary enterprise systems resist data exchange, and project-cycle-driven implementation prevents long-term interoperability planning, creating dependency.
- **Data sovereignty.** Unresolved questions about data ownership, access rights, and governance authority create additional friction.

A use case approach can drive constructive solutions

A systematic and tightly defined use case, anchored to a specific, intended performance outcome, is needed to help align incentives and guide future investments. This approach should accomplish a prescriptive set of clearly defined goals, and articulate both a "current state" and "future state." The documentation process is paramount, and forces precision about who will be involved, how they will interact, what information they need, what they will do, and what will be accomplished in the end. The endorsement of priority use cases aligns interests from across institutions, provides clear milestones, and steers incremental investments towards measurable performance outcomes.

Our research identified four critical HSCF use cases, which we elaborate in detail:

1. **Allocating resources for health products to meet needs.** *How much do we need, what can we afford, and how do we prioritise?*
2. **Setting accurate reimbursement rates and prices.** *Are prices and reimbursement grounded in reality?*
3. **Translating allocated resources into reliable and consistent supply.** *Can facilities translate allocated resources into availability?*
4. **Demonstrating last-mile performance and accountability.** *Do products reach patients as intended?*

Across all use cases, information-based failures arise because of clear policy gaps: no institutional actor is accountable for data exchange; procurement contracts and operating agreements do not oblige data sharing; metadata are incongruent and difficult to use; inter-institutional data sharing agreements are absent or insufficiently specific; and common data views are treated as special projects, rather than routine operations.

Recommendations

The empirical lack of systems integration, the (de)motivating forces of political economy, and the challenges elucidated by the use cases all indicate fundamental changes are needed to how information systems are financed and governed. Structural barriers and competing organisational incentives need to be tackled more directly, foundational components of information access and exchange need to be supported, and technology should be better leveraged to derive intelligence from disparate data.

Six policy opportunities could help achieve these aims:

1. **Assign and fund accountability roles for data exchange.** Designate an existing institution as the "Exchange Manager," evaluated on successful data exchange rather than platform management.
2. **Incentivise data exchange and build into operating agreements.** Write verifiable data exchange requirements into contracts, grants, and MOUs, and tie payments and disbursements to demonstrated exchange.
3. **Require open APIs and government data ownership in all system procurements.** Every new procurement, regardless of software model, should deliver documented APIs, standard data export formats, and unambiguous mechanisms for government administration.
4. **Finance integration as a recurrent cost.** Sustain interoperability infrastructure through small transaction levies on insurance claims and central medical store operations and through maintenance contracts paid for outcomes.
5. **Plan and procure against use cases, not platforms.** Base procurement specifications, funding approvals, and performance evaluation on a prioritised portfolio of use cases that solve specific operational data gaps.
6. **Build a health product market intelligence layer.** Aggregate contract prices, facility procurement costs, regulatory data, and international reference prices into a routinely updated health product price index to inform purchasing, tariff setting, and budget formulation.

For each policy opportunity, country governments, programme funders, normative bodies, and private sector actors have a role to play, and this unique moment of disruption in the global health architecture provides a window for change.

Achieving tighter information integration is possible and will yield dividends for health systems and patients alike. We must acknowledge the structural forces and incentives that reinforce silos and tackle them head-on with smartly crafted policy and accountability mechanisms.

Introduction

Health supply chains underperform

One in four people worldwide lack reliable access to essential medicines, with a disproportionate deficit in low- and middle-income countries (LMICs) (Ozawa et al., 2019). The consequences of this gap extend well beyond unmet clinical need. Out-of-pocket spending on pharmaceuticals pushed over 150 million people into medical poverty in 2019 alone (World Health Organization & The World Bank, 2021). Stock-out rates for some essential medicines have actually deteriorated since the Sustainable Development Goals were declared in 2015 (Olaniran et al., 2022). While the above failures are often associated with constraints in the logistics process, access to health products depends equally on performance of and decisions made within finance and public financial management (PFM) systems.

Financing and PFM bottlenecks have cascading effects

Fragmented supply chain (SC) financing and governance arrangements exacerbate performance gaps. In four countries where SC financing was evaluated in detail (Ethiopia, Ghana, Nigeria, Tanzania), delayed budget releases, protracted procurement cycles, and misalignment between budget ceilings and health product need were common across very different institutional contexts (Balsara et al., 2025). In Kenya, a study found counties executed less than half of their medicine budgets, with tracer stock-outs driven by treasury delays and unsettled bills. Unfortunately, this situation (or similar) is not uncommon in LMICs and emblematic of the cascading effects that stem from suboptimal finance systems and/or governing arrangements (Mukasa et al., 2017).

Financial bottlenecks also increase total costs. When central medical stores cannot fill orders, facilities and patients turn to the open market and pay higher prices (Fitzpatrick, 2022). In Ghana, for example, the Christian Health Association network negotiates pharmaceutical prices 30–40% below the public sector: a direct result of on-time payments for drugs delivered (*Key Informant 3, Personal Communication*, March 20, 2026).

The margin for inefficiency has always been thin, but the outlook is particularly grim. Overseas development assistance fell by an estimated 23 percent in 2025, driven by synchronised cuts from major Western donors (The ONE Campaign, 2026). The US global health supply chain programme, which annually has procured over USD 1 billion in health products for 73 countries, is being fundamentally, and somewhat hastily, restructured. The transition will increase the risk of stockouts for HIV, malaria, family planning, and maternal health products across Sub-Saharan Africa and South Asia (Krugman, 2025; Nepomnyashchiy et al., 2025).

Domestic fiscal space can't make up the gap, especially as foreign exchange reserves are depleted and currencies devalued, making the cost of imported medicines even greater (Diwan et al., 2026). Moreover, countries most dependent on external health product support are also those with the smallest domestic health budgets. The persistence of these bottlenecks suggests the challenge is

broader than just resource mobilisation but rather the ability of systems to convert resources into available products.

Information gaps and asymmetries drag efficiency

Efficient supply chains require high-quality information and timely data exchange. For example, accurately assessing health product needs requires congruent and sufficiently disaggregated data on population size and mobility, disease burden, prior consumption, available stock, and programme eligibility (at minimum). In most LMICs, these data are typically stored in a variety of static and dynamic information systems (managed by different actors), difficult to access and parse, lack common standards, and require enormous effort to make useful.

Relating financial data adds an additional layer of complexity, and when SC and financing data are siloed, the resulting information gaps have cascading effects. For example, lack of timely budget and account information slows procurement cycles; delayed claims adjudication squeezes facility liquidity; and lack of information about market prices reduces purchasing power. Further, these information gaps create conditions that enable and sometimes incentivise undesired behaviour. Information asymmetry between central buyers and peripheral facilities makes it difficult to verify stock levels or confirm that health products reached patients. In environments of chronic scarcity, facility workers may (rationally) amass excess stock or manipulate consumption reports to align with prescribed targets.

Where countries have invested in connecting data streams, the returns are tangible. In Tanzania, integrating logistics, health, and financial systems eliminated duplicate data entry and enabled real-time budget tracking (Dillip et al., 2022; Kuwawenaruwa et al., 2020). In India, using TB treatment records to generate payment authorisations via the public financial management system resulted in automated direct cash transfers, increasing treatment adherence (Dave & Rupani, 2022). South Africa's Central Chronic Medicine Dispensing and Distribution (CCMDD) programme links clinical data to the logistics system through SyNCH for community HIV medicine distribution—a programme-specific bridge rather than system-wide integration. This reduces travel costs for patients and frees up health worker time for improved clinical efficiency (Dorward et al., 2020; Sekopa & Netangaheni, 2024).

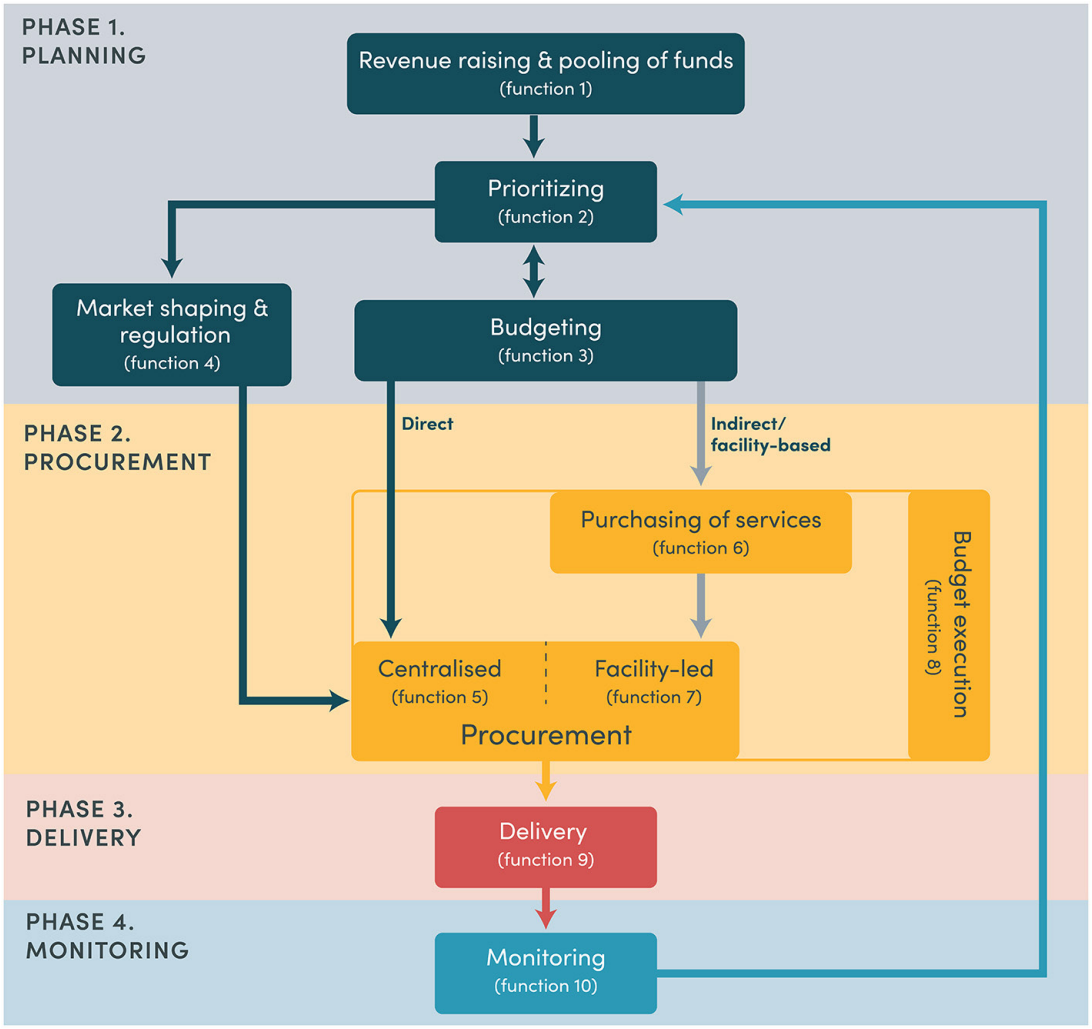
There are legitimate, structural constraints on how much visibility any LMIC health system can attain. Reliable electricity and internet connectivity remain a challenge. Deploying and maintaining software at thousands of peripheral facilities is expensive, and no single platform will meet every operational need. These constraints are real, yet the fragmentation documented in this paper cannot be explained by infrastructure limitations alone. Even countries with relatively high digital maturity still lack automated data exchange that may rectify information gaps and boost efficiency.

Precise points-of-failure need to be mapped

To strategically tackle SC financing barriers, we need better ways of understanding the intersection points and dependencies between two rather distinct domains. "Health financing" (HF) and "health supply chain" (as conceptual disciplines) maintain their own international and national frameworks, strategies, and policies; are often governed by different institutions or line ministries; and are administered by staff with specialised expertise. Each has semantic preferences that propagate through guidance documents and domain-specific information systems, making effective, inter-domain communication a challenge.

Baker and colleagues proposed a novel conceptual framework for health supply chain financing (HSCF), defining ten distinct functions across four phases (planning, procurement, delivery, and monitoring; Baker et al., 2025). This framework is a first step towards bridging disciplines, developing a common nomenclature, and identifying the critical moments where people and information must converge.

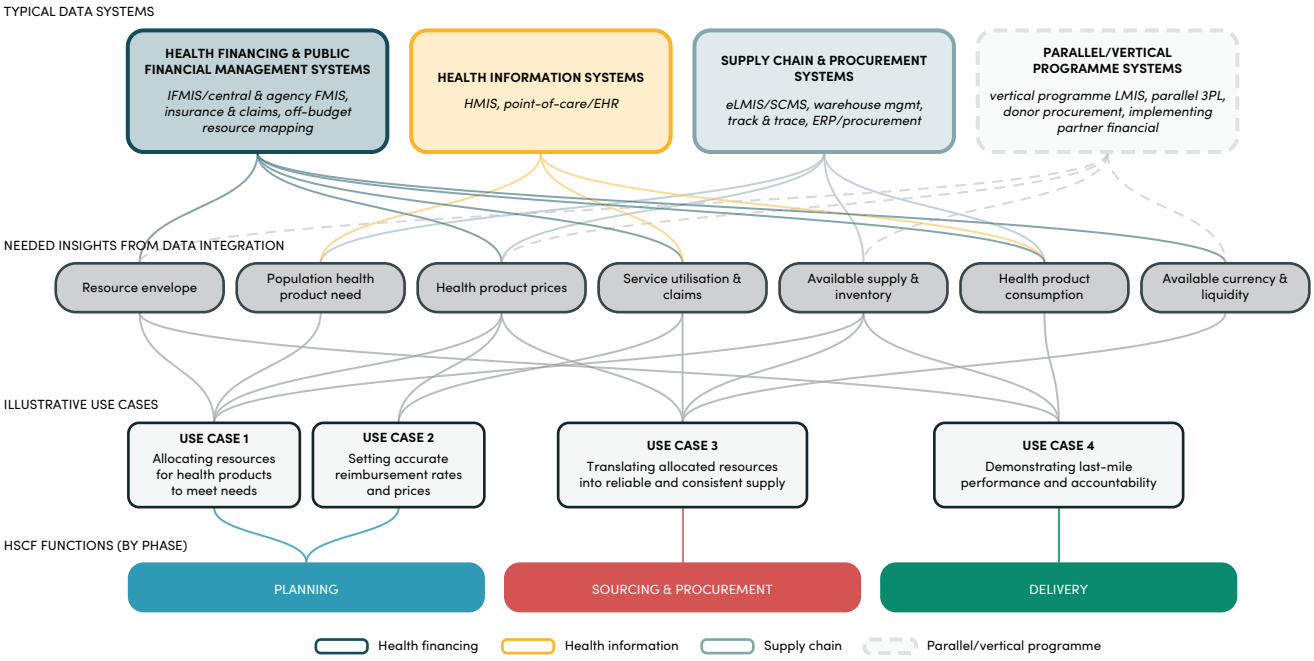
FIGURE 1. Financing of supply chains: proposed conceptual framework
(Baker et al., 2025)



Assessing current information flows within this framework is particularly challenging. Extant information systems don't map cleanly to institutional actors, financing, or SC flows, nor is it possible to catalogue the information shared through formal deliberation or informal communication. Figure 2 illustrates some of the information flows between typical data systems and supply chain functions,[1] anchoring on 4 high-level use cases discussed in this paper.

Accomplishing the objectives of each functional phase requires using information typically housed within multiple information systems. Seven critical integrations are outlined in the middle layer that require multi-source data synthesis and are requisite for strong SC performance. Currently, most of these integrations can only be accomplished manually, through data extracts and spreadsheet compilation, and often lack quality and comprehensiveness.

FIGURE 2. Typical health supply chain information flows and needed insights from data integration



The following investigation and supporting analyses leverage the Baker et al. HSCF framework to assess the current state of data integration, identify root causes for fragmentation, understand core use cases information systems must support, and identify policy opportunities most likely to foster visibility and systems intelligence. As we will argue, historical health data architecture and governance arrangements often sustain and reproduce fragmentation, even where the technical means for integration exist. Nevertheless, smartly crafted and tailored policies, financing vehicles,

1 This diagram elaborates on the monitoring function writ large, so it is not a specific component in the diagram. It is based on a forthcoming update to the conceptual framework, in which Phase 2 is renamed "sourcing": we therefore label the phase "sourcing and procurement". For the rest of the paper, we use the category "procurement" when listing functions according to the original framework; elsewhere, we use the term "sourcing and procurement".

and product design can push through these structural barriers and better align information systems with health sector goals.

Key terms and operational definitions used throughout this paper (e.g., integration, interoperability, master data, and digital public infrastructure) are set out in Annex 1.

The current state of data ecosystems

To assess the current state of data integration, we constructed an inventory of **311 digital systems** across **47 LMICs** in Sub-Saharan Africa and South and Southeast Asia. We classified each system by HSCF function and associated phase (Figure 1), software platform family, software governance model, data standards used, and documented integration status. We validated these findings through qualitative deep dives, including key informant interviews with government officials or supporting implementing partners in four countries: Malawi, Rwanda, Ghana, and Tanzania. A full description of the methods is detailed in Annex 5.

The development and analysis of this inventory were intended to:

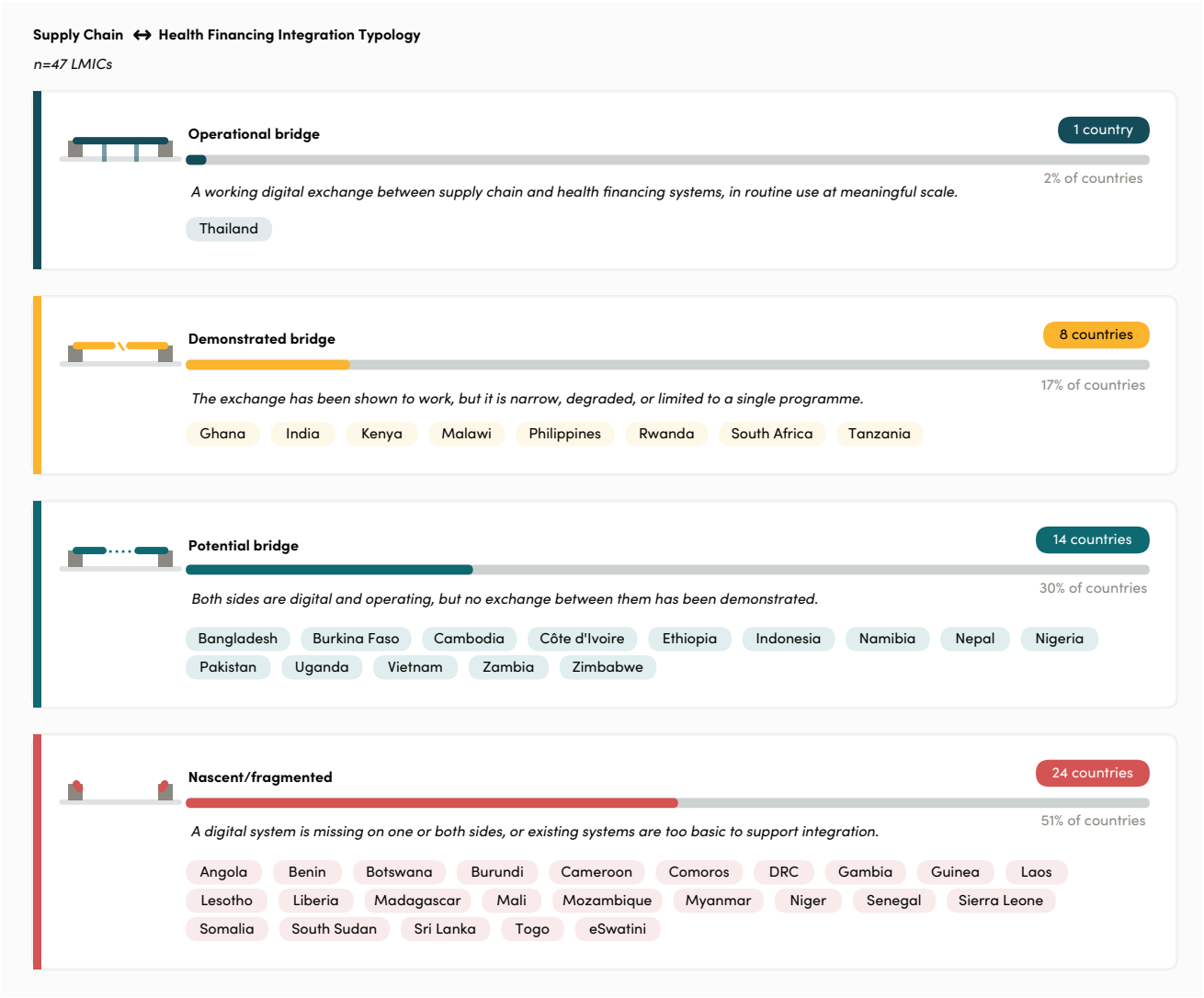
1. Identify features or patterns in these ecosystems that should inform national or global policy
2. Identify typical ecosystem arrangements and/or country or system-level archetypes that might help tailor policy recommendations
3. Assess and compare current data integration journeys and progress
4. Identify high-return investment opportunities for expansion and efficiency

This inventory is a snapshot in time and based on best available information, analysis, and author judgement. Many systems identified in the landscape lack sufficient documentation, which is an important finding itself, and further validation is warranted. While imperfect, the picture that emerges from these data is telling and several key observations are outlined below.

