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Systems Thinking for Supply Chains: Identifying Bottlenecks Using Process Mapping of a Child Health Intervention in the Democratic Republic of the Congo (DRC)

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Abstract: The quality of supply chains in public health interventions in low- and middle-income countries can determine how effectively a program is able to treat its intended population group and subsequently achieve its health targets. We aimed to disentangle where challenges exist hierarchically and administratively through the application of process mapping to the supply chain of an integrated community case management (iCCM) intervention in the Democratic Republic of the Congo (DRC). We conducted a document review, semi-structured key informant interviews, and focus group discussions with program agents involved in supply chain processes of the child health intervention. Enterprise architecture was used to map the intervention's supply chain and its participatory actors, and detailed bottlenecks of the chain through the application of a health systems framework. The results of this study will be used to inform a system dynamics model of the supply chain of iCCM in DRC. The greatest bottlenecks leading to stockouts at the community level occurred upstream (from national to province and from zone to health facility). While the use of local procurement processes was partially attempted to strengthen systems, parallel supply chain activities compromised sustainable system integration and development. Initial delays in stock dispensation were due to international procurement at the supplier, inducing a trickle-down effect. Inadequate quantification of supply needs and subsequent insufficient product procuration were the single most important steps that led to stockouts. This study demonstrated that the community health supply chain would be most impacted by improvements made in processes at the highest administrative strata, while exposing its delicate dependence on activities at the lowest levels. Visibility of inventory at all levels and improved data quality and use through a transparent tracking system have the potential to significantly reduce stockouts. Future interventions should take care to not develop parallel processes or exclude local health system agents to avoid disruption and ensure sustainable health outcome gains. Causal loop studies and system dynamics can further identify the systems interactions and relationships and their underlying causal mechanisms in need of intervention.

Keywords: supply chain; process mapping; systems thinking; iCCM; integrated community case management

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1. Introduction

The timely and sufficient availability of medical products is at once among the most important and least understood aspects of the public health machinery in low- and middle-income countries (LMICs) [1]. This is particularly true when multisectoral programs intersect with existing public processes for health service delivery [2–4]. In the Democratic Republic of the Congo (DRC), typical health system challenges observed in LMICs are further exacerbated by a tenuous political climate, vast geography, and a complicated network of both internal and external health actors with varying responsibilities and interests [5]. Understanding how the country's local systems operate within this complex landscape for the procurement and distribution of medical products is essential to strengthening existing supply chain systems and tailoring sustainable efforts in public health.

There are currently scores of active public health programs in DRC, operating within a health system set against the backdrop of a complex political economy [5]. This contributes to the growing body of overlapping supply chain schemes that are largely managed by private entities, multilateral agencies, and non-governmental organizations outside of the charge or in partial collaboration with the country's Ministry of Health (MoH) [5]. For both the private and public sectors, these chains can involve assorted wholesalers, manufacturers, and distributors, which can ultimately affect the quality and availability of diagnostic supplies and medicines at the lowest levels [1]. In the case of community-based health interventions that target rural or underserved areas in DRC, these intricacies are even more accentuated by distal resupply and delivery points, service packages comprised of a variety of disparate medical products, and layers of providers and lay people with intersecting roles.

Systems thinking, an approach to complex problem solving that considers the interdependencies and emergent properties among a system's component parts, offers an optimal lens through which to assess complexity in health interventions [6]. The supply chains of these interventions, particularly in LMICs, serve as prime candidates for the application of systems thinking due to the often nonlinear dynamics among their structures, unpredictable context, and a multiplicity of driving agents. Process mapping, a common systems thinking tool used in the application of enterprise architecture, allows planners to better unpack bottlenecks in programs, identify critical actors that govern their processes, and determine meaningful action that can be taken to address health system constraints [7]. In addition to these, process mapping is a valuable tool for studying supply chains as it visually depicts the sequential flow of activities, identifies inefficiencies, and pinpoints their corresponding levels and actors, facilitating targeted improvements in overall logistics management [8–10]. Historically, this has not been applied to assess the supply chains of LMICs. We apply the principles of enterprise architecture to assess the supply chains of an integrated community case management (iCCM) program targeting childhood malaria, pneumonia, and diarrhea in a province of DRC. iCCM is considered a complex intervention due to its reliance on interconnected healthcare subsystems, and the unpredictable dynamics of the actors that operate within them [11]. We overlaid the application of the process mapping tool with the categories of the supply chain and commodities building block of the Community Health Systems Framework, which classifies an defines specific areas for the assessment of supply chains in community health systems of LMICs (Figure 1) [11]. These include the themes of drugs and commodities; quantification; procurement; distribution and transport; resupply and allocation; availability and stockouts; inventory and storage; protocols and standard operating procedures; and commodity quality and sustainability.

In this paper, we attempt to trace the pathway of medical commodities within the iCCM intervention and elucidate the agents implicated in DRC's complex iCCM supply chain scheme. We also highlight the experiences of these agents and challenges with the assurance of the availability of commodities at the community level.