Operational integration is rare

We classified countries into four tiers based on the strength of evidence for digital data exchange between SC and HF systems (Figure 3). Strikingly, for only one country—Thailand—could we verify a functioning digital chain that covered a majority of public sector transactions ("**operational bridge**"). Eight countries (Ghana, India, Kenya, Malawi, the Philippines, Rwanda, South Africa, and Tanzania) had "**demonstrated bridges**," where some form of data exchange has been shown but is narrow, degraded, or programme-specific. Fourteen countries have functioning digital systems for both SC and HF, but there is no evidence they have been connected ("**potential bridges**"). The remaining 24 countries are missing digital systems on one or both sides of the equation, or their systems are too basic for digital interoperability to be a realistic near-term goal ("**nascent/fragmented**").

FIGURE 3. Evidence of routine supply chain and health finance systems integration



Thailand is the sole country in which we find a nationally scaled and mature connection (described in Annex 2). The hospital information system generates billing records simultaneously with pharmacy dispensing in over 300 public hospitals (Wasi et al., 2020). While impressive, noted intelligence gaps remain on the SC side as there exists no integrated view of stock remaining after dispensation (World Health Organization, SEARO, 2016).

Both Tanzania and South Africa are notable examples that almost achieve operational bridge status. In Tanzania, insurance reimbursements verifiably flow into facility bank accounts (Binyaruka et al., 2024) and are recorded in the facility financial accounting system (FFARS) (Ruhago et al., 2023). A web-based prime vendor ordering platform (PVMIS, integrated with the facility hospital information system) launched in 2023 to streamline orders from private sector

distributors (Stoermer et al., 2024). Despite these advances, digital exchange between the financing and procurement systems could not be verified, and the official prime vendor payment procedure remains manual (PO-RALG, 2022; Binyaruka et al., 2024).

In South Africa, the National Surveillance Centre provides a sustained, government-stewarded view across the supply chain and routinely incorporates accounts payable and arrears in supply planning; however, this integration process is largely manual. South Africa's significance therefore lies less in end-to-end technical interoperability than in the institutionalisation of common information, analytical and governance processes at scale (described in Annex 2).

The eight "**demonstrated bridge**" countries have shown interoperability is possible, and may offer useful lessons for others. For example, Malawi's interoperability layer successfully transferred records between OpenLMIS and the HMIS, then went dormant because common data registries weren't sustained (Krafft, 2021; Mtenje et al., 2023). This is a primary blocker in many countries and is discussed in detail in Annex 2. Ghana and Kenya are other notable examples. Ghana's NHIS Integrated Electronic Payment System (NIEPS) documents cross-referencing of insurance claims with facility stock data, and Kenya's Taifa Care platform links claims processing to registered facilities. Yet neither has a system-to-system chain enabling HSCF functions.

The 14 "**potential bridge**" countries may represent the largest untapped opportunity. In most, an eLMIS captures health product stock and consumption data, an insurance or financial management system processes claims and/or tracks budget execution, and an HMIS monitors service delivery. These systems function within their respective domains, yet linking data across systems to adjudicate claims or confirm intended use isn't yet possible. Côte d'Ivoire illustrates this pattern. Both eSIGL (logistics management system) and CNAM/CMU (biometric enrolment and member management for national health insurance) are operational at national scale, with no automated data exchange between them (Haazen, 2020; Silvestre, 2018).

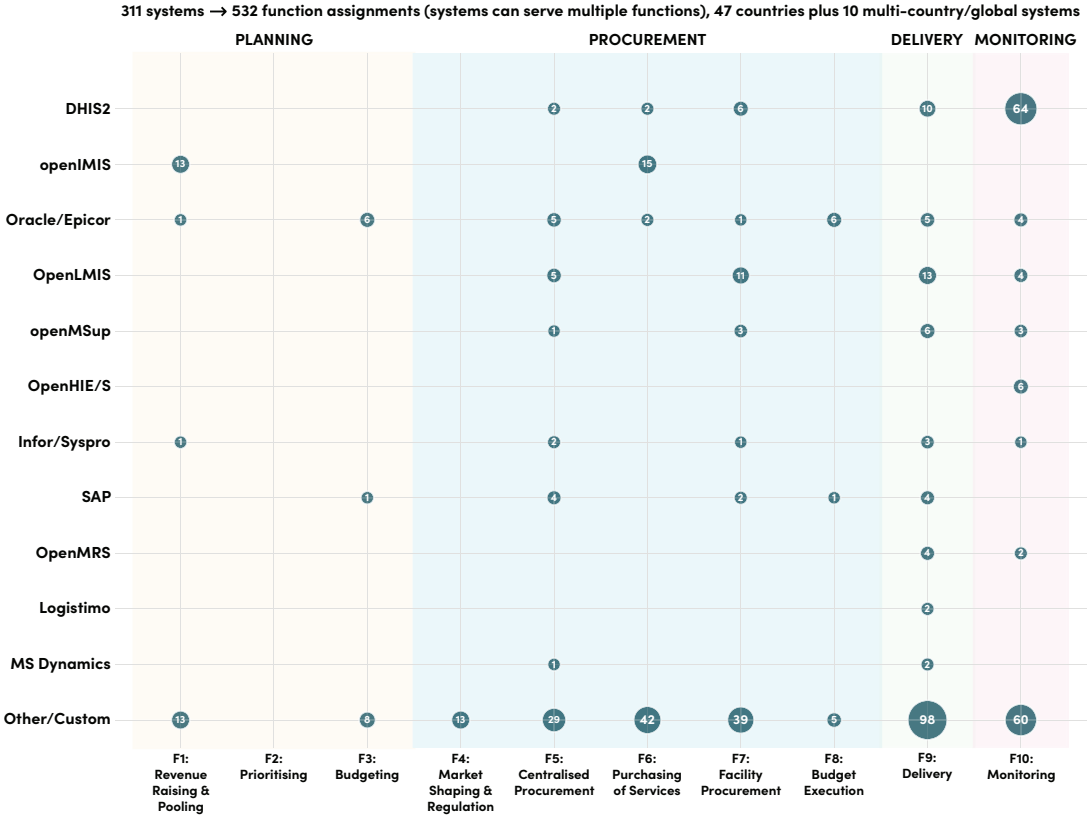
Digital support tools might be lacking for certain supply chain financing functions

Using the Baker et al. HSCF framework (Figure 1), the 311 systems in the inventory were mapped to 532 function assignments (301 systems are country-specific; 10 are multi-country or global). Figure 4 plots the frequency of these systems across function, phase, and by platform. Table A1 (Annex 3) summarises what is included in each functional mapping.

We identified 147 systems serving the delivery function (warehousing, distribution, inventory management, cold chain) and 144 serving monitoring (DHIS2 dashboards, hospital information systems, interoperability layers). These are the functions where donor investment has been concentrated over the past decade, largely through PEPFAR and Global Fund support for health product logistics and programme monitoring.

The planning and financial management functions are potentially underserved. We found just 15 systems supporting budgeting, 13 for market shaping and regulation, 12 for budget execution, and not a single system serving prioritisation. This gap partially reflects the type of tools described in the HSCF framework: "regional resource allocation formulas, national health sector strategic plan, health benefits package, essential medicines list, and/or procurement list." These instruments are often static policy artefacts that exist in most countries. Yet we found little mention of them in the published documentation for digital systems in the inventory[2] and no routine systems devoted to supporting prioritisation, suggesting either a documentation gap or real disconnect in digital support. Most countries appear to have left financial decision-making largely analogue or managed through ad hoc spreadsheet exercises (a finding confirmed in our qualitative interviews).

FIGURE 4. Software platform frequency by supply chain financing function



A small number of platform families dominate, but custom-built systems are pervasive

The inventory reveals recognisable clusters of technology. DHIS2 appears in 64 deployments across 43 of the 47 countries (Benin, India, the Philippines and Thailand have none). OpenLMIS appears

2 Aside from the occasional mention as a downstream constraint on supply chain procurement platforms.

in 13 systems across 10 countries, almost exclusively in Sub-Saharan Africa. OpenIMIS, the only open-source platform purpose-built for health insurance and social protection, was identified in 15 deployments across 12 countries in Sub-Saharan Africa and South Asia. Oracle/Epicor underpins IFMIS and warehouse management in several countries. SAP runs the Government Pharmaceutical Organization in Thailand, the central medical store ERP in Rwanda, and central health procurement in India (GPO Thailand, 2024).

Global digital public goods account for 108 of the 311 systems (35 percent) and offer the potential for shared learning and reusable integration approaches.

The majority of systems, however, aren't in these families. Nearly half of the inventory (146 of 311 systems) runs on technology stacks that are purpose-built for a single country or could not be identified from public documentation. Government-built systems alone account for 122 systems, the largest single software model in the inventory. This is particularly pronounced on the HF side. National insurance claims platforms, IFMIS configurations, and procurement portals tend to be built or heavily customised to country-specific administrative requirements.

The family clusters are relevant for structural integration. Where the same platform family appears in both SC and HF within a country, integration is more about configuration. The data models are known, application programming interfaces (APIs) are documented, and other countries may have solved similar problems. Our analysis found that only in Kenya does a single platform family (Oracle/Epicor) serve both a supply chain and a health financing system. In the more typical case, connecting SC and HF data requires bridging two different technology stacks, each with its own data and governance model. Feasible, but more complex.

Functional interoperability layers are rare, despite widespread policy commitment

National health strategies routinely name data exchange, system integration, or interoperability as strategic objectives, yet little empirical evidence exists of functioning architecture.

The WHO SMART Guidelines, the OpenHIE reference architecture, and FHIR provide increasingly mature technical guidance (HL7 International, 2026; Mehl et al., 2021; OpenHIE, 2022), but the technology to act on these commitments is rarely deployed. OpenHIM has just 7 deployments across 7 countries in our inventory. India (ABDM/HCX), Indonesia (SATUSEHAT), Thailand (Health Link / MOPH Cloud), Ghana (NIEPS), Kenya (Taifa Care), and South Africa (National Surveillance Center) have developed custom integration mediators.

A lack of data standards reinforces the system fragmentation. Supply chain systems aim for GS1 product identification codes; health financing systems rely on PFM data standards, including the UN Classification of the Functions of Government and charts of accounts; and digital health systems increasingly leverage International Classification of Diseases (ICD) diagnostic classifications and

HL7 messaging standards. FHIR is a modern HL7 version built for cross-domain use but rarely appears in operational deployments. **Of the 311 systems in our inventory, 106 (34%) have no documented adoption of standards at all.** Without a shared way to identify a medicine, facility, or transaction, even well-designed APIs fail to enable meaningful data exchange unless someone builds and maintains a translation layer.

Sub-Saharan African countries have largely adopted a common set of platforms for SC and monitoring functions, creating a degree of shared technical capacity. By contrast, South and Southeast Asian countries have more frequently invested in national digital architectures built to government specification, such as India's ABDM and Indonesia's SATUSEHAT, aiming to unify health data under a single platform.

These different approaches to a common problem come with distinct trade-offs around portability, cost, institutional ownership, and vendor dependency. We do not find a relationship between chosen pathway and SC-HF integration. What matters more than the software model is whether interoperability is treated as an essential system requirement.

Software model archetypes exist

We found six distinct software models for how the digital systems in the inventory were developed, procured, or adopted. Each has different implications for ownership, flexibility, sustainability, and ease of integration (outlined in Annex 3). Figure 5 shows the distribution across the inventory; Figure 6 maps which models serve which functions in the HSCF framework.

Two patterns in these data seem particularly relevant for integration. First, no software system serves all ten SC-HF functions. Within a single country, the digital ecosystem is almost always a composite of different models. A typical mix might include an open-source eLMIS for facility ordering, a commercial ERP at the central warehouse, a government-built IFMIS for budget execution, and a donor-funded, custom dashboard for monitoring. Countries with larger digital footprints typically manage three or more software models simultaneously (19 of the 47 countries in inventory), which means that connecting SC data to financial data requires negotiating across ownership boundaries.

Second, the regional pattern is suggestive. Government-built systems are the largest single category in the inventory (122 of 311 systems) and predominate in South and Southeast Asia (83 of 127 systems there), while global digital public goods account for the largest share of systems in sub-Saharan Africa (89 of 179[3] systems, 50 percent). This likely reflects differences in domestic IT capacity, fiscal space, and historical patterns of donor engagement in health system digitisation.

3 This figure includes multi-country deployed systems with country-specific software instances.

Selecting a software model determines who controls the product roadmap, pays for maintenance, and holds the authority to mandate data sharing. These are governance choices as much as technical ones, and often decisions are rushed due to political or project pressure, compounding future integration challenges.

FIGURE 5. Software model distribution

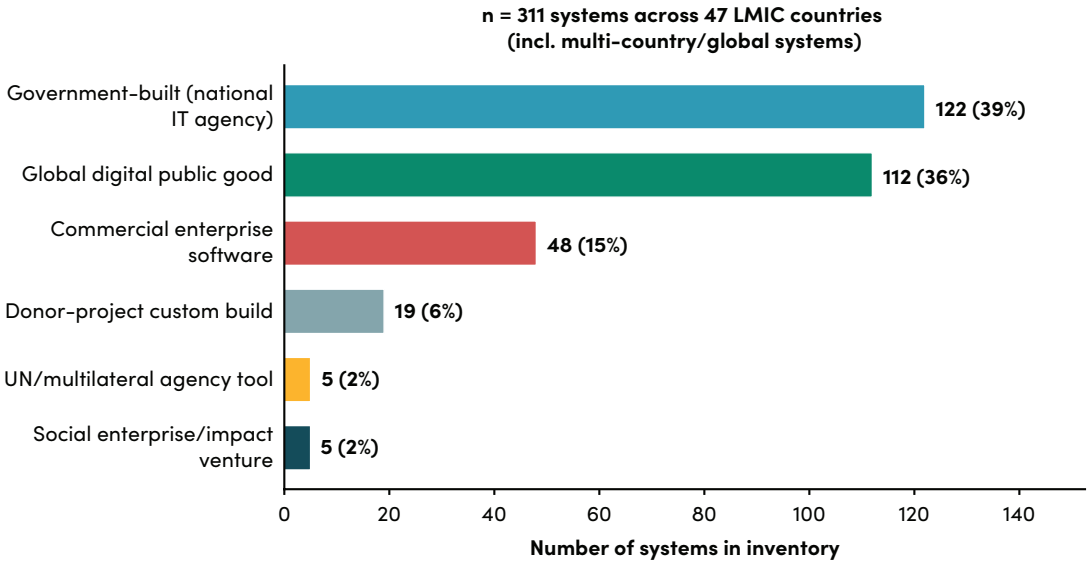
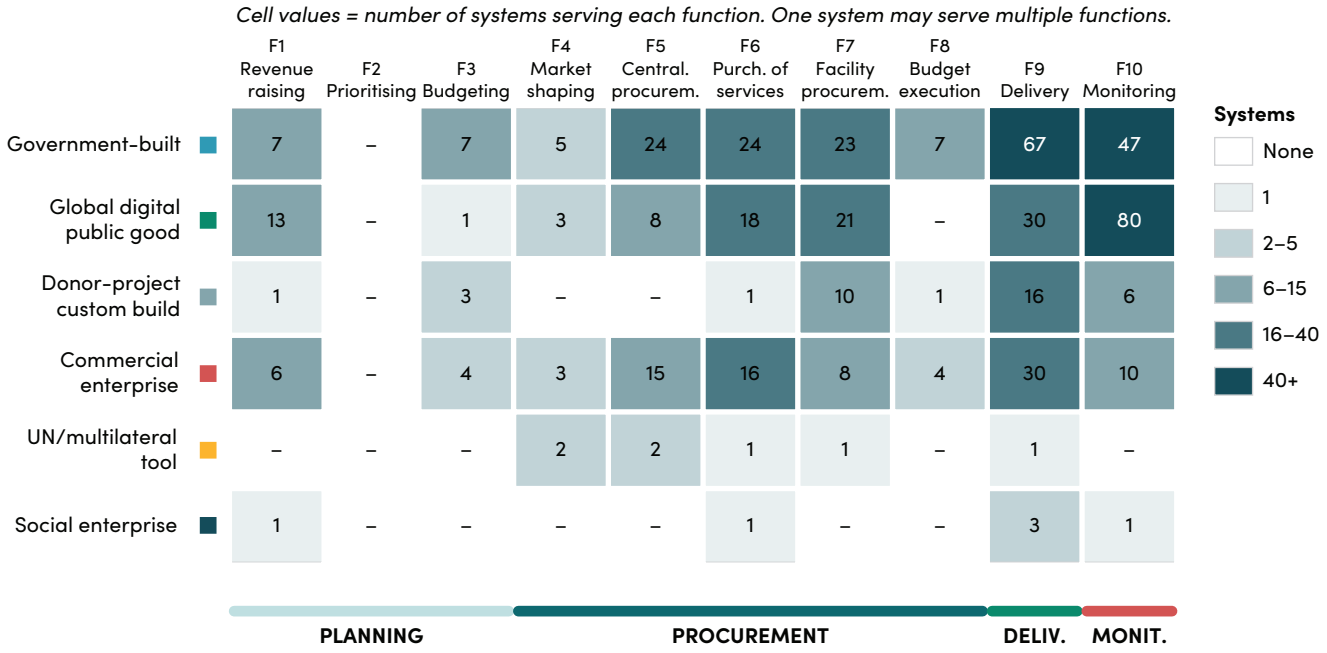


FIGURE 6. Software model by supply chain financing function



Root causes of information fragmentation

To understand the structural barriers to information integration, we must first trace historical origins. Over the last 20+ years, information systems in LMICs have been shaped by political, economic, and commercial forces that can actively reinforce fragmentation and demotivate cooperation.

The origins of siloed systems

Three distinct data ecosystems — SC, health monitoring, and finance — evolved on parallel tracks (see Table A2 in Annex 4 for tabular summary).

Since the early 2000s, development assistance for health (DAH) has prioritised vertical disease initiatives. Major global health initiatives (GHIs), led by PEPFAR, the Global Fund, Gavi, and UNICEF, heavily invested in logistics infrastructure to improve health product availability. This led to a proliferation of country-level, centralised procurement platforms. While these investments delivered clear gains in health product availability, the digital products developed in tandem were designed to fulfil distinct programme benchmarks rather than to interoperate with national architecture (Supply Chain Funders' Forum & Integration Taskforce, 2026).

A corresponding pattern emerged within health management information systems. Currently active in over 90 countries, DHIS2 has established itself as the de facto tool for aggregate health metrics, often supplying data for forecasting, tracking, and quantification activities. In settings where DHIS2 has been expanded to incorporate financial or logistics data (e.g., Tanzania, Senegal, Ghana, Mozambique, and Indonesia), its application is usually narrow (Saugene, 2024; Sitompul et al., 2025; Titlestad et al., 2017). Similarly, patient-level tools reflect this GHI, vertical orientation. OpenMRS, the leading open-source electronic medical record framework deployed in low- and middle-income countries (LMICs), was originally engineered around HIV and TB treatment interventions. Large-scale implementations that adapt electronic medical records to provide a comprehensive, hospital-wide perspective continue to be exceptional (Mohammed-Rajput et al., 2011; Ferry et al., 2021).

Finance systems (e.g., IFMIS), often backed through World Bank PFM reform programmes, have been instrumental in boosting transparency and accountability for public funds; yet, these systems keep a narrow focus on budgets and execution. It's incredibly challenging to link particular resources flowing through IFMIS with specific health products purchased or consumed. Similarly, claims platforms, which have expanded rapidly as countries pursue universal health coverage, are capable of quantifying reimbursements, but not easily linked to procurement or stocks. The result is an ecosystem of independently capable systems that aren't designed to exchange information.

In recent years, frameworks, middleware, and applications have emerged to help actors rationalise across these exceedingly complex ecosystems and meet data user needs. These include the Open Group Architecture Framework (TOGAF), Open Health Information Exchange (OpenHIE), Open

Health Information Mediator (OpenHIM), and the Open Concept Lab. While essential, these tools are often underutilised, or adopted without an adequate compliance apparatus.

The political economy of aid and institutional turf

DAH is structured around vertical disease programmes with independent accountability requirements. As such, bilateral, multilateral, and philanthropic development partners each require separate reporting frameworks, and more often than not, separate information systems.

Research on the political economy of GHI reform found that key informants at both global and country levels perceived competition amongst initiatives as a zero-sum game, where organisations jostle for roles and funding, expanding mandates to justify replenishment requests rather than consolidating with peers (Witter et al., 2025). This competitive dynamic extends to data systems. Each initiative has institutional reasons to maintain its own reporting infrastructure, namely it must demonstrate value to funders.

For decades, we have relied on lofty health and development goals to coordinate a complex web of institutional actors, each with their own intermediate goals. While well-understood and lamented in hallway conversations, the inherent tension between organisational objectives and sector objectives is mostly ignored in formal discourse and policy.

Information asymmetries

More directly, possessing information confers organisational power. The "principal-agent problem," widely accepted in economics, managerial science, and political science, provides a useful lens (Ssennyonjo et al., 2021). When one person or organisation (the "agent") works for another (the "principal"), there is a constant risk that the agent's incentives are not aligned with the principal's goals. Information asymmetry substantially increases this risk, as the principal cannot fully know what the agent is doing. In global health, we can consider multilateral organisations as "agents" working on behalf of their donors and recipient countries (the "principals"). The multilaterals are incentivised to capture the information and keep it to themselves, as this information asymmetry gives them substantial power over their principals.

Routine operational reporting narrows the information gap between agent and principal, making it more likely that agents act towards system-level, rather than organisational, goals. However, reports can be gamed. Rightly or wrongly, organisations who share their data may perceive a loss in their competitive edge. Without clear rules, incentives, or legally binding agreements to force sharing, the least risky choice for any institution is to hold onto its own information (Brinkerhoff & Bossert, 2014). Integration therefore represents redistribution of information and influence, not just technical connection between systems.

Organisational accountability trumps systems accountability

Donor-funded programmes are accountable upward to their boards and funders, and donor-specific information systems reflect this priority (DATIM for PEPFAR, the Global Fund's grant management system, Gavi's country reporting portals). No doubt, these investments have benefited health systems, both directly and indirectly. For example, the development of DATIM resulted in substantial expansion to DHIS2 functionality and reach. However, fewer resources and effort have been devoted to enabling integration and interoperation with national systems because the structural incentives aren't as strong.

Ministries guard budget authority

Ministries of Finance oversee IFMIS, which were built to strengthen public financial control functions, not to support operational decision-making for other line ministries. There are strong institutional motives to control what budget and execution data are visible to other stakeholders, as information can shift bargaining power during key negotiations, such as annual budgeting cycles. Performance gaps, like budget execution delays, may erode perceptions of credibility, further restricting the desire for full system transparency. While MoF officials are driven by valid priorities concerning fiscal discipline and the proper management of public resources, excessive gatekeeping can hinder supply chain operators who require current information for day-to-day decisions. Often vital data on cashflows, payment tracking, and outstanding debt remain hidden, which masks upstream financial causes of stock-outs and product shortages.

Programme managers protect vertical territory

Within Ministries of Health, disease programme managers (for HIV, malaria, TB, immunisation) have historically controlled their own health product pipelines, quantification processes, and reporting relationships with international donors. Integration of SC data across programmes threatens this autonomy. A programme manager whose health products are quantified and tracked through a unified national process has less control over procurement decisions and less direct reporting to the donor that funds their programme.

Decentralisation compounds the problem

In countries that have decentralised health management, the responsibility for financing and procuring health products is splintered among entities at national, regional, and district levels with very different capabilities. A political economy analysis of subnational health management in Kenya, Malawi, and Uganda found that shifting power dynamics within the health system led to unclear roles and responsibilities amid a growing number of actors, with development partners wielding outsized influence and underfunded plans weakening accountability structures (Rodríguez et al., 2023).

Commercial dynamics and technical debt

The commercial and contractual relationships through which digital systems are built and maintained create their own fragmentation dynamics.

Proprietary systems resist interoperability

"Vendor lock-in" occurs when a system becomes so dependent on a specific vendor's technology that switching becomes prohibitively expensive. Across health systems, vendor lock is pervasive and can result in large inefficiencies and substandard performance. Commercial products use proprietary data models and aren't configured to easily connect to other platforms (commercial, open-source, or other). There is little financial incentive to do so. Large ERP platforms (SAP, Oracle, etc.) would prefer to activate modules (for additional costs) that meet the client's complete set of requirements, rather than support integration into existing digital ecosystems to achieve holistic functionality.

Vendor lock isn't relegated to commercial software models. Examples abound of open-source software that fails to use open standards, effectively ratcheting up the cost and complexity of transitioning existing data and features to a different product.

Technical partners aren't incentivised for sustainability

Building and configuring digital health systems in LMICs is often executed by implementing partners (private sector or not-for-profit) operating under time-bound contracts. These contracts, regardless of funding source, tend to focus on the vision of a particular programme vertical or government department, without substantive co-design or direction from those most likely to ensure long-term system operation (e.g., digital transformation, ICT, or planning teams). While technical partners are frequently tasked to develop "sustainable" products, they are rewarded and encouraged by shorter-term progress milestones that satisfy the immediate circle of stakeholders and minimise dependencies across the system. Often when projects conclude, governments are left with poorly documented products and no legitimate financial vehicle or technical staff to operate them.

Semantic fragmentation and legacy systems accumulate technical debt

The proliferation of custom, non-standardised systems creates compounding problems over time. Without common metadata (e.g., health terminology, facility and product codes) the corpus of data that must be rationalised grows indefinitely, rendering more "noise" and less "signal." Rarely are legacy data systems properly phased out; rather, they persist in sub-standard or degraded quality or scale, staying afloat on razor thin budgets. These systems might contain invaluable data or perform a truly necessary function, yet the technology and software model are dated and resources unavailable to upgrade or fix bugs. There are financial, political, and human resource implications to

maintaining sub-standard systems, yet the result is always an accumulation of technical debt that tanks value.

Data sovereignty

As countries begin to assert greater control over their health data, unresolved questions about data ownership, access rights, and governance authority create additional barriers to integration. The current sovereignty discussions are grounded in an equity and rights-based framework. While politically essential, this framing isn't sufficiently specific to solve the technical and operational challenges that can protect sovereignty while maximising information utility for public health objectives. For example, sovereignty concerns are frequently invoked in the context of infrastructure. Should LMICs host data locally or remotely, on government or private party equipment? Answers may not be obvious and are tied up with many other competing interests and development goals. These discussions are further complicated by (mis)perceptions about technological capabilities, vulnerabilities, privacy, and security. The result is often a stalemate on policy, or unrealistic policies, that require unnecessary (and insecure) workarounds (e.g., government employees sharing data over personal email).

Questions of appropriate access and use are front and centre. Under the US "America First Global Health Strategy", 33 countries have signed five-year bilateral MOUs (as of July 2026) tying continued US health aid to co-financing and strict data-sharing provisions. In some cases, these included sharing pathogen specimens and genetic sequence data for 25 years and granting US access to country health databases (US Department of State, 2025). These agreements rightly raised concerns around ownership, hosting, cross-border access and reuse of health data. Resistance emerged, with Botswana, Zambia and Zimbabwe initially rejecting deals citing data sharing terms, and a legal challenge in Kenya prompting MOU revisions to comply with domestic data protection law (Hirschfeld et al., 2026; Rigby et al., 2026). This process has exposed the geopolitical tension inherent in donor-supported health data systems, forcing LMIC governments to address who controls their integrated datasets, systems selection choices, and under what legal jurisdiction.

Absence of countervailing incentives

Perhaps the most important observation is not that disincentives exist, but that the global health architecture has done very little to counteract them. Integration requires active incentive design and evidence exists on what tends to work. For example, a parallel review of nine health supply chain integration efforts across Africa and Asia found that governance, not technology, was the determinant of whether investments produce lasting system performance gains or remained isolated pilots (Supply Chain Funders' Forum & Integration Taskforce, 2026).

Lack of financial incentives

No GHIs or donors routinely condition financing on demonstrated interoperability between the data systems. Grant proposals may include interoperability as a strategic objective, but disbursement is not tied to successful data exchange. A country can receive funding for an eLMIS and funding for an IFMIS from different sources and deploy both "successfully" within their respective domains without the two systems ever exchanging a data point.

Unclear accountability and performance appraisal for integration outcomes

Within countries, it's not always clear what actors are responsible for ensuring data are exchanged. As described, SC finance information lives between line ministries, parastatal actors, implementers, donors, and the private sector. Increasingly, ICT or digital health divisions within the MoH are charged with health data interoperability, yet they are not in an organisational position to account for the connection that falls under the purview of other line ministries or departments. Cabinet-level government entities can be charged with providing foundational infrastructure, policy, and tools to serve sector needs, but these bodies are newly established and often underfunded. It wouldn't be realistic for them to be accountable for successful data exchange when they have no agency over either end of the connections. The result of this accountability gap is that no one is responsible for successful information exchange.

No consequences for fragmentation

When SC and financial data remain siloed and the resulting inefficiency produces stockouts, delayed procurement, or misallocated budgets, the causal chain is too long and diffuse to assign responsibility. The burden is ultimately borne by patients or facility administrators, who have little or no agency over the data ecosystem. The absence of identifiable, attributable consequences for fragmentation means there is no negative feedback loop to correct the problem. In effect, health product availability becomes disconnected from the actors making financing, budgeting, and supply chain decisions.

Aligning systems with use cases

The current data ecosystems are not meeting the needs of users or HSCF goals. A more thoughtful approach to digital development and governance is required that can effectively elucidate organisational and sector needs to steer improvements.

Designing digital systems with the user in mind is not a new concept. The term "use case" was coined by Swedish computer scientist Ivar Jacobson in 1987 as a way to specify functional software requirements. The core idea was that developers should specify what a system ***does*** for its users,

rather than what a system ***is*** (Jacobson, 1987). In health and development programmes, invocations of "use cases" are increasingly frequent, but typically **loosely defined and insufficiently specific**.

User-oriented development has been more conscientiously incorporated into health provider-facing tools (e.g., community health worker apps, electronic health records) as they tend to mimic clinical processes or job aids. But more upstream systems (like those related to enterprise planning and monitoring) are often designed based on available or desired data sets, not user actions or decision points. Use cases should be understood as effective mechanisms for alignment across diverse actors and goals.

Applying use cases to supply chain financing in LMICs

We argue that a more rigorous, use-case-based approach to information investments is most likely to break through political and technical silos, foster accountability, and improve decision making.

Best practice, derived from the literature and the authors' experience, is to adopt a systematic process[4] that accomplishes six clear goals:

1. **Convenes** all necessary stakeholders for comprehensive and concurrent input
2. **Develops consensus** on the specific performance outcomes the health system needs to achieve, along with the system failure points, root causes, and information gaps and asymmetries blocking progress
3. **Articulates use cases** in a standard format for the current state, and a more ideal, future state, anchored to the intended outcome
4. **Prioritises use cases** based on expected benefit, feasibility, and return on investment
5. **Identifies common features**, datasets, and processes across prioritised use cases
6. **Translates use case requirements** into technical systems development specification, protocols and guidelines, policies, and appraisal criteria, tied to the outcome each use case is meant to deliver

The format for use case documentation is most essential. Stakeholders should identify a specific actor (individual or group), trying to accomplish a specific task (decision or action), at a specific point in time (planning/operational cycle or externally triggered). Defining the problem in this structure—**[specific role] must [specific task] at [specific time] to [specific goal]**—forces precision about who the system serves and what value it delivers. It also makes the conversation accessible to health system actors who are not digital specialists. A district pharmacist can see themselves much more clearly in a use case diagram than in technical system specifications.

4 This logic mirrors a segmentation principle drawn from a broader review of health supply chain integration efforts: scaling rarely succeeds through system-wide reform, but consistently follows proof of concept in a single, bounded segment (Supply Chain Funders' Forum & Integration Taskforce, 2026).

Use cases should be grounded in lived experience (and context messiness), yet strive to break down goals into more manageable, requisite parts. Further, use cases should articulate a *current state*, which reflects users' experiences and the existing data ecosystem, and a *future state*, a hypothetical description of the user journey with targeted technological solutions and process improvements.

Incremental systems investments should be driven by prioritised use cases. A bounded, well-addressed use case can demonstrate measurable results quickly enough to build the evidence and stakeholder confidence needed to justify expanding to the next use case or segment. Further, operationalising one use case often institutionalises the architecture and processes necessary to meet the needs of other use cases. The risk of rolling out systems for every user need is that very few are holistically met.

Illustrative use cases

Based on our evidence synthesis and key informant interviews, we present four use cases that articulate supply chain financing challenges often faced by stakeholders in LMICs. These use cases are complex and involve multiple actors, institutions, data systems, and concurrent workflows. Collectively, they demonstrate how siloed information leads to inaccurate resource mobilisation, increased financial risk, and sub-optimal resource allocation. Each scenario names the insights it depends on from the middle layer of Figure 2, tying the narratives back to the seven integrations that require multi-source data synthesis.

For each high-level use case, we offer

- a description of the current state,
- consequences of current state,
- a potential future state,
- what currently blocks the future state,
- incremental steps to enable the future state,
- and one or more operational use cases, each summarized in the standard format described above.

The four use cases follow the phases in Figure 2, with two related to planning, one to sourcing and procurement, and one to delivery (Table 1). Together, they draw on all seven integration insights. They are not independent, and so failures in one feed the others. For example, reimbursement tariffs set below procurement costs (Use Case 2) drain the facility revenue that funds resupply (Use Case 3). This can cause rationing at facilities (Use Case 3), which is recorded as low consumption and lowers the following year's quantification (Use Case 1).

TABLE 1. Summary of illustrative use cases

Use Case	Phase and Archetype	Primary Actors	Integration Insights (Figure 2)	Main Blocker	Recommendations
1. Allocating resources for health products to meet needs	Planning; direct, budget-funded procurement through a CMS	MoH pharmaceutical services; MoH planning director; MoF budget analysts	Population health product need; health product prices; available supply & inventory; resource envelope	Stock, donor and arrears data are held by separate institutions; no quantification method agreed with the MoF	1, 2, 6
2. Setting accurate reimbursement rates and prices	Planning; indirect procurement through insurance reimbursement	MoH tariff-setting and actuarial teams	Health product prices; service utilisation & claims	CMS prices and claims data are not shared or harmonised; open-market prices not recorded	2, 3, 6
3. Translating allocated resources into reliable and consistent supply	Sourcing and procurement; facility-based procurement with multiple revenue streams	Facility administrator and pharmacist; insurer claims team	Available currency & liquidity; service utilisation & claims; available supply & inventory; health product prices	Payment queues and central stock levels are invisible to facilities	2, 3, 4
4. Demonstrating last-mile performance and accountability	Delivery; direct distribution from a CMS to facilities	CMS managing director; CMS quality assurance lead	Available supply & inventory; health product consumption; resource envelope	Order, dispatch and dispensing systems use different codes; facility records are inaccessible to the CMS	1, 3, 6

Use Case 1: Allocating resources for health products to meet needs

"How much do we need, what can we afford, and how do we prioritise?"

Archetype: Direct/budget-funded procurement through a central medical store

Integration insights required (Figure 2): population health product need, health product prices, available supply & inventory, and resource envelope

Each fiscal year, the Ministry of Health (MoH) must determine how many essential medicines the country needs, estimate what they will cost, secure funding from the Treasury, and divide that funding across districts. The process spans months and involves dozens of actors across government and external partners. The data are stored in multiple information systems that are not connected. At each step, decisions are made on partial information and consequences compound downstream.

Current State:

Estimating health product need. To develop the drug budget request to Treasury, the MoH pharmaceutical services team convenes an annual quantification exercise, including a pharmacist or SC officer from the central medical store (CMS), an epidemiologist from the MoH, programme officers for each health product category, and a donor-funded technical adviser who manages the quantification software. This group needs, at minimum, four primary categories of information for each district:

1. Population estimates
2. Disease burden and epidemiological trends
3. Consumption of each medicine in prior cycles
4. Available supply and inventory

Data reside in multiple systems or static sources and vary in level of detail and quality. For example, population figures come from the national statistics office, but are several years out of date. Mathematical, epidemiological models exist for some diseases, but not others. Patterns in care access, diagnosis, and treatment are recorded in separate health information systems (e.g., client-level health record systems and population-level HMIS). True consumption data are not yet available due to gaps in digital dispensation records, so sub-optimal proxies are used from the national logistics system (eLMIS).

These data must be manually pulled from each source and are not easily matched. While the country has a master health facility registry, not every digital system is synced with the latest version. Similarly, a master product code list exists, but must be updated frequently and changes do not propagate through to all systems. As a result, data exports from each system are meaningfully different and must be reconciled in spreadsheets each time they are compiled.

Further, the exercise covers only domestically funded essential medicines. Donor-funded products for HIV, TB, malaria, vaccines, and family planning are quantified through parallel processes and run by separate programmes, with different timelines and tools. The quantification team has limited visibility into what these programmes plan to supply and actually purchase, even though the products end up in the same facilities, serving the same patients.

Despite these challenges, the quantification team works to develop estimates grounded in data they are able to locate. The plan must then be calibrated with what supply already exists within the system. This includes medicines in transit from suppliers and inventory at central, regional, and facility level. This information also exists across fragmented SC systems and does not capture sufficient detail to assess the state of the inventory. The team makes marginal adjustments where inventory data are visible.

Costing. The quantified health products must now be priced. The CMS procurement officer holds contract prices in the store's management system, but only for its own purchases. There is not a national mechanism tracking what medicines actually cost across all channels, so the procurement officer has little information available.

The largest blind spot lies in the donated health products. Some donor-supplied products arrive at the central warehouse without any cost to the government. The only financial record of their existence is an annual resource mapping exercise, which is based on donor budget projections rather than actual expenditures. This complicates costing in several ways, including the ability to project and budget for carrying and logistics costs. Consequently, the planning team cannot produce reliable figures that show what the domestic budget covers, what donors have committed, and where gaps remain.

Currency fluctuations also threaten the plan integrity. In the past several years the domestic currency has weakened, and a price estimate made in October may be 20% too low by the time funds are released in March. Exchange rate risk is acknowledged in planning discussions, but is not effectively incorporated into the projections.

Defending the budget request. The MoH planning director receives the costed quantification and submits it to the Ministry of Finance (MoF). The request is routinely about double what will end up being appropriated, a pattern that has persisted for years. MoF budget analysts respond with a lump-sum allocation based on the prior year budget, adjusted at the margins. The quantification, for all its rigour, has little bearing on the final envelope.

The planning team struggles to make the case for more. Doing so would require strong evidence for total need, total available inventory, total gap, and population impacts if medicines are not provided. While empirical data exist to feed and enhance these estimates, they are dispersed throughout paper and electronic systems and have yet to be assembled into a cohesive analytical pipeline.

Outstanding debts pose another challenge. Currently, the CMS is owed several million USD by the Treasury. Creditor days approach a year, and some suppliers are withholding shipments to CMS. But these debts do not appear in the budget request as prior obligations. The system treats each year's appropriation as fresh money, even though a large share will clear arrears before any new medicines are procured.

Allocation to districts. The appropriated budget, however insufficient, must be divided across districts. The MoH planning department, working with the Ministry of Local Government, applies a formula based on population denominators and disease burden.

The formula is calculated in a spreadsheet and does not account for available supply and inventory. A district sitting on four months of stock and one running on empty shelves may receive the same per-capita allocation.

There is also no mechanism to adjust mid-year. When a district approaches its ceiling, the district health officer may cap orders from health centres, rationing supply to stay within budget. The logistics system records this as lower consumption than expected. That figure may feed into next year's quantification as reduced demand, producing a feedback loop where a lower budget request results in a lower allocation.

Consequences of Current State:

Several key consequences emerge from this vignette:

- lack of data standards and fragmentation slows the process; intensive effort is required to harmonise needed data
- insufficient detail and/or data quality constrain the insights health teams need to mobilise sufficient domestic resources and equitably allocate resources sub-nationally
- budget inertia and actor coping mechanisms work together to calcify and perpetuate system biases.

Ultimately, information fragmentation results in fewer resources for the supply chain overall, misaligned allocation, and preventable pharmaceutical access gaps.

Future State:

The MoH pharmaceutical services team convenes the annual quantification exercise with the same team. This time, however, the data they need are already assembled. A SC planning dashboard displays consolidated consumption data alongside morbidity trends and population denominators, updated quarterly. The team reviews the data and begins analysis on day one.

The dashboard also shows what donor programmes have committed to supply, valued in financial terms and broken down by product and district. The planning team can see total anticipated supply against total estimated need in a single view. The costed gap between them is calculated automatically. When the MoH planning director submits the budget request, the MoF analyst reviewing it can see the same numbers. The negotiation shifts from a lump-sum ask against last year's baseline to a documented gap with quantified consequences at different funding levels.

The allocation formula for districts now accounts for what is already on shelves and in transit. A district with adequate stock receives less, while one facing shortages receives more. Mid-year adjustments are possible as consumption patterns diverge from projections. When a district health officer caps orders to stay within budget, the system flags the divergence between reported consumption and expected demand, prompting a review rather than silently feeding a lower figure into next year's estimates.

Fewer patients are turned away from facilities due to avoidable stockouts. Domestic resources remain insufficient, but they are distributed more equitably, and the case for additional funding is grounded in evidence both sides can verify.

What Blocks the Future State:

The data needed for this future state largely exist; the obstacles are institutional. Donor programmes report commitments to their own boards, in their own formats, and have little incentive to share with the MoH in an interoperable format. The CMS may be reluctant to publicise its arrears. No institution is accountable for combining data from different sources, so it is rebuilt by hand every year. Therefore, the future state depends as much on governance as it does on technology This requires an institution accountable for keeping the product catalogue and facility registry synchronised (see Recommendation 1); data exchange requirements in donor agreements and in MoH–MoF budget guidance, including agreement in advance on the quantification method and output format (Recommendation 2); and routine triangulation of the data that are already available (Recommendation 6).

Incremental Improvements:

Stepwise measures that begin to unlock the future state, ordered roughly from low to high digital maturity:

1. Record **arrears as prior obligations** in the budget request so the appropriation debate starts from net, rather than gross, resources.
2. Extend the **allocation formula with stock on hand** and in transit (extracted from SC data systems).
3. Adopt a **national product catalogue** and **master facility registry** as mandatory references for relevant data systems. Require systems stewards to align, interoperate, or crosswalk all relevant data to these national standards.
4. Develop a **data dictionary and information repository** that describes and houses all data elements required for best-practice quantification, costing, and allocation exercises. The data dictionary should be explicit about all required dimensions of the required data, from where data must be extracted, and known gaps, duplication, or other limitations.
5. Develop **standard protocols for data joining, cleaning, analysis, and record keeping**. These protocols should be a "how-to" guide for all required data manipulation, target analytical outputs, documentation, methodological options and choices, and bias and error identification. Exhaustive documentation of exercises provides context on inputs, assumptions, and decisions to inform future cycles and identify where incremental improvements would unlock further intelligence (such as the ability to map expenditure to disease programme).

6. Develop **analytical pipelines** to automate data aggregation, cleaning, analysis, and visualisation. These pipelines should leverage public enterprise architecture (e.g., a transactional interoperability management service) to routinely extract data from systems and populate the information repository. Required management and manipulation described in the standard protocols can be programmed to run routinely, providing updated analytical outputs and visuals when new data become available.

Operational use cases

Use Case 1a: Quantify national health product need

Use case statement: *The quantification lead in MoH pharmaceutical services must assemble a defensible estimate of national health product need, calibrated against stock already in the system and donor-committed supply, during the annual quantification exercise, to ensure the budget request reflects actual need.*

1a

WHO (ACTOR)
The quantification lead in MoH pharmaceutical services

WHAT (DECISION/ACTION)
Assemble a defensible estimate of national health product need, calibrated against stock already in the system and donor-committed supply

WHEN (TRIGGER)
The annual quantification exercise, ahead of the domestic budget request

HOW (INFORMATION CONSULTED)
Population denominators (statistics office), disease trajectories (universities/partner models), morbidity (HMIS), consumption proxies (eLMIS), stock on hand and in transit (warehouse systems), donor commitments (resource-mapping spreadsheets)

WHY (IMPORTANCE)
A strong, evidential quantification plan can mobilise additional resources and reach more clients with essential medicines (compared to prior cycles). A poorly constructed plan may result in a lower budget allocation and compound negative, downstream outcomes (e.g., waste, expiry, stockouts, and population health).

CURRENT STATE	FUTURE STATE
Data are assembled through manual reconciliation across unlinked systems over several weeks. Donor-funded health products are quantified in parallel; costs are obscured.	A business intelligence layer automatically consolidates consumption, morbidity, population, stock, and donor commitments using shared data standards, cleans and analyses the data, and populates decision-oriented visualisations in web-based access points.

F1 Revenue Raising and Pooling | F2 Prioritising | F3 Budgeting | F10 Monitoring

Use Case 1b: Defend the health product budget request

Use case statement: *The MoH planning director must defend the costed gap between quantified need and committed resources during the budget submission cycle to maximise the likelihood of accurate budgets.*

1b

WHO (ACTOR)
The MoH planning director

WHAT (DECISION/ACTION)
Defend the costed gap between quantified need and committed resources in negotiation with MoF

WHEN (TRIGGER)
The budget submission cycle

HOW (INFORMATION CONSULTED)
Total quantified need (quantification exercise), donor commitments in cash and in kind (resource mapping), stock in transit (warehouse systems), prior-year arrears (CMS accounts), execution against the current envelope (IFMIS)

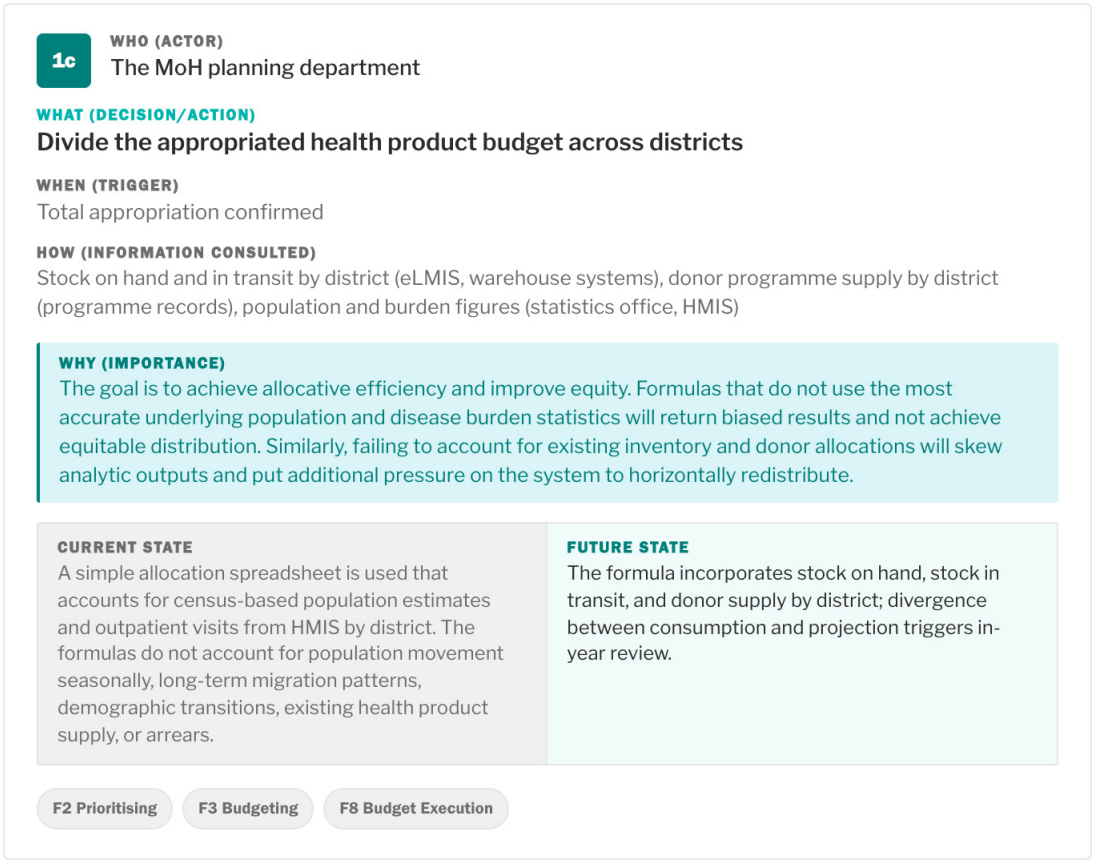
WHY (IMPORTANCE)
A well-evidenced defence can quantify health system and population consequences at different funding levels. Absence of a robust defence increases the likelihood of budget inertia or missed opportunities for increasing fiscal space.

CURRENT STATE	FUTURE STATE
The request is defended without credible evidence for need, commitments, stock, arrears, or programme consequences.	Analytic pipelines are available to quantify downstream outcomes that may result from budget shortfalls. Multiple scenario analyses can be run for various funding thresholds and assumptions. Outcomes may include expected health product shortfalls (across regions, populations, and diseases), out-of-pocket payments for essential medicines, excess morbidity and economic impact (e.g., wage loss).

F1 Revenue Raising and Pooling | F2 Prioritising | F3 Budgeting | F10 Monitoring

Use Case 1c: Allocate the appropriation across districts

Use case statement: *The MoH planning department must divide the appropriated health product budget across districts once the appropriation is confirmed, to allocate resources according to need, existing stock and donor supply.*



Use Case 2: Setting accurate reimbursement rates and prices

"Are prices and reimbursement grounded in reality?"

Archetype: Indirect procurement through insurance reimbursement and strategic purchasing

Integration insights required (Figure 2): health product prices and service utilisation & claims

In countries with national health insurance, the insurer publishes a price list detailing how much will be paid back to facilities for medicines prescribed. If the list pays less than medicines actually cost to buy, facilities lose money on prescriptions filled, further straining insufficient budgets. Setting these prices well requires data on actual costs to facilities for procuring each medicine, which may vary considerably by supplier, by facility type, and by region.

Current State:

Undertaking a tariff review. The MoH initiates a periodic review of pharmaceutical reimbursement rates, sometimes on a fixed annual cycle, sometimes triggered by complaints from health facilities that the current rates no longer cover their costs. The tariff-setting team, a small unit of health economists, pharmacists, and data analysts, must determine the actual cost a health facility incurs to procure each medicine on the formulary.

The team starts by requesting the central medical store's current contract prices. The store's procurement officer extracts a price list from the enterprise system and sends it by email as a static spreadsheet, reflecting prices at the time of the last tender, which may have been negotiated a year or more earlier. The tariff team has no way to query the store's system directly or to track contract price movements over time.

The team also needs to know open-market prices, since facilities must turn to private sector providers when CMS is not able to fill orders completely. Those transactions are recorded in facility-level ledgers that are neither digitised nor aggregated. Ideally, the team would survey a sample of facilities across regions and levels of care to estimate open-market costs, but there is neither the budget nor adequate staff for a survey of this depth. Further, the team must calculate the cumulative markup between manufacturer and patient as health products pass through a central store, a regional warehouse, a distributor, and a facility pharmacy. These costs have never been empirically quantified, only estimated.

Variance must also be considered. Costs incurred by facilities will vary based on location, size, scope, and infrastructure; however, the tariff is not differentiated. A rural health centre procuring from a distant private supplier faces fundamentally different economics than an urban referral hospital drawing from the central store. Whether the tariff systematically underfunds some providers and overfunds others is unknown, as the data inputs and methods required for a variance analysis have not been elaborated.

The team supplements its patchy data with published international reference prices, ad hoc consultations with the MoH pharmaceutical services directorate and some facility managers, and figures from the previous review.

Setting and publishing the rates. Based on this incomplete picture, the tariff team must decide which product rates to adjust, by how much, and whether to introduce any differentiation by facility type or region. These are consequential decisions. The tariff functions as a de facto price-setting mechanism for the entire pharmaceutical market.

The new rates are published and, within months, the assumptions underpinning them begin to erode. The local currency has weakened, reducing purchasing power for staples like fuel. This has knock-on effects to the price of transport and logistics and drives health product prices up. The tariff team is aware of this problem, but does not have real-time data on actual purchases and struggles to estimate the impacts, idiosyncratic or system-wide.

Facility administrators report that reimbursement no longer covers procurement costs. A wholesale distributor stops supplying against the framework contract because the tariff-derived margins no longer cover its own costs. The government must resort to more expensive logistics arrangements. These problems arise as political grievances, from professional associations, district health teams, and Parliament.

Reform raises the stakes. The government begins designing a capitation payment model that bundles medicines into prospective facility payments. The actuarial team is asked to estimate the cost of medicines a facility will need to dispense during each payment period, segmented by facility type, catchment population, and disease burden. This is a more granular, and higher stakes, version of the prior tariff review. Underestimation means facilities will ration medicines or shift costs to patients, while overestimation results in overpayment to some facilities, while others face shortfalls.

The capitation rate's accuracy depends on two signals: expected demand and expected cost. Both should be grounded in empirical data and account for population and ecological trends. For example, demand could be estimated using prior claims data covering consumption by patient, facility, and condition. The tariff team knows this single source might ignore relevant, contextual information, such as trends in demographics and seasonal migration, but a more sophisticated analysis requires more time and data not readily at hand.

For costs, the team must estimate both the cost of product and distribution. Historical data does exist, but access is difficult. The insurance authority has drug-level claims data and the central store has procurement cost data, yet these are not harmonised by product or facility. Further, the cost for procuring on the open market is largely unknown.

Due to time and budget pressure, executive decisions are made and the capitation rates set, without a full understanding of how rates will affect certain facilities or the system as a whole.

Consequences of Current State:

Several consequences emerge from this vignette:

- Prices set on old or partial cost data may put strain on facilities and the pharmaceutical market.
- Once margins turn negative, facilities must ration medicines or pass costs to patients.
- Late payment and emergency deliveries add premiums that the tariff does not reflect, compounding the effects.

Ultimately, the gap between tariffs and costs reduces facilities' ability to procure, resulting in stockouts.

Future State:

The tariff team begins the same review. This time, current contract prices are already available and updated at each tender renegotiation. Historical price trends show cost movements over the past three years. Aggregated procurement data from a growing number of facilities show actual medicine costs across different settings.

The team finds central store fill rates differ significantly across areas, and that areas with low central store fill rates — for example, remote areas with infrequent distribution cycles — are forced to rely heavily on the open market, resulting in much higher procurement expenses. Therefore, the team modifies rates for selected high-volume health products, tailoring them by facility type. The updated tariff accommodates these regional variations by providing an elevated rate for facilities in districts where open-market procurement is prevalent, ensuring that reimbursements more accurately mirror their real operational costs.

Between scheduled reviews, a quarterly report flags products with the fastest-widening gap between tariff and procurement cost. The team initiates early adjustments for those products rather than waiting for the full cycle.

The capitation design proceeds on firmer ground. The actuarial team estimates facility-level medicine costs using consumption data alongside procurement costs. Capitation rates are calibrated to actual conditions rather than approximated from averages, and stress-tested against currency and supply disruption scenarios before implementation.

Fewer facilities absorb losses on dispensed medicines and fewer patients are directed to private pharmacies.

What Blocks the Future State:

Even where data is available, the tariff team cannot access it. The central store holds its contract prices, and the insurer holds its claims, but neither is obliged to share with the other in a comparable format. Open-market purchase prices are recorded only in facility ledgers. A standing data exchange agreement between the insurer and the central store (Recommendation 2), documented interfaces to both systems (Recommendation 3), and a routinely updated health product price index (Recommendation 6) would narrow the room for tariffs to diverge from real procurement prices.

Incremental Improvements:

Stepwise measures that begin to unlock the future state, ordered roughly from low to high digital maturity:

1. Establish a standing data-sharing agreement for the central store to send contract **price updates to the tariff team** at each tender renegotiation. Updates should carry effective dates, product identifiers aligned to the national catalogue, and landed-cost components so figures remain comparable across tenders.
2. Compile a **health product price repository**, beginning with contract prices and adding sampled open-market prices by facility type and region. Sampling can start with a modest facility panel, and ledger pages can be photographed and transcribed where records are paper.
3. Use the insurer's current analytics division to **generate quarterly reports on tariff relevance** using existing claims data. The claims warehouse should contain sufficient data to monitor some key trends. Potential indicators include shifting expenditure patterns across the benefit package and a downward trend in product dispensing despite consistent diagnosis rates.
4. Formalise a **data exchange and governance agreement between the insurance authority and the central store**, anchored on the national product catalogue and master facility registry. The agreement should specify the metadata exchanged, frequency, and custodianship, and should precede any platform investment.
5. Develop **analytical pipelines** that link claims-derived demand with SC cost data through the national interoperability layer. Outputs should include quarterly tariff-gap flags for early adjustment and capitation model inputs that update as tenders close and claims accumulate, with scenario testing against currency and supply disruption assumptions.

Operational use cases

Use Case 2a: Set accurate reimbursement tariffs

Use case statement: *The insurer's tariff-setting team must set or adjust pharmaceutical reimbursement rates at each review cycle, to keep tariffs in line with what facilities actually pay.*

2a

WHO (ACTOR)
The insurer's tariff-setting team

WHAT (DECISION/ACTION)
Set or adjust pharmaceutical reimbursement rates, including differentiation when appropriate

WHEN (TRIGGER)
Periodic review cycle

HOW (INFORMATION CONSULTED)
Current and historical contract prices (CMS enterprise system), open-market costs by facility type and region (facility ledgers, surveys), dispensing patterns (claims platform), exchange rate and import cost movements (central bank, customs)

WHY (IMPORTANCE)
The tariff functions as the price-setting reference for the pharmaceutical market. Rates grounded in current procurement costs reduce strain on health facilities, incentivise distributors, and make trade-offs more explicit. Rates set too low compress facility margins and shift costs to patients.

CURRENT STATE	FUTURE STATE
Rates are set from a static contract price list, international reference prices, and the previous review's figures. Open-market premiums and cumulative markups are unmeasured, and no routine analysis links reimbursement rates to procurement costs.	An analytic pipeline joins contract price history, sampled open-market prices by facility type and region, and claims-derived dispensing patterns. Scheduled reviews start from current data, quarterly flags identify products with the fastest-widening tariff gaps, and differentiated rates can be tested against segmentation evidence before adoption.

F4 Market Shaping and Regulation | F6 Purchasing of Services | F10 Monitoring

Use Case 3: Translating allocated resources into reliable and consistent supply

"Can facilities translate allocated resources into availability?"

Archetype: Indirect/facility-based procurement with multiple revenue streams and procurement pathways

Integration insights required (Figure 2): available currency & liquidity, service utilisation & claims, available supply & inventory, and health product prices

A health facility's ability to keep essential medicines on the shelves depends on cash flow. Revenue arrives through several channels: budget allocation drawn down through the central medical store,

insurance reimbursements for medicines dispensed to enrolled patients, and user fees collected at the point of care. A delay in any one channel can shock the facility's revolving drug fund. Delays across several channels may collapse the fund, resulting in emergency measures or unavailability of stock.

Current State:

Preparing the facility reorder. At the end of the month, the facility pharmacist reviews stock levels against consumption patterns and prepares a resupply order. Current stock on hand and quantities dispensed since the last order are entered into the national logistics system (eLMIS), which generates a calculated reorder quantity for each product. Before the order can go forward, the facility administrator must check available and incoming funds to determine how much they can afford.

The administrator has to review and reconcile four different sources to get a complete picture of liquidity at any point in time:

1. a bank statement showing cash on hand
2. the insurance claims platform showing submitted, but unpaid, reimbursements
3. a tally of deliveries from the central store against the budget allocation
4. the facility cashbook recording user fee collections

The fund cannot cover the full need, and the pharmacist is asked to make cuts before the order proceeds.

Navigating the claims queue. A significant share of the revolving fund's expected revenue comes from insurance claims. The facility's claims officer submitted last month's batch to the national health insurance authority three weeks ago. Each claim documented the patient encounter, diagnosis, services rendered, and medicines dispensed. The authority's claims processing team is adjudicating the submissions, checking for completeness, coding accuracy, and benefit package compliance. Several claims have been rejected and returned for correction. The rest have been approved and entered in a payment queue.

The administrator cannot see the position of the facility's approved claims in this queue. The platform shows submissions and rejections, but not the timing or amount of eventual payment after deductions. A reimbursement cycle, designed to run 30 to 60 days, has stretched to five months. The administrator pencils in the hoped-for amount but cannot count on it.

Meanwhile, government subsidies to the insurance scheme arrived late from Treasury last quarter, so the insurer is managing a constrained pool and prioritising among thousands of facility claims.

Receiving reduced orders. The district pharmacist consolidates the facility's order with others and submits it to the central medical store. However, the store is experiencing its own liquidity crisis. The facility ordered 47 line items, yet the delivery truck arrives with 26. The facility pharmacist

checks the consignment against the order, updates the stock cards, and reports the shortfall to the administrator.

Buying on the open market. With the central store unable to fill nearly half the order and five months of insurance revenue still outstanding, the administrator must decide whether to purchase the missing items from a private supplier. A pharmaceutical distributor in the nearest town can supply most of the missing items, though at prices roughly double the central store contract rate and only on 30-day credit.

The administrator weighs which gaps are critical enough to fill at these prices. Oxytocin for the maternity ward and oral rehydration salts for the paediatric unit make the cut, while second-line antibiotics do not.

Rationing at the shelf. With the revolving fund depleted and the resupply incomplete, the pharmacist manages a shrinking stock through a form of triage that is not formally documented. For example, smaller courses of antibiotics are dispensed than the treatment protocols specify, cheaper alternatives are substituted for clinician prescriptions, and some patients are told to purchase their scripts out of pocket from a private pharmacy nearby.

The logistics and warehousing systems are not designed to capture this level of nuance. Reduced orders and reduced consumption may carry forward in the quantitative estimates used to determine health product need in future cycles (see Use Case 1, Estimating health product need, and Use Case 1a).

Consequences of Current State:

Several consequences emerge from this typical vignette:

- opaque payment queues prevent facilities from planning cash flow, so procurement commitments are made without confidence in executability
- payment delays inflate costs all along the chain, including the premiums facilities pay for open-market purchases and the lost purchasing power from currency depreciation between claim submission and payment
- undocumented rationing becomes a false demand signal that feeds future planning cycles

Ultimately, the system spends more for each medicine delivered, patients must pay out of pocket for products meant to be covered by insurance, and facility and district health staff spend inordinate amounts of time sifting through information across data systems to answer simple questions.

Future State:

The facility pharmacist prepares the monthly reorder as before. This time, the facility administrator already knows the spending envelope. A financial dashboard shows the current bank balance, the position of outstanding insurance claims in the payment queue with expected clearance dates,

deliveries received against the district allocation, and user fee collections. The administrator can project cash flow for the coming month with confidence.

Before submitting the order, the pharmacist can see which products are currently out of stock at the central warehouse. Three of the 47 items on the order are flagged as unavailable. The administrator sources these from a private supplier now, while cash is available, rather than discovering the gap on delivery day. The purchase is made at a known price, within the credit window.

The central store, still short of working capital, fills the remaining 44 items at roughly 80% of quantities requested. The pharmacist still rations for some products, but fewer patients are told to buy medicines out of pocket. The substitutions and shortened courses that previously went unrecorded are now visible in the data, distinguishable from genuinely low demand.

What Blocks the Future State:

Facility administrators sit at the end of several payment chains (central allocations from the treasury, via the central store, and reimbursements from the insurer) but cannot see the details of them. The insurer has little incentive to publish the state of its payment queue, because doing so exposes its own liquidity problems. The administrator also cannot see stock levels in the central stores. Making this information visible does not require much new money, but it does require a mandate: payment-status reporting written into insurer and central store operating agreements (Recommendation 2), claims and stock data exposed through documented interfaces (Recommendation 3), and a recurrent budget for the tracking tools, which could be financed through a small levy on claims processing (Recommendation 4).

Incremental Improvements:

Stepwise measures that begin to unlock the future state, ordered roughly from low to high digital maturity.

1. **Digitise claims adjudication and payment tracking** to improve execution transparency. Myriad tools exist (including open-source and free) that allow for tracking multi-stakeholder workflows. At first, the system does not need to interoperate or automatically exchange data with insurance or financial systems. Rather, the entire workflow should be described, with each step, action, individual, and approval documented. The workflow can then be digitised and users granted access to see where in the process transactions are at any moment in time. If they appear "stuck," users know who to call for updates. Similarly, if delays are expected, users can indicate this in the tracker so other users have context. Further, the metadata from these transactions provides critical information to identify and mitigate bottlenecks.
2. Provide a **simple, read-only view of current stock availability** in central/regional stores for facility and district pharmacists. In lieu of fully digitised ordering, data on essential

medicines and health products could be routinely extracted from supply chain systems and compiled in a repository with a dashboard accessible to those managing orders and resupply. While accuracy and timeliness might be a challenge, having a snapshot of stock availability will improve tactical planning and help avoid unnecessary delays that result from obscured visibility.

3. Standardise a **monthly facility liquidity snapshot** (cash, claims outstanding, deliveries, fee collections) reported to the district through a simple digital form or dataset in the HMIS. Summary data from these reports could help to identify and mitigate bottlenecks, and provide additional support to facilities experiencing a substantial crunch.
4. Adopt a **national product catalogue** and **master facility registry** as mandatory references for all digital systems. Once data are aligned by product and facility, aspects of claims adjudication and facility account reconciliation can be automated.

Operational use cases

Use Case 3a: Commit facility resources for resupply

Use case statement: *The facility administrator managing the revolving drug fund must decide how much of the required resupply the facility can afford at each monthly reorder, to keep essential medicines in stock without exhausting the fund.*

3a

WHO (ACTOR)
The facility administrator managing the revolving drug fund

WHAT (DECISION/ACTION)
Decide how much of the necessary resupply the facility can afford

WHEN (TRIGGER)
The monthly reorder cycle; incomplete deliveries; emergency procurements

HOW (INFORMATION CONSULTED)
Cash on hand (bank statement), claims position and expected payment dates (insurer's claims platform), deliveries received against the district allocation (delivery notes, eLMIS), user fee collections (facility cashbook), open-market pharmacy prices (ad hoc)

WHY (IMPORTANCE)
Maintaining a healthy revolving drug fund is a balancing act. Depleting available cash too quickly can result in poor stock management and unfunded emergency purchases later in the cycle; committing too little leaves essential medicines unstocked and shifts costs to patients.

CURRENT STATE	FUTURE STATE
Liquidity is reconciled on paper from four unconnected sources; commitments are made without confidence in executability.	A financial dashboard shows cash, claims queue position with expected payment dates, deliveries against allocation, and fee collections; cash flow is projected and warehouse stockouts are visible before ordering.

F6 Purchasing of Services | F7 Facility Procurement | F8 Budget Execution

Use Case 4: Demonstrating last-mile performance and accountability

"Do health products reach patients as intended?"

Archetype: Direct/budget-funded distribution from a central medical store to health facilities

Integration insights required (Figure 2): available supply & inventory, health product consumption, and resource envelope

The central medical store's managing director receives an annual budget that covers roughly half of the country's quantified need. The store must stretch that budget across hundreds of products, negotiate with suppliers owed money from previous cycles, and distribute health products to facilities nationwide. The store can document every outbound shipment, but its visibility ends once a shipment arrives at a health facility.

Current State:

A newspaper story triggers an investigation. A national newspaper publishes a story about government-labelled medicines found for sale at a roadside market. A member of Parliament tables a question about health product leakage, citing an audit report showing the store's fill rate dropped below 60%. The MoH Permanent Secretary requests a briefing, and a parliamentary committee schedules a hearing. The managing director must quickly account for everything the store shipped and explain the fill rate's decline.

Assembling and reporting evidence. The logistics and finance teams pull dispatch records for the fiscal year. The warehouse enterprise system holds clean data on every outbound consignment, including product, quantity, batch, destination, date, and signed delivery confirmation from the receiving facility. The store can validate every departure from the warehouse and its destination.

The fill rate question is harder. The eLMIS captures district orders and the enterprise system captures dispatches, but the two systems use different product codes and facility identifiers. The logistics team spends days manually matching records to reconstruct a national fill rate. The picture confirms that in the first quarter the store filled most orders close to fully, but by mid-year budget lines were exhausted and suppliers with unpaid invoices were declining new orders. The fill rate decline tracked alongside the budget depletion.

The managing director presents the dispatch data and fill rate analysis. The committee acknowledges the budget constraint, then asks what percent of health products delivered to facilities are proven to have reached patients.

The store can show that facilities signed for receipt, but the audit trail ends there. Facility-level stock management, dispensing, wastage, and transfers are recorded in registers the CMS cannot access.

The eLMIS tracks aggregate monthly stock figures but does not capture dispensing transactions. The committee cites the newspaper story again. If medicines are appearing in markets, delivery confirmation alone does not constitute accountability.

Reconciling dispatch data with facility records. The quality assurance team is instructed to compare, for a sample of high-value products, the store's shipments against facility reports of receipt, dispensing, and current stock. The officer starts with dispatch records by product, batch, and facility. eLMIS reports aggregate monthly figures without batch numbers, so a specific batch cannot be traced to a specific facility.

Getting closer to the truth requires visiting each facility, physically counting stock, and cross-referencing against paper dispensing registers. The store supplies hundreds of facilities and the quality assurance team has three staff. Without routine data, identifying leakage hotspots is near impossible.

Consequences of Current State:

Several consequences emerge from this episode:

- the inability to validate intended use erodes Treasury trust, and insufficiently answered questions increase budget scepticism
- accountability remains episodic and sample-based, because every reconciliation must be rebuilt by hand from mismatched codes and paper registers
- scarcity raises the street value of health products, higher value strengthens the incentive to divert, and each suspected leak further constrains the budget

Ultimately, the store cannot demonstrate that health products reached patients, so Treasury discounts its funding requests, scarcity deepens, and the incentive to divert increases.

Future State:

The newspaper story runs and the parliamentary question is tabled; however, this time the logistics team does not need days to reconstruct a fill rate. The eLMIS and the warehouse enterprise system are connected through an integration layer. The fill rate is calculated automatically and published on a dashboard that MoH and MoF can already access.

The managing director can show, within hours, that the fill rate decline tracked the budget depletion curve and that adequately funded product categories maintained near-full fill rates.

On the question of post-delivery accountability, the managing director has a partial but credible answer. For a priority list of high-value products, batch-level tracking now connects dispatches to facility receipt and reported dispensing. Discrepancies are flagged automatically. The quality

assurance team focuses its limited capacity on the 20% of facilities showing the largest gaps, rather than random or directed sampling. The committee receives data showing precisely where accountability remains difficult.

Over successive years, the store builds a cumulative evidence base showing whether discrepancies are declining, stable, or concentrated. Treasury allocates with greater confidence that additional resources will reach patients. Reductions in scarcity reduce incentives to push health products to the black market.

What Blocks the Future State:

The CMS's visibility ends at the facility door because dispensing and stock records sit with facilities and districts rather than the store. Where systems do exist, they may use different product codes and facility identifiers. This gap could be closed by having a shared master data system maintained by an institution accountable for data exchange (Recommendation 1), dispensing systems that expose their data through documented interfaces as they are rolled out (Recommendation 3), and routine discrepancy analysis that can be used to direct scarce audit capacity to points of highest concern (Recommendation 6). Facilities and districts may resist greater visibility since it allows for greater scrutiny of them; presenting the data as a tool for defending budgets, not only for detecting leakage, could help build support.

Incremental Improvements:

Stepwise measures that begin to unlock the future state, ordered roughly from low to high digital maturity.

1. Adopt a **national product catalogue** and **master facility registry** as mandatory references for all data systems to enhance accountability and system intelligence. If national enterprise architecture is lacking, registries should be manually updated every quarter (at minimum) and published on the government website.
2. Produce a **monthly fill-rate report** and circulate it to MoH and MoF leadership.
3. Add **batch numbers to eLMIS receipt records** for a priority list of high-value products, expanding coverage as practice stabilises.
4. Develop an **analytical pipeline** and statistical methods to identify potential discrepancies using available population, programme, and health record data. Specifying successful methods will require manual data compilation, exploratory analysis, and ground truthing.
5. As facility dispensing systems come online (e.g., digital registers or electronic health records), **require exposed APIs and routine, automated data extraction** using the national interoperability layer and central data repository.
6. Automate **dispatch-to-receipt matching** through the national interoperability layer and connected systems, with discrepancy flags used to prioritise investigations.

Operational use cases

Use Case 4a: Explain fill-rate performance

The CMS managing director must produce a credible national fill rate and explain its movement when an inquiry arises to justify any shortages.

4a

WHO (ACTOR)
The CMS managing director, supported by the logistics and finance teams

WHAT (DECISION/ACTION)
Produce a credible, national fill rate on demand and attribute its movement to root causes

WHEN (TRIGGER)
Episodic and often externally motivated (press or parliamentary inquiry)

HOW (INFORMATION CONSULTED)
District orders (eLMIS), outbound dispatches (warehouse enterprise system), budget line depletion and supplier arrears against the fiscal calendar (IFMIS, CMS accounts)

WHY (IMPORTANCE)
The fill rate is the headline performance measure and is often the first number cited in any leakage inquiry. Unexplained declines undermine the credibility of the central store's operational management and fiscal accountability. The ability to explain variations in fill rates improves credibility.

CURRENT STATE	FUTURE STATE
Calculation of the fill rate requires days of manual matching between systems that use different product codes and facility identifiers, and the analysis cannot easily be reproduced.	The eLMIS and warehouse enterprise system are connected through the integration layer. The fill rate is calculated automatically, published to a dashboard MoH and MoF can access, and displayed against the budget curve so funding and operational causes are distinguishable.

F5 Centralised Procurement | F10 Monitoring

Use Case 4b: Trace priority health products from dispatch to dispensing

Use case statement: *The CMS quality assurance lead must demonstrate that dispatched batches were received and dispensed at destination facilities during routine or triggered quality assurance reviews, to show that spent resources were translated into patient access.*

4b

WHO (ACTOR)
The CMS quality assurance lead

WHAT (DECISION/ACTION)
Demonstrate that dispatched batches were received and dispensed at the destination facility

WHEN (TRIGGER)
Episodic or routine quality assurance process

HOW (INFORMATION CONSULTED)
Batch-level dispatch records (warehouse ERP), facility receipt confirmations (signed delivery notes), dispensing records (paper registers and some electronic health records)

WHY (IMPORTANCE)
Inability to verify budgeted resources translate into patient health products erodes trust in the institution and clouds credibility when requesting additional budget.

CURRENT STATE	FUTURE STATE
The audit trail ends at facility receipt, typically a signed paper delivery note. The component systems (warehouse ERP, eLMIS, facility dispensing tools) are frequently deployed but not connected, product catalogues are unsynchronised, health products arrive without standard barcodes, and reconciliation requires physical stock counts against paper registers tallies.	Batch-level tracking for a priority product list connects warehouse dispatch to eLMIS receipt on shared codes, with discrepancies flagged as consignments close out. Facility dispensing systems automatically push data into the interoperability layer for verification analysis and discrepancy analysis. CMS and MoH can access a routinely updated view by facility and district of indicators and discrepancies to prioritise investigations.

F5 Centralised Procurement | F9 Delivery | F10 Monitoring

Foundational components and preconditions for future states

Across the four use cases, common elements emerge that would need to be addressed to bring about the future state. Together, these components constitute a **minimum viable architecture** for the data ecosystems to meet user needs.

Common foundational components:

1. **Harmonised national product catalogue.** Every identified use case requires that a health product name and formulation has a unique identifier across the eLMIS, CMS enterprise system, HMIS, and insurance claims platform. Without a single, maintained product catalogue propagated across systems, automated data exchange is not possible. This is a fundamental technical constraint identified in many countries.

2. **Master health facility registry.** Every identified use case requires matching data about the same facility/location across systems. Without a shared registry, relevant data housed across different systems cannot be triangulated or adequately used to improve performance. This registry must be actively maintained and synchronised, not just published as a static reference.
3. **Integration layer (middleware).** Every identified use case requires routine, automated data exchange between at least two systems that were built independently and do not natively share data. A governed middleware layer is needed to route data between systems using the shared product catalogue and facility registry; without it, transaction costs from data exchange (human and capital) escalate and usable insights are delayed.
4. **Shared analytics solution with role-based access.** Every identified use case requires an access point where different institutional actors (MoH, MoF, CMS, district health teams, facility administrators) can view relevant, up-to-date data and insights without requiring direct access to each other's source systems. This layer should include user interactivity (ability to specify and adjust analytic methods and data views) and multi-modal information dissemination (i.e., not solely web-based dashboards).
5. **Governance agreement on data access, use, and quality.** Every identified use case requires that institutions which currently do not share data formally agree to do so, under defined terms. Agreements should be adequately detailed and routinely updated, e.g., annually. Key specifications include role(s) responsible in each relevant organisational entity; variables, dimensions, and disaggregation required; methods for extraction, transmission, and loading; frequency of exchange; and validation metrics.
6. **Off-budget and donor financing visibility.** Most use cases depend directly on visibility of the full resource envelope, including donor commitments and in-kind health product flows. A standardised mechanism for capturing off-budget financing is a precondition for any integrated planning view. Further, a country must have a standard data exchange and analytic protocol across financial systems to compare and merge congruent data to meet planning needs.

Policy opportunities

From this investigation we identify six policy recommendations across three layers: governance, information infrastructure, and intelligence. If adopted, these policies would help align institutional incentives with health sector SC goals, foster sustainable integration, and enable future states described in the use cases.

Intentionally, we have avoided general process or architecture recommendations (like "better coordination" or "invest in DPI") in favour of options that would be more distinct and incremental. Recommendations are primarily focused on within-country actors and governance;

however, we specify for each item how external funders, normative bodies, and the private sector should support country aims.

FIGURE 7. Policy opportunities and actor-specific recommendations

	COUNTRY GOVERNMENTS	EXTERNAL FUNDERS	NORMATIVE BODIES	PRIVATE SECTOR
1 **GOVERNANCE** Assign and fund accountability roles for data exchange	Designate an "Exchange Manager" accountable for successful data exchange, not platform management. Establish professional civil-service cadre with requisite skills and career path.	Reserve a share of DAH for DPI-H and the Exchange Management function, scaled to country maturity, covering skilled personnel and recurrent operating costs.	WHO: publish guidance on the staffing, skills, and procedures for a successful Exchange Manager function, as a companion to the DPI-H reference architecture.	Offer outcome-contracted metadata management services, paid on measured results (e.g., registry accuracy), without per petuating vendor lock.
2 **GOVERNANCE** Incentivise data exchange and build into operating agreements	Write verifiable data-exchange requirements into all system contracts and MOUs; tie payments and disbursements to demonstrated exchange.	Embed interoperability in grants, procurement criteria, and disbursement milestones; pool funds for integration work; hold potential-bridge countries to the highest standard.	WHO, World Bank, ITU: adopt a common interoperability assessment framework that countries and funders reference inoperating agreements	Compete on a demonstrated data-exchange track record; document every integration interface and configuration for government handover.
3 **INFORMATION INFRASTRUCTURE** Require open APIs and government data ownership in all system procurements	Mandate open, documented APIs, standard data export, and government data ownership in every procurement; consider source-code escrow; clear technical debt in government-built systems.	Decline to finance systems, renewals, or upgrades that lack standards-compliant data export and unambiguous government data administration.	Publish a model procurement clause package: API requirements, data ownership, export formats, source-code escrow, integration testing.	Pre-certify API compliance and publish integration documentation; develop voluntary interoperability certification through trade bodies.
4 **INFORMATION INFRASTRUCTURE** Finance integration as a recurrent cost	Reserve a small levy on insurance claims, medical-store transactions, and DAH for DPI-H upkeep; shift systems maintenance to performance-based contracts.	Designate part of co-financing increments for integration; fund operation of connections on 5–10 year horizons; co-finance the transition to a domestic levy.	World Bank PFM practice: guidance on classifying interoperability costs as recurrent operational expenditure in government charts of accounts.	Price interoperability-as-a-service to be sustainable on domestic revenue, tied to measurable service levels rather than licensing or per-user fees.
5 **INTELLIGENCE** Plan and procure against use cases, not platforms	Build a prioritised use-case portfolio to drive procurement specifications, investment decisions, and performance evaluation; refresh it annually.	Support the convening process and abide by adopted use cases; require use-case articulation in proposals.	Embed use-case planning in WHO/World Bank investment-case methodology and the DPI-H reference architecture; Global Fund should require it in RSSH grants.	Respond to articulated use cases rather than feature lists; avoid platform-first proposals.
6 **INTELLIGENCE** Build a health product market intelligence layer	Establish a national health product price index from four data streams; share price data with peer countries; triangulate existing data; apply predictive analytics.	Finance initial data aggregation and creative capture (e.g., facility crowdsourcing); invest in cross-country price-sharing platforms and incentivise participation.	WHO Essential Medicines, with the Global Drug Facility and UNICEF: rebuild a routinely updated cross-country price reference on GS1 product standards.	

DAH = development assistance for health · DPI-H = digital public infrastructure for health.

Governance layer

Recommendation 1: Assign and fund accountability roles for data exchange

Country policy

Designate an existing institutional actor (for ease of reference, "Exchange Manager") with a legislated or gazetted mandate, cross-ministerial convening authority, and institutional continuity across political transitions. The appropriate entity will vary by country context and institutional arrangements. For example, in Zambia the SMART Zambia Institute (under the Office of the President) holds a formal, cross-government digital infrastructure mandate but lacks sufficient health-sector funding to fully implement and enforce policies. In Ghana and Malawi, digital health divisions within the MoH have been assigned coordination roles but are also underfunded and do not have cross-ministerial authority. In the higher resource setting of Estonia, the X-Road/TEHIK model

leverages the private sector more actively, demonstrating an alternative route (Metsallik et al., 2018). Regardless of entity, the most important feature is accountability, tied to performance and funding.

Focus mandates on connection, not construction. The mandate and accountability mechanisms for the institutional Exchange Manager should narrowly focus on successful data exchange. The Manager should be responsible for the outcome, while preserving choice in approach and tools used to achieve it. Earlier we examined the trade-offs of various software models (Annex 3 for additional detail). While some governments possess the requisite technical expertise to develop and manage software from scratch (and choose to), others might need, or prefer, to rely on licensed products. The procurement options are governed by local policies, and in most LMICs we found a model mix, reflecting various needs, choices, and budgets. Focusing the mandate on the successful exchange of clearly outlined metadata, rather than management of a particular platform (e.g., IFMIS, eLMIS, etc.), would increase flexibility and align organisational incentives with sector goals.

This division of labour is consistent with broader integration guidance to define governments' stewardship role before deploying new technology. Governments can retain authority over accountability structures and decision rights, while delegating operational execution, including data exchange, through clearly scoped service agreements (Supply Chain Funders' Forum & Integration Taskforce, 2026).

Define specific performance appraisal metrics, tied to crucial DPI-H components. Performance metrics shouldn't be tied to a system's mere existence. As we have seen in evidence synthesis and user journeys, there are a set of foundational components that are preconditional to meeting SC financing intelligence needs. These include, at minimum, a national product catalogue, master facility registry, and a transactional service to shepherd data between systems (i.e., OpenHIM or equivalent). Again, the Exchange Manager should not be evaluated based on the existence of these tools, but accountable for the comprehensiveness and timeliness of metadata and success of data flows. Specific performance metrics might include:

- percent of transaction requests managed successfully through interoperability layer
- validated registry revisions
- mean time to propagate registry update

To be successful, this shift in accountability must be met with similar structural adjustments for data systems stewards (discussed below).

Establish Exchange Manager roles in the civil service as a distinct professional cadre, with job descriptions, qualification standards, and salary scales that reflect the technical labour market for health informatics rather than defaulting to general ICT or administrative grades. Successfully managing end-to-end interoperability across complex domains like SC and HF requires specialised knowledge and skills. Frequently, there is no career path for these individuals within government, which discourages retention and requires extensive reliance on TA to make data exchange happen.

Even if positions can't be immediately funded with domestic resources, there must be an institutional home for them.

External funder role

Invest a percentage of DAH for DPI-H and, specifically, support the Exchange Manager role. This funding should be structured as the DAH set-aside described in Recommendation 4. Countries in the nascent/fragmented category should receive a higher percentage of the funding envelope to develop core services. Proper accountability mechanisms can and should be built into donor-country agreements. Funding should be flexible enough to support the salaries and professional development of the skilled personnel required to manage, maintain, and evolve the DPI-H (e.g., system administrators, data scientists, software developers, technical support staff). Allocations should also cover essential activities such as cloud hosting fees, software licences, security updates, bug fixes, routine technical audits, and the continuous refinement of the platform and the upkeep, verification, and cleaning of core digital registries.

Normative body role

The WHO should **develop comprehensive guidance** on the human resource complement, skills, and procedures that would enable a successful Exchange Manager function within LMIC settings. This guidance can be a companion piece to the forthcoming DPI-H reference architecture and be explicit on governance arrangements that foster sustainability.

Private sector role

Effective governance requires legitimacy from the political and administrative apparatus, but exchange management operations must not necessarily be confined to the public sector. Private sector firms could offer robust, professional metadata management services, but structured as **outcome-contracted services**. This model shifts the focus from simply providing software or hours to achieving specific, measurable outcomes. An example might be achieving a 95% accuracy rate for updating facility metadata in the registry, linked to payment or bonus structure. Many countries may elect to rely on private sector services while internal capacity is being developed and essential positions filled. Yet, companies will need to tailor their offerings and show they are willing and able to operate outcome-driven, time-bound contracts without perpetuating vendor lock.

Recommendation 2: Incentivise data exchange and build into operating agreements

Country policy

Require demonstrated data exchange in contractual performance metrics. All new digital health or financial management system investments, regardless of funder (domestic, external, or hybrid

partnerships), should include a verifiable requirement that the funded system demonstrate data exchange in a specified format, level of detail, and frequency. The data exchange transactions should be negotiated in advance, verifiable by country authorities (e.g., Exchange Manager), and tied to payment/disbursements. These requirements should filter into all sub-agreements and formal contract vehicles.

For example, an external funder commits to invest in SC performance improvements for country Z. A tender is raised to provide systems integration and analytic support and is awarded to a private sector company. Within this arrangement, the external funder and Country Z should agree on performance and accountability metrics that include data exchange targets (with both having a role to play). Similarly, the contractor's performance should be (at least partially) assessed based on these exchange targets, with payment conditional on threshold achievements. This arrangement coalesces actors around a common set of integration outcomes, which are more readily measured and better align financial and reputational incentives.

Revise memoranda of understanding (MOUs) or operational agreements to include data exchange details. MOUs between bilateral governments, or governments and implementing partners (e.g., international or local non-governmental organisations (NGOs)), are typically required in the presence of funding or in-kind support. These documents outline the terms by which each party will operate and honour their commitments. Historically, these MOUs have not detailed specifics of data exchange, with the notable exception of the recent "America First Global Health Strategy" and US Government country agreements. The directionality of the support shouldn't preclude negotiating mutually advantageous data sharing. Parties should agree on content and system specifics that will enable interoperability and data use throughout the health system. For example, countries could require financial, health product, and programme data be made available in a specific format (with all requisite disaggregation) and transferred via a specific vehicle (e.g., exposed national API emanating from the interoperability layer).

There is precedent for this approach from *within* the US Government. PEPFAR standardised expenditure reporting through a mandatory reporting requirement (OMB Control No. 1405-0208). All implementing partners were mandated to report financial data by programme area and cost category to improve transparency and calculate the unit costs of HIV/AIDS services. This substantially changed how agencies and implementers were evaluated and funded. The initiative was successful because the terms of data exchange were highly specified and were required for legal compliance.

While adjudication of MOUs in LMICs presents another challenge, there is a necessity for clear, binding language in these agreements. Rather than revising the top-level agreement, countries could specify data sharing arrangements in the periodic implementation plans associated with these MOUs.

External funder role

Funders should **incorporate interoperability requirements into grant agreements, procurement evaluation criteria, and disbursement milestones** for all new digital health and finance investments. This is particularly true for Global Fund RSSH grants, World Bank FMIS projects, Gavi data systems and CCEOP investments. Where multiple funders are financing different systems in the same country, establish joint review mechanisms to assess cross-system data exchange and strategically fill gaps. Funders should pool a portion of funding into a shared facility that the Exchange Manager can draw upon to finance the connection work that no individual grant currently covers. Any information systems supported should be required to adopt documented APIs, shared data standards, and be architecturally capable of future exchange even if the country's "digital highway" is not yet in place. Investing in connections between systems is substantially cheaper, even in the near term, than continuing to operate silos and rely on manual processes for data integration.

The 14 potential-bridge countries in our typology, where functioning digital systems exist on both sides but have never been connected, should be held to the highest standard. These countries have the technical infrastructure, but lack incentives. For the 24 nascent or fragmented countries, where basic digital systems are still being established, the funding requirements should focus on integration-readiness in system design and congruency of data, rather than immediate interoperability. The nine operational- and demonstrated-bridge countries should be incentivised to deepen or restore existing connections, rather than create new ones.

The boards governing GHIs and bilateral programmes should incorporate data exchange outcomes into agency strategies and require management to report against them. Agencies should be accountable for integration outcomes in countries where they invest in the digital ecosystem and have a responsibility to shape incentives in the right direction.

Normative body role

Relevant multilateral bodies—WHO, the World Bank, and the International Telecommunication Union (ITU)— should formally **adopt or adapt a common interoperability assessment framework** that countries and funders can reference when designing operating agreements. This framework should define minimum standards for data exchange readiness (based on DPI-H reference architecture) and provide an assessment methodology that accounts for differences in country digital maturity, strategy, and software model mix.

Private sector role

Implementing partners bidding on contracts for data systems should **prepare to be evaluated on their demonstrated track record in delivering interoperability/data exchange**, not merely in delivering functional standalone systems. Implementing partners should painstakingly document all integration interfaces, data exchange protocols, and configuration decisions in a format that

the government can maintain after the contract ends, thereby enhancing trust in their technical approach and professionalism. If governments and funders know that engaging the private sector for specific services does not preclude or obstruct country governance, capacity, or sustainability, they will be much more likely to rely on those services when needed. Any sign of data gate-keeping or vendor lock-in will damage trust.

Information infrastructure layer

Recommendation 3: Require open APIs and government data ownership in all system procurements

Whereas Recommendation 2 addresses what a system must do (demonstrated exchange), this recommendation addresses what a system must expose and who owns it. Our inventory documents six distinct software models operating across the 47 countries studied (35 in sub-Saharan Africa and 12 in South and Southeast Asia). No single model is inherently superior for data integration. What matters most is technical documentation, data portability, and government ownership, which *must* include administrative access to all information the system contains.

Country policy

Mandate open, documented APIs in all new procurements. All new digital health and financial management system procurements, regardless of software model, should include contractual requirements for open and documented APIs, data export in standard formats (FHIR, CSV, or equivalent as appropriate to the system's function), and unambiguous government ownership of all data generated or processed by the system. For proprietary systems, procurement contracts should consider requiring source code escrow arrangements that ensure government access to the codebase if the vendor relationship ends unsatisfactorily.

For existing proprietary systems that lack documented integration interfaces, the requirement should be applied at the next contract renewal or maintenance cycle. For new builds and new procurements, the requirement should apply from inception. This distinction is particularly relevant for the 24 nascent and fragmented countries in our typology, where the next systems procured may define the digital health architecture for a decade. Ensuring that systems are integration-compatible from the start is substantially easier and cheaper than retrofitting a system after deployment.

Clear technical debt of existing, government-built systems. Government-built and managed systems warrant specific attention since there aren't the same contractual levers to pull. Internally developed systems need to be properly documented, including APIs, standard data export, and compatibility with the national product catalogue and facility registry maintained by the Exchange Manager. Systems unable to comply with policy should be highly scrutinised and alternatives considered or targeted assistance secured.

External funder role

Funders should **include open API and data ownership requirements in all funded system procurements**. Systems that cannot demonstrate standards-compliant data export and government data ownership should not receive external financing. Funders should also refuse to finance system renewals or upgrades that do not include API documentation and data export capabilities as explicit deliverables.

Normative body role

Relevant UN bodies (WHO, World Bank, ITU, etc.) should **publish a model procurement clause** package for data systems that countries can adopt or adapt. This package should cover API requirements, data ownership provisions, data export format specifications, source code escrow for proprietary systems, and integration testing requirements. A standard clause package would reduce the transaction costs for individual countries and create a common baseline that vendors can align to rather than negotiating bespoke terms in each procurement.

Private sector role

Vendors who **pre-certify API compliance and publish integration documentation** gain a competitive advantage under this framework. Industry trade organisations, including those representing commercial ERP vendors active in LMIC health and financial management markets, should develop a voluntary interoperability certification that governments and funders can reference in procurement evaluation. Vendors who demonstrate compliance first may be positioned to capture a growing share of data system investments.

Recommendation 4: Finance integration as a recurrent cost

Integration infrastructure must be supported by sound PFM practices. Clear budget classifications, provision for recurrent operating costs, and sustainable financing arrangements are critical to ensuring systems functionality beyond donor- or project-funded investments.

Country policy

Develop a DPI-H transaction levy. Countries with functioning insurance or claims-processing systems should consider reserving a small percentage of insurance claims processing fees or central medical store transaction charges for maintaining the interoperability infrastructure on which those transactions depend. This creates a self-sustaining funding mechanism that is tied to usage volume, scales with system maturity, and does not depend on external project cycles. The mechanism is most immediately feasible in the single operational-bridge country and the eight demonstrated-bridge countries in our typology, where insurance transactions already generate revenue that could be partially redirected. The percentage doesn't need to be large; the operational

costs of maintaining an interoperability layer, shared registries, and metadata services are modest relative to the transaction volumes of a national insurance scheme or central medical store.

A similar levy should apply to DAH. Countries should consider requiring a percentage of all health programme assistance be devoted to maintaining the foundational core of the data ecosystem, which is necessary for effective service delivery, evaluation, and planning. The levy should be clearly reserved for the exchange management function and DPI-H components. A corollary exists for ethical review and research clearance. In many countries, a fee is required for technical experts to review and decide, which is set as a portion of the overall research budget as a proxy for scale and complexity. More squarely analogous is the markup percentage frequently charged by medical stores to manage and distribute health products. Data, like other commodities, have a carrying cost and budgets should reflect it.

Shift to performance-based contracting for systems maintenance. The prevailing model for sustaining digital health infrastructure in LMICs is to second technical assistance (TA) personnel from implementing partners into government teams, particularly when qualified staff are not available. This model can build capacity of government employees working alongside external technical experts, but also creates dependency and is prone to project-cycle-related instability. A better option is to contract for outcomes rather than inputs. For example, TA providers could be paid for system uptime, data quality metrics, and successful data exchange outcomes rather than for person-days of technical support. This shifts the risk to the service provider (who must deliver results to be paid) and creates incentives for knowledge transfer (since the provider's profitability depends on efficient operations, not on maximising billable hours). The Exchange Manager role should be empowered to contract on these terms.

External funder role

As countries increase domestic HF under Gavi and Global Fund transition frameworks, **a portion of the co-financing increment should be designated for data system integration and maintenance**. Co-financing agreements currently focus on health product procurement and service delivery costs while data system infrastructure is treated as a project expense rather than as a recurrent operational cost countries must absorb. Embedding integration costs into co-financing agreements normalises them as part of the health system's operating budget and creates a transition pathway from external project funding to domestic recurrent financing.

Funders should also **shift from financing the construction of systems to financing the sustained operation of connections between systems**. This requires longer time horizons (five-to-ten-year commitments rather than three-year project cycles) and different disbursement triggers (outcome-based rather than milestone-based). Funders should also support the transition from project-funded to domestically funded integration infrastructure by co-financing the first years of

a DPI-H transaction levy or integration budget line, with a declining external share over a defined transition period.

Normative body role

The World Bank's public financial management practice should **develop guidance on how interoperability and data exchange costs can be classified within government charts of accounts as recurrent operational expenditure** rather than capital or project expenditure. This is a technical, yet consequential, accounting question. When integration infrastructure is classified as a capital expense, it is funded once and depreciated over time. When it is classified as recurrent expenditure, it is budgeted annually alongside other recurrent costs, like utilities or rent. If recurrent budget codes don't exist in the chart of accounts, governments can't spend money on maintaining integration architecture.

Private sector role

Managed service providers should **develop pricing models for interoperability-as-a-service** that align with government budget cycles and can be sustained on domestic revenue after an initial period of donor support. The pricing model should be transparent, predictable, and tied to measurable service levels (uptime, data quality, exchange success rates) rather than to platform licensing fees or per-user charges that scale unpredictably. Providers who can demonstrate that their service model is financially sustainable on domestic revenue within a defined transition period will be positioned to capture long-term contracts rather than competing for short-cycle project funding.

Intelligence layer

Recommendation 5: Plan and procure against use cases, not platforms

As documented in the ecosystems inventory and root cause analysis, hundreds of systems have been built to specification for individual programmes, with limited interoperability between them and almost no connection to domestic financial systems. We propose more explicitly articulating the value and intended outcomes of digital systems investments with thorough use-case specification, adoption, and monitoring. This approach extends beyond mapping digital investments to strategic priorities, focusing instead on intelligence needed to advance downstream health objectives in the causal chain.

Country policy

Develop a set of priority use cases to guide all digital systems investments. Countries developing or revising national strategies should structure information system investment priorities around a portfolio of prioritised use cases, rather than vertical or functional programme needs. Each use

case should identify a specific actor, attempting a specific task, at a specific point in the planning or operational cycle, who requires data that currently do not reach them in usable form. This approach should augment and reinforce the existing health sector strategies and elaborate steps in a hypothesised causal chain. A use-case focus will help actors cooperate across institutional silos, structure investments towards a more common goal, articulate the expected outcomes, and hold systems stewards to account. Use case priorities and specifications should be reevaluated periodically (e.g., annually) to keep pace with sector needs and reforms.

Connect use cases to procurement, performance, and financial monitoring. The output of the process, a prioritised use case portfolio, should serve as the basis for three downstream decisions. First, procurement specifications for new systems or system enhancements should be written to address prioritised use cases rather than to acquire a particular platform. Second, investment decisions by both domestic budget authorities and external funders should be evaluated against the portfolio; funding requests that do not address a prioritised use case should face a higher burden of scrutiny. Third, performance evaluation of the Exchange Manager and of funded systems should be tied to whether prioritised use cases are being served with better data than before. Additionally, budget execution and expenditure analysis should be set up to monitor the costs of use case implementation to assist with future value judgements.

External funder role

Funders should **support the convening process** itself and **abide by the direction** outlined by adopted use cases. Funders should require use-case articulation in grant proposals for data system investments. A proposal that cannot identify the specific actors, decisions, and data gaps its investment will address should not be funded.

Normative body role

WHO and the World Bank should **incorporate use-case-driven planning as a standard component of digital health investment case methodology**. The Global Fund should require use case articulation in RSSH grant proposals that include data system components. The forthcoming WHO DPI-H reference architecture should include a use case planning module with templates, facilitation guidance, and assessment criteria that countries can adopt.

Private sector role

Technology vendors responding to government procurement should position themselves to **address articulated use cases rather than feature lists**. Vendors who engage with use-case specifications rather than proposing platform-first solutions will be better positioned to win contracts under this framework and, more importantly, to deliver systems that add value.

Recommendation 6: Build a health product market intelligence layer

Country policy

Establish a national health product price index. Countries should aggregate several data streams into a routinely updated, publicly accessible health product price index. Market intelligence should be viewed as a financing and purchasing tool, not merely a digital solution. It supports strategic purchasing, reimbursement design, market shaping, and budget formulation by providing timely information on prices, suppliers, demand, and availability.

The first stream to incorporate is central/regional medical store contract prices, already captured in warehouse enterprise systems or procurement management systems.

The second is open-market procurement costs from facility records, which are typically recorded in paper ledgers or simple spreadsheets and rarely aggregated. Digitising and aggregating even a sample of facility procurement records would represent a substantial advance. For example, the World Bank utilises a remote, citizen-driven data platform called the Food Price Crowdsourcing Africa initiative to monitor market prices for food staples in LMICs (Solano-Hermosilla et al., 2022). A similar sampling approach and small incentive mechanism could feed data from the periphery.

The third includes data from the regulatory or revenue authorities that value the price of health products once they land (capable of capturing data across fragmented and partner-supported SC).

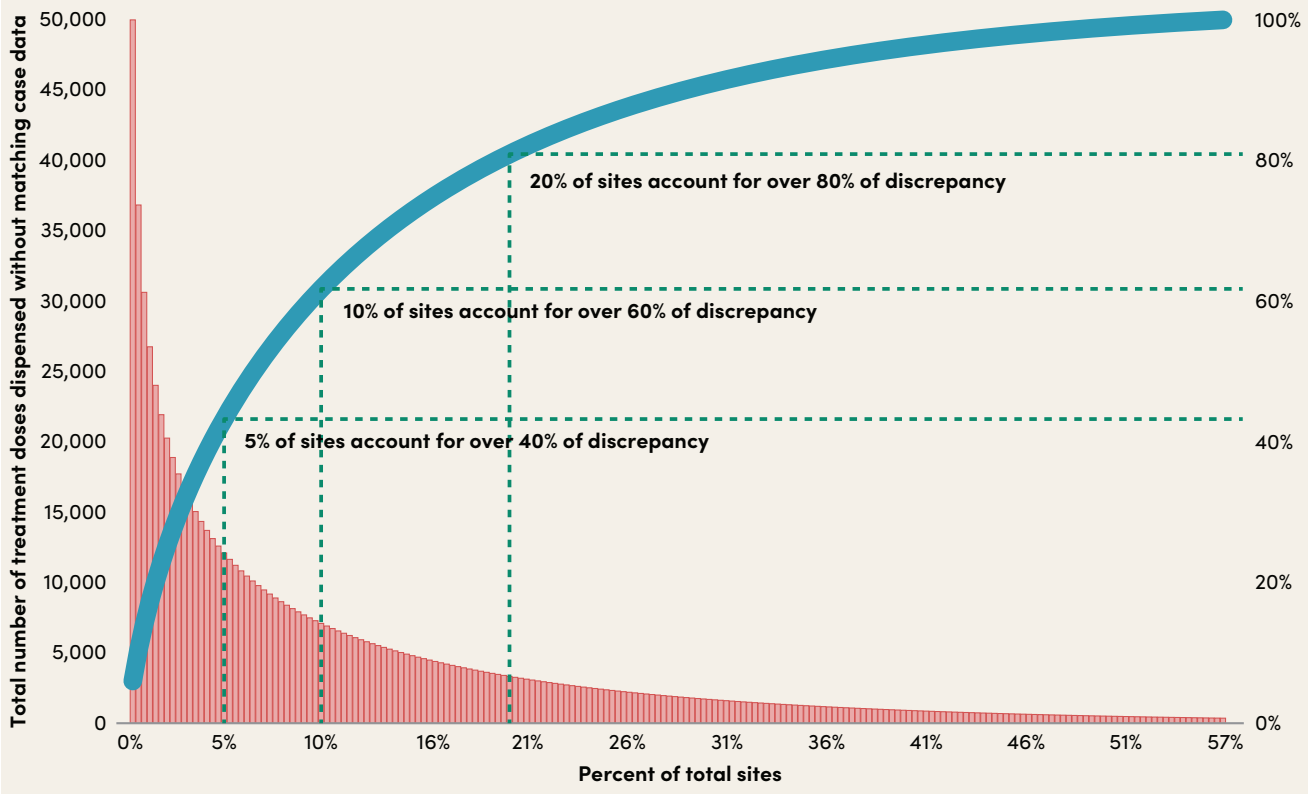
The fourth stream consists of international reference prices, available from the WHO/Health Action International (HAI) Medicine Prices database, the Global Drug Facility, and UNICEF Supply Division procurement data. A price index combining these streams would allow tariff-setting teams, procurement planners, and budget analysts to see what medicines actually cost across the system rather than relying on outdated contract prices.

Develop health product price data sharing agreements with other countries. Several countries in our sample articulated a need to better understand what prices other countries have successfully negotiated with suppliers as useful benchmarks for their own negotiations. Developing bilateral or regional routine data sharing would increase market intelligence and could increase purchasing power.

Triangulate existing data to answer priority questions. Digital systems strategies are often grand and aspirational, including goals like "achieve end-to-end visibility of health product distribution." No doubt, systems can and will become more sophisticated towards these objectives, especially in countries with comparatively mature data ecosystems. But simpler methods of data triangulation, paired with targeted enquiry, are often overlooked.

An analysis using facility-level data from Malawi found that the national discrepancy between antimalarial doses distributed and malaria cases reported was not uniform across locations. Five percent of health facilities accounted for roughly 40 percent of the total overage, and 20 percent of facilities accounted for 80 percent (Smith, 2015). The implication was that targeted supervision of 115 sites rather than blanket visits to all sites would be most effective, at a fraction of the cost. This type of analysis, which requires matching health product data with service utilisation data, can be quite powerful and instructive for programme management. Audit reports tend to focus on summary statistics, whereas routine, automated versions of this Pareto-type concentration analysis could help managers to selectively intervene when time and resources are tight. Data triangulation is possible in countries with even the most basic digital repositories and could help inform what data analytics are automated in the future.

FIGURE 8. Example of Pareto concentration analysis output



Leverage predictive analytics to anticipate both upstream and downstream trends.

The AI boom and proliferation of models and tools should enable more sophisticated use of advanced analytics to enhance HSCF intelligence.

On the upstream side, pharmaceutical procurement in LMICs is exposed to disruptions and fluctuations that heavily influence cost. Changes to manufacturing capacity, variations in exchange

rates, and geopolitical disruptions all contribute. Predictive models that integrate these upstream signals with country-specific procurement calendars and currency exposure could enable more realistic cost scenarios to be factored into annual budget formulation.

On the downstream side, facility-level demand for specific medicines is shaped by factors that are partially predictable, but rarely modelled. Seasonal disease patterns (malaria in rainy seasons, respiratory infections in cold seasons), demographic characteristics of catchment populations, facility type and level of care, proximity to referral hospitals, and the presence or absence of insurance coverage all influence consumption in ways that a sufficiently rich dataset could capture. Where data are linked, machine learning approaches could generate facility-specific demand forecasts that improve on the current practice of allocating based on population denominators and historical averages.

AI-powered or not, current forecasts and quantification tools should be enhanced with whatever data are available to better model alternative scenarios for less frequent, but not improbable, disruption events.

External funder role

Funders should **finance the initial data aggregation and creative mechanisms to capture missing data** (e.g., facility crowd-source methods) within countries. They should also invest in cross-country data sharing platforms (see the cross-country price reference discussed under Normative body role) and incentivise participation, thus promoting increases to global and regional price transparency.

Normative body role

The primary international reference price database for LMIC pharmaceutical procurement, the Management Sciences for Health (MSH) International Medical Products Price Guide, ceased updating in 2015 and has not been replaced. The WHO/HAI medicine price survey methodology remains available but produces periodic snapshots rather than routine intelligence. World Health Assembly Resolution 72.8 (2019) called for improved transparency of markets for medicines, yet the response has been a directory of national data sources rather than an integrated platform. WHO's Essential Medicines unit, working with the Global Drug Facility and UNICEF Supply Division (both of which already hold procurement data that could seed such a platform), should **prioritise rebuilding a routinely updated cross-country price reference for LMIC pharmaceutical procurement**. GS1 Healthcare's product identification standards would provide the common product language that the MSH guide lacked, enabling comparison across countries and procurement channels. Reviving and modernising this function could improve benchmarks and tariff-setting within countries by augmenting domestic data sources.

Conclusion

This paper demonstrates that information systems supporting health financing, public financial management, and supply chains remain highly fragmented, limiting the routine exchange and use of data across institutions. While important progress has been made in digitising individual functions, interoperability remains weak, resulting in missed opportunities to connect financial, health product, and performance information. Consequently, decision-makers often lack the visibility needed to understand how financing decisions influence procurement, product availability, and service delivery outcomes.

Our findings suggest that the primary challenge is not technological capability, but the governance arrangements that shape how information is shared and used. Sustainable integration requires stronger accountability mechanisms, clearer institutional mandates, and greater alignment across health financing, public financial management, and supply chain systems. Improving interoperability therefore depends as much on governance and incentives as it does on digital infrastructure and technical standards.

Additional strategic thinking and learning is needed on this topic. In particular, we need better methods for quantifying the value of information systems maturity progression and data integration. Evaluating trade-offs for incremental investments requires a good understanding of both the expected costs and benefits, neither of which is adequately measured. Cost projections for information systems are of highly variable quality and rarely validated with empirical expenditures as projects are rolled out.

Quantifying benefits is even more challenging. Functional improvements to information systems and human resource capacity accumulate diffuse benefits over a longer time horizon and counterfactuals are challenging to construct. In any budget cycle, comparing these investments with additional drugs, nurses, or medical equipment is imprecise, at best. Better planning tools and models are needed to assist countries to estimate and compare these benefits.

Annex 1: Key terms and operational definitions

Given the interdisciplinary nature of this topic, we define some key concepts, drawing heavily on the forthcoming World Health Organization (WHO) reference architecture for health digital public infrastructure (DPI-H).[5]

1. **Integration**, for the purposes of this paper, refers broadly to the desired end-point of relating and merging structured datasets to augment the usefulness of the information contained therein. This process could use any tool or method and be completed manually or orchestrated automatically by a digital system. It should not be restricted to a narrow engineering definition of point-to-point connection between two or more digital systems and should not be interpreted as system consolidation. Many pathways exist for integration and the optimal mix will depend on context, governance, infrastructure, and digital maturity.
2. **Interoperability** (or "**interoperation**") refers to the standards-based capability of heterogeneous information systems to communicate, exchange data, and use the exchanged information to execute functions effectively. Interoperability has four domains: technical (data physically moves between systems), structural (data are organised consistently), semantic (meaning is preserved on both ends), and organisational (legal frameworks, consent, and data-sharing agreements make exchange lawful and trusted). Interoperability enables effective integration.
3. **Master data** are the shared reference lists on which transactions depend, like facility codes, product codes, and units of measure. A **registry** is a governed, authoritative information system that captures and maintains the unique attributes and identifiers of these entities using a predefined canonical minimum data set, served as an accessible digital service.
4. An **interoperability layer** (also referred to as "**middleware**" or "**integration layer**") is a transactional service that routes, validates, and audits exchanges between independently built systems, based on shared registries. The layer might be a single piece of software or code, or multiple components working together. Exchange transactions might be manually executed or automatically scheduled. The important thing is that each exchange is logged and validated, increasing consistency and data integrity.
5. **Open standards** are an agreed, publicly available format or protocol for representing or exchanging data. **Open source** is a software licensing and ownership model. These two concepts should not be conflated. Proprietary software can adhere to open standards, and open-source software doesn't necessarily use open standards.
6. **Digital public infrastructure (DPI)** is a set of shared digital systems, secure and interoperable, built on open standards and specifications to deliver equitable access to public and private services at societal scale, governed by applicable legal frameworks.

5 At time of writing the reference architecture is available for public comment and review: https://www.who.int/news-room/articles-detail/call-for-public-comments-and-invitation-to-review

Annex 2: Country case studies

Thailand — pharmacy dispensing generates billing data in real time

Thailand has multiple operational SC-HF connections, all anchored by HOSxP, an open-source hospital information system deployed in approximately 300 public hospitals, integrating pharmacy dispensing with National Health Security Office (NHSO) e-Claim submissions (Wasi et al., 2020). When a pharmacist dispenses a medicine, the system simultaneously generates the billing record for NHSO reimbursement, validated against the NHSO Drug Catalogue (National Health Security Office, Government of Thailand, 2022). In a second bridge, the Government Pharmaceutical Organization (GPO) operates a Vendor Managed Inventory (VMI) system for vaccines, where facilities electronically transmit inventory data and the GPO generates replenishment orders. This has saved a reported US$6.6 million per year compared to the prior system (PATH et al., 2011). For high-cost "E2" specialty medications, a third, more limited bridge is utilised. The NHSO administers electronic prior authorisation, allowing approval data to flow directly into the GPO's centralised procurement planning.

Thailand is the only LMIC country identified where medication dispensing and billing are a single digital event at hospital level. Linked HOSxP and e-Claim systems support processing claims with drug-level detail for the Universal Coverage Scheme (UCS). This means that every health encounter in Thailand covered by UCS generates a digital financial record that includes what was dispensed. The E2 prior authorisation pathway is the only validated case globally where insurance approval data feeds directly into centralised procurement planning.

Private pharmacies and hospitals (~30% of care) are mostly outside public data systems. Out-of-pocket spending is low (~9% of health expenditures) but untracked digitally (World Health Organization, 2025a). SC visibility is comparatively weaker. The highly indirect procurement model and lack of digital integration across major systems precludes system-wide views of stock or shortages.

Existing systems already generate the data at point of care. HOSxP records what was dispensed. The NHSO e-Claim system records what was billed. DMSIC records what was paid. These three datasets, if consolidated, would provide a nearly complete picture of pharmaceutical flows through the public system. Currently, they sit in separate institutional silos with no middleware connecting them.

South Africa — government-stewarded supply chain intelligence without a financing bridge

South Africa is classified as a demonstrated rather than operational bridge. The National Supply Chain Control Tower integrates supply chain, contract and supplier-payment information, but routine exchange with the health financing systems that record government health expenditure is not yet established. South Africa's Control Tower supports stewardship of a decentralised

pharmaceutical system in which provinces manage their own budgets and procurement against nationally negotiated, pooled framework contracts. Rather than replacing existing operational systems, the Control Tower integrates information from disparate warehouse management systems, RxSolution and Stock Visibility System via APIs, supplier reporting, contract management, medicine pricing, supplier payment status and ageing, and debtor information to create a shared evidence base for national and provincial planning, monitoring and decision-making. Supplier-reported information is independently validated against operational and financial datasets, strengthening transparency and providing the government with a trusted view of medicine availability, supplier performance and emerging supply risks.

The South African model demonstrates that the greatest value of interoperability lies not simply in connecting systems, but in enabling improved planning, financial stewardship and resource allocation. The Control Tower combines operational, contractual and financial intelligence to identify emerging supply risks, supplier performance issues and payment bottlenecks before they affect medicine availability. Supported by a central planning team, provinces develop annual pharmaceutical budget submissions with a consistent national evidence base on core medicine supply chain metrics, visibility of supplier payment commitments, and accurate pricing assumptions. This information is utilised by established pharmacy, depot, and finance governance processes to consolidate cross-programme budget requirements before submission to provincial treasuries.

The Control Tower provides integrated visibility across provincial supply chains while respecting provincial operational autonomy. It covers all provincial warehouses, supplier payment commitments across purchasing authorities, visibility into a minimum viable dataset across all health facilities, and supplier pipeline visibility. It utilises master facility and product registries, including accurate pricing information.

In the context of decentralised fiscal responsibility, provincial pharmaceutical expenditure is captured in the Basic Accounting System (BAS) but not routinely linked to SC platforms (e.g., National Surveillance Centre). This missing link—expenditure in BAS not routinely joined to supply chain platforms—is why South Africa is classified as a demonstrated rather than operational bridge. Improving visibility and automated routine insights would support increased granularity of planning linking supply chain and financial performance indicators.

South Africa has also demonstrated interoperability at scale through other digital health initiatives. During the COVID-19 response, the Electronic Vaccination Data System (EVDS) linked beneficiary registration, real-time vaccine administration, inventory allocation and reimbursement to support a national vaccination programme across public and private facilities and mass vaccination sites. At scale, EVDS enabled the tracking and delivery of ~38 million vaccinations nation-wide, demonstrating that end-to-end real-time integration of eligibility management, services, supply, and financing data is feasible at scale when aligned to a clear priority use case.

Malawi — practical challenges with master data management

Malawi has been a leader for data governance and digital health architecture in Sub-Saharan Africa. The 2023 Global Digital Health Monitor ranks Malawi at Phase 5 for national health information exchange architecture, alongside Portugal, Saudi Arabia, Tanzania and the United Arab Emirates. This is a reflection of the country's investment in interoperability that belies its status as one of the world's lowest-income countries (World Health Organization, 2023).

Malawi was an early adopter of the OpenHIE architecture, intended to support standardised data exchange between systems across the health sector. In 2019, the newly established Digital Health Division (DHD) within the MoH developed a generic data exchange interface (based on the open-source OpenHIM tool) that would assist systems to share key information. This "middleware" served a key matchmaking function and rectified an ongoing congruency challenge that hampers data use. For example, health facilities and dispensaries are core units upon which we need to map data. In Malawi and other countries, these lists are extensive and constantly in flux as facilities open, close, or move. The same is true of product lists, diagnoses and treatments, and human resources. Data integration is often compromised because siloed systems independently manage similar yet distinct lists and metadata. For two decades, harmonising these lists has been one of the largest coordination challenges.

In Malawi, multiple systems (both digital and paper) house critical data for SC that don't routinely exchange data and use different metadata. The integration burden falls to individuals, such as pharmacists tasked with stock management, who are burdened with manually extracting and making sense of incongruent information. DHD hoped to partially address this burden by allowing users to see facility health product statistics *within* HMIS, which is widely accessible and could leverage OpenHIM and the newly created health facility and product registries.

In the early days of implementation, OpenHIM transferred records between OpenLMIS and DHIS2, producing composite indicators that for the first time allowed planners to compare caseload-to-consumption ratios and stock-on-hand against demand at the facility level. In addition, the country was able to use the interoperability layer to connect to the Global Family Planning Visibility and Analytics Network (GFPVAN), a platform that tracks donor-funded health product pipelines. This connection gave the Reproductive Health Department visibility into procurement, shipment status, central inventory, and stock-on-hand in health facilities — a view it previously lacked.

Unfortunately, neither connection is functional at time of writing. Despite the value, the pipeline broke down due to the rather mundane challenge of metadata synchronisation. As product information changed quickly in procurement systems, the new info did not get reflected in the registries or HMIS. The same issue emerged as facilities' metadata changed. OpenHIM could not verify the data against the registries, thwarting the transactions. Constant errors had to be evaluated by the DHD and the administrators of OpenLMIS.

Malawi has stated its intent to better harmonise systems with national metadata registries and restore these links; however, their experience underscores a major governance gap in how we finance and manage interoperability.

In every setting, various systems hold a critical piece of the puzzle and are managed by different groups of technicians, which in turn are remunerated and supervised by different organisational entities. Frequently the organisational 'stewards' operate from different sections across line ministries, parastatals, and development partners. Ultimately, no entity is accountable for successful data exchange. In most arrangements, financing or performance appraisal (systems or individuals) is not tied to interoperation. In cases where interoperation crosses funding streams (especially between development partners), disincentives may prevail (see Root Causes of Fragmentation).

Malawi's experience is a clear case where the technology is in place but targeted governance is needed to achieve integration.

Annex 3: Ecosystem inventory detail

System functional assignments

TABLE A1. Categorisation of digital systems by HSCF function

Function	Count	What's Included
F1: Revenue Raising & Pooling	28	100% health financing systems. Insurance enrolment and fund pooling platforms: BPJS, NIEPS Ghana, CNAM CMU, NHIF Tanzania, IHTS Kenya (SHA), and openIMIS deployments in 12 countries. Integrated insurance platforms that handle both enrolment and claims get F1+F6. Enrolment-only portals (PhilHealth Member Portal) are F1 only.
F2: Prioritising	0	No system in the inventory was assigned to this function. Prioritisation — deciding which health needs and health products to fund — is performed through committee processes, policy documents and spreadsheets, none of which met the inclusion criterion of a named software system. This is an absence of digital support, not an absence of the function.
F3: Budgeting	15	IFMIS/PFM systems (iBAS++, GIFMIS, SMART-IFMIS, PFMS, IFMIS Kenya/Rwanda/Zambia, IFMS Uganda, BAS), dedicated quantification tools (QAT, QuanTB), and Rwanda's RMS SAP ERP. 80% health financing, 20% supply chain.
F4: Market Shaping & Regulation	13	100% supply chain. Medicines-registration software (Pharmadex deployments, CDSCO/SUGAM, DRAP) and functioning traceability software (UNICEF TRVST, EFDA Ethiopia, Pakistan Track and Trace, mPedigree). Regulatory-authority systems without an evidenced supply chain financing role are excluded, as are plans and strategies.
F5: Centralised Procurement	49	Central medical stores (KEMSA, MSD Tanzania, CMST Malawi, EPSS Ethiopia, CAMEG, CENAME, RMS Rwanda) and their ERP/warehouse systems, e-procurement portals (GeM India, PhilGEPS, LKPP Indonesia, BUVI Rwanda), and state procurement corporations. 98% supply chain. Where government buys health products centrally. OpenLMIS/eLMIS (9), Oracle/Epicor (6), and SAP (4) are dominant platforms.
F6: Purchasing of Services	61	Insurance claims processing and provider payment systems. Includes claims-only platforms (PhilHealth e-Claims, MJPJAY CMS, CMCHIS) and the claims side of integrated platforms (NHSO, BPJS, NIEPS). 89% health financing. Significant overlap with F1 — systems that enrol members and process claims carry both codes. openIMIS (15), Oracle/Epicor (2).
F7: Facility Procurement	63	eLMIS systems where facilities order from central stores — this is the core OpenLMIS/eLMIS use case (21 systems on these platforms). Also DHIS2 LMIS modules (6 systems), revolving drug fund mechanisms, PVMIS/Jazia PVS. The facility-level procurement function. 97% supply chain. The third-most populated function, after F9 and F10.
F8: Budget Execution	12	IFMIS/PFM systems that actually release government funds — iBAS++, GIFMIS, SMART-IFMIS, PFMS, IFMIS Kenya/Rwanda/Zambia, IFMS Uganda, BAS/PERSAL, FFARS. 92% health financing. Also includes RMS SAP ERP (the only SC system here, tracking health product cost pass-through). Tightly overlaps with F3 — most IFMIS systems carry both F3+F8.
F9: Delivery	147	The largest function — 47% of all 311 systems serve delivery. Warehouses, eLMIS, dispensing, distribution, cold chain, inventory management — the operational backbone of the supply chain. OpenLMIS/eLMIS (25), e-Aushadhi/DVDMS (15), DHIS2 (10), mSupply (9), Oracle/Epicor (6), SAP (4). 92% supply chain. Essentially every supply chain system in the inventory touches delivery.
F10: Monitoring	144	DHIS2/HMIS dominates (62 systems — 43% of F10). Also dashboards, hospital information systems (HOSxP, iHOMIS, GoTHOMIS), interoperability layers (OpenHIM, ABDM/SATUSEHAT), and the monitoring components of insurance platforms. The most cross-domain function: 85 cross-cutting, 44 supply chain, 14 health financing and 1 donor financial system.

Notes: Categorisation of 311 systems across 47 countries according to Baker et al. (2025) HSCF framework function. 532 function assignments (average 1.7 functions per system).

Software archetypes description

The most prevalent software model within the total health IT inventory is government-built (122 systems, representing 39% of the inventory). These systems are either developed directly by governmental agencies or by contracted vendors working specifically to detailed government specifications and requirements. Examples include India's National Informatics Centre, Thailand's National Health Security Office (NHSO), Indonesia's Badan Penyelenggara Jaminan Sosial Kesehatan (BPJS, the national health insurance administrator), Rwanda's Intelligent Health Benefits System (IHBS/KWIVUZA), and Tanzania's GoTHOMIS.

Under this development model, the government maintains complete ownership of the source code, holds exclusive control over the product roadmap (dictating new features, upgrades, and direction), and does not incur ongoing software licence fees. The model offers governments sovereignty over the digital product, ensuring alignment with national standards and security policies, as well as the management of access control, important for protecting national health data. Furthermore, resources and expertise can be retained domestically (inshoring). However, the feasibility of this approach is dependent on the capacity of the national government's IT infrastructure and workforce. If weak, this model can lead to protracted development timelines, systems that fall short of user needs, and long-term maintenance challenges. Multiple custom-builds also increase complexity for interoperability, as each tends to use its own programming language, standards, and metadata.

Global digital public goods—open-source platforms stewarded by international foundations—constitute 108 systems (35% of the inventory). DHIS2 accounts for 58 of these 108 entries, with openIMIS (15), OpenLMIS/eLMIS (14), OpenHIM (7), and mSupply (7) making up most of the remainder. This model is especially prevalent in sub-Saharan Africa, where donor-funded implementation has been the primary adoption pathway. The model is appealing at face value—free to license, community-developed, and often architecturally well-suited for interoperability (RESTful APIs, FHIR support, health information exchange layers). But implementation costs are not trivial, and ongoing core development depends on continued donor funding to the global steward. DHIS2's 2026–2028 strategy itself acknowledges a significant decline in global funding for LMIC information systems, and OpenLMIS recently transferred management to a new entity (Vitalliance) partly in response to sustainability pressures (Alban, 2021; HISP Centre, 2025). Whether these platforms can maintain their current trajectory without sustained external support is an open question, representing a key risk to long-term adoption.

Donor-project custom builds (18 systems, 6%) are arguably the most sustainability-vulnerable, often built by implementing partners under time-limited contracts, with ownership that is ambiguous. Malawi's Electronic Health Information Network System (eHIN), whose usage degraded after project-funded devices wore out and airtime budgets ended, is one cautionary example (*Key Informant 5, Personal Communication*, March 24, 2026). However, some of these systems successfully transition to government ownership (Ezezika et al., 2022; Roth, 2026). While they can be highly customised

to local needs, post-project operation is threatened by the lack of a clear and funded, long-term maintenance plan and questionable ownership. Using mHealth apps in Uganda as a proxy for health information systems more broadly suggests that most donor projects never move past the pilot phase (Tomlinson et al., 2013).

The commercial enterprise software model (47 systems, 15%) fills a narrower but important niche, particularly for enterprise warehouse management (Oracle, SAP, Infor WMS), multi-enterprise networks (One Network, underpinning GhiLMIS), and government enterprise and financial management (FreeBalance, Microsoft Dynamics). These systems typically offer mature functionality, robust security, comprehensive audit trails, regulatory compliance and vendor-supported product lifecycles, making them well suited to core enterprise functions where reliability, financial integrity and business continuity are critical. They also benefit from ongoing product investment and technical support. These advantages should be balanced against potentially higher implementation and recurring licensing costs, reduced flexibility, and the potential for vendor lock-in.

UN and multilateral agency tools (5 systems, 2%) are generally stable but serve agency mandates rather than country-specific integration priorities. **Social enterprises and impact ventures (5 systems, 2%)** bring private-sector agility to specific problems (Zipline's drone logistics, CarePay's mobile health wallet), but their sustainability depends on transaction volume or government payment reliability that cannot always be assumed (Dzisi et al., 2026; Lockhart et al., 2021; Mhlanga et al., 2021). While innovative, their narrow focus and reliance on transaction-based revenue streams can make them potentially fragile components of the national IT landscape.

The choice of system should be guided by local requirements, institutional capacity, total cost of ownership, business process risk profile, and long-term requirements. Governments with strong digital governance, procurement capability, contract management and enterprise architecture can effectively manage many of the risks outlined through appropriate contracting, interoperability requirements, data ownership provisions and lifecycle planning across a heterogeneous system landscape.

Annex 4: Summary of financing and supply chain trends

TABLE A2. Financing and supply chain trends

Era	Public Financial Management (PFM)	Supply Chain (SC)	Friction & System Challenges
1970s–1990s	Introduced line-item budgets. Donor funds were largely kept off-budget (Ouda, 2016; Scott, 2015).	WHO Essential Medicines List (EML) established as a register of minimum medicine needs for every health-care system (World Health Organization, 1977). Establishment and expansion of publicly managed SC (Vogel & Stephens, 1989; Yadav et al., 2011).	Financial systems were rigid and separated from SC realities. Line-item budgets oversimplified needs.
1990s–2000s	Introduced Medium-Term Expenditure Frameworks and Program-Based Budgets (PBBs) for fiscal discipline (Collaborative Africa Budget Reform Initiative, 2019; Schiavo-Campo, 1994).	Pooled procurement advanced by UN agencies like UNICEF and UNFPA (Parmaksiz et al., 2022).	Duplication of systems created inefficiencies and heavy reporting burdens.
2000–2010	Donor financing massively increased but bypassed national systems (Dieleman et al., 2015).	New large SC established through GHI, such as the Global Fund founded in 2002 and PEPFAR founded in 2003 (Fauci & Eisinger, 2018; Schocken, 2013).	Massive donor-driven procurement created dependency and limited national integration.
2011–2020	Further PFM reforms strengthened PBBs and Treasury Single Accounts in LMICs through emphasis on primary health care (WHO, 2025b).	Digitisation spread as countries managing public health supply chains adopted open-source eLMIS platforms (JSI Research & Training Institute, Inc., 2008).	Separate programmes created inconsistent, manual forecasting. Interoperability incentives were largely absent.
2021–2026	Post-pandemic reforms emphasise agility and flexibilities within PFM (Gurazada, 2021).	Global platforms like COVAX exposed fragilities (Gavi, 2022). USAID begins restructuring (Nepomnyashchiy et al., 2025).	Low domestic resource mobilisation (DRM) to cover system gaps left by declining total DAH as countries reprioritise towards other sectors (Barasa et al., 2025).

Annex 5: Methods

Rapid evidence review and synthesis

To situate our analysis and findings in extant knowledge, frameworks, and concepts, we conducted a search of Scopus and Web of Science for published literature regarding health information systems, SC management, HF and public financial management in LMICs from 2005–2026. This returned over 2000 results, which were initially screened for relevance based on title and abstract. Post screening, 89 items were exported to NotebookLM which was used to classify documents around the following thematic areas:

- SC and HF ontologies, frameworks, key concepts, and operational definitions
- the use, challenges, and successes of digital tools and systems at the intersection of SC and HF
- external assistance models in LMICs, including historical trends, consequential events/ policy, and challenges with coordination
- governance structures for SC information systems as related to core SC functions
- challenges and successes of data integration
- evidence on performance gaps of SC in LMICs and proposed relationships with financing and quality data

To expand our search, we used findings from our thematic analysis to identify specific cases of SC and HF system development and integration that were most relevant. We then performed a targeted search of grey literature, included policy reports, programme documentation, and strategy documents to improve our understanding of these cases.

Inventory construction

We constructed a comprehensive inventory of relevant information systems operating across 47 LMICs (35 in Sub-Saharan Africa, 12 in South and Southeast Asia). We identified systems through AI-agent-assisted (Claude Code — Sonnet 4.6, Opus 4.6, Fable 5) iterative web research targeting government health ministry publications, implementing partner documentation (e.g., USAID/ GHSC-PSM project reports, WHO country cooperation strategies, World Bank health sector reviews), platform developer documentation (e.g., DHIS2, OpenLMIS, OpenMRS deployment registries), and peer-reviewed literature indexed in PubMed and Google Scholar. Where official sources were insufficient, we consulted grey literature to fill in gaps, including NGO project evaluations, donor agency assessments, and conference proceedings.

There were three inclusion criteria:

1. Each entry had to be a **named software system instance** that captures, stores, processes, or transmits health supply chain, health financing, or health programme data.
2. Each system had to **serve at least one of the ten supply chain financing functions** defined by Baker et al. (2025).

3. Each system had to **operate in an LMIC** at national or sub-national level, or be a multi-country platform used by LMICs.

Multi-country entries are restricted to platforms operated as a single shared instance (e.g., PEPFAR DATIM, wambo.org) while products deployed as separate national instances (e.g., openIMIS, mSupply, OpenLMIS) are recorded as country-level entries.

Each system was classified by primary system domain (supply chain, health financing, or cross-cutting), sub-category (e.g., warehouse management, electronic health record, etc.), and mapped to the Baker et al. (2025) framework. For each entry, we also captured information on the implementing partner(s) and funder(s), software platform, software model, data standards used, implementation start, and current operational status. Generally, the inventory is limited to active systems, though some legacy systems are captured if they are instrumental to the ecosystem or not fully phased out.

Each entry carried a two-tier evidence rating. Every cited source was retrieved and read in full and assessed against the specific system attributes captured in the inventory. An entry is graded Tier A where its own source carries the claims made of it, or where the system was confirmed directly through in-country verification or a key informant interview; and Tier B where the source confirms the system's existence and identity but not every attribute claimed, or where the entry's own citation failed but at least one other verified source supports the system. The inventory catalogues 197 Tier A and 114 Tier B entries (63% and 37% of 311 respectively).

The inventory was built iteratively across eight major versions with explicit version flagging and a change audit trail to maintain provenance. The inventory underwent automated (Claude Fable 5) and author-led fact checking. Entries and confidence ratings were validated line-by-line through author review of source documents and updated based on primary data from the evidence synthesis and the key informant interviews.

Integration typology assessment

Countries were classified into four SC-HF integration tiers based on credible evidence of routine digital data exchange between supply chain and health financing systems:

1. **Operational bridge** — a confirmed working SC-HF digital data chain at meaningful scale
2. **Demonstrated bridge** — some SC-HF exchange shown, but narrow, degraded, or programme-specific
3. **Potential bridge** — both SC and HF digital systems exist, but no demonstrated exchange
4. **Nascent/fragmented** — systems missing on one or both sides, or too basic for meaningful integration

Classification drew on the verified inventory and its references, qualitative deep dives, and key informant interviews.

Platform ecosystem analysis

Software platforms were mapped across all inventoried systems and normalised into platform families (e.g., DHIS2, OpenLMIS, OpenMRS, SAP, OpenHIM, custom government builds). Where platform information was not available in initial documentation, targeted research was conducted to identify the underlying technology stack. The analysis identified natural integration pathways where countries deploy the same platform family for both SC and HF functions, as these shared-platform environments present lower technical barriers to data exchange. Data standards adoption (HL7 FHIR, GS1, ICD-10/11) was assessed per system where documentation was available.

Visualisation

Visualisations were generated using Python (matplotlib).

Key informant interviews

We supplemented our evidence review through a series of unstructured Key Informant Interviews (KIIs). We conducted seven interviews representing perspectives from Ministries of Health, digital specialists, national SC managers, and finally, global partners who hold expertise in health finance, SC and digital public infrastructure. This included domestic insights from Malawi and Rwanda as well as international partner perspectives from Ghana and Tanzania. Informants were purposely selected to represent a broad range of technical expertise across health and SC functions.

Data from these interviews were used in several ways. First, the KIIs supplemented evidence review for any key data sources not captured in our initial search. Second, the KIIs validated our data ecosystem analysis to ensure that initial findings were relevant and reflective of the experience of those managing health finance and SC systems. Third, data formed the basis of the use cases anchoring this report and recommendations.

Limitations

The inventory likely undercounts private-sector and proprietary systems due to limited public documentation. System operational status may have changed between the time of documentation and publication. Sub-national variation is substantial in large federated countries (particularly India and Pakistan, where state/provincial systems were catalogued individually but aggregated to national scores for cross-country comparison).

The volume of this review and inventory was substantial and needed AI-assisted tools to complete. AI can and does generate inaccurate information. The findings were validated as much as possible with the knowledge of the researchers, but additional verification by experts most familiar with each country's context and systems would be preferred.

AI disclosure

The ideas, analytical framework, methods, and policy recommendations are the authors' own. Language models supported evidence retrieval, initial thematic classification, and automated fact-checking. Each of these was reviewed by the authors before use. Language models (namely, Google Gemini 3.0 and 3.5 and Claude Opus 4.6, Sonnet 4.6, and Fable 5) supported web search, information management and retrieval, qualitative and quantitative analysis (see above), role-based feedback, fact-checking, summarising methods, summarising results, and refining prose.

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