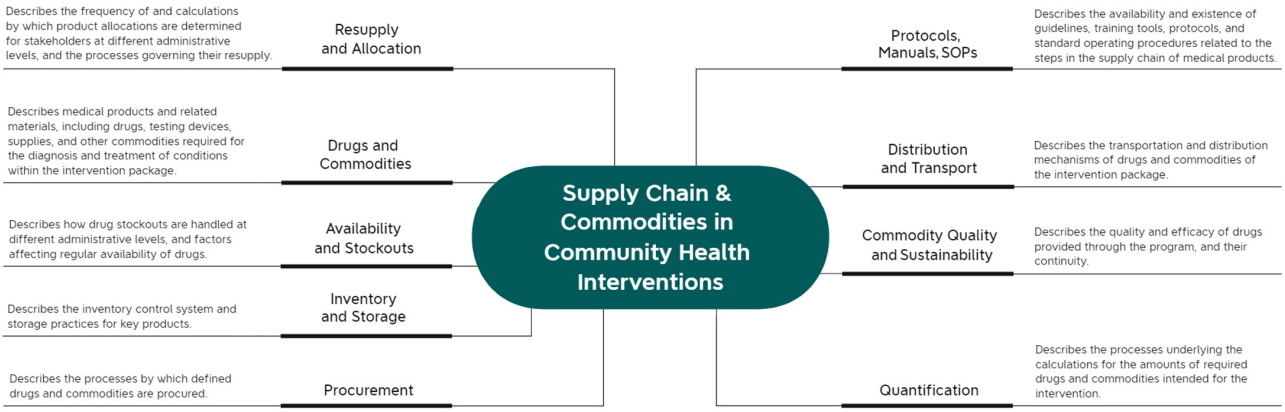

Figure 1. Supply chain and commodities domain and categories of the Building Blocks of Community Health Systems. Adapted from https://kumu.io/iccm/iccm-systems-framework#iccm-systems-framework/supply-chain-commodities?focus=1 (accessed on 16 December 2023).

2. Materials and Methods

2.1. Study Setting

The study was undertaken in an iCCM program implemented in ten zones of Tanganyika Province, DRC between September and November 2016 (Figure 2). The program description and data collection protocol are published elsewhere [12]. Briefly, the iCCM program was implemented as an at-scale intervention in the province between 2013 and 2017 to address child mortality attributable to malaria, pneumonia, and diarrhea [13]. Diagnostics and treatment were provided by community health workers (CHWs), known as Relais Communautaires (ReCos), who administered services directly in communities of defined hard-to-reach catchment areas. Funding was provided by the government of Canada to recruit and train ReCo cadres, collect data, support supervision, ensure the procurement and distribution of medical products, and facilitate policy reform. Implementation was supported by an international non-governmental organization (NGO), the provincial MoH, and the World Health Organization (WHO).

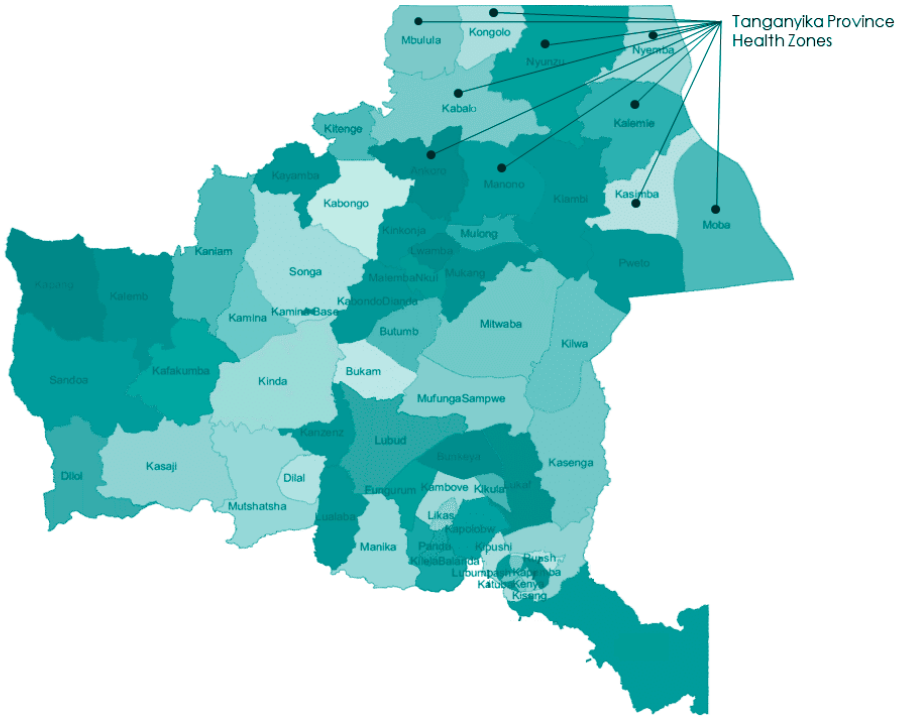

Figure 2. Ten health zones of Tanganyika Province, DRC, comprising the study setting.

2.2. Study Design, Data Collection, and Analysis

We followed a qualitative study design using the standard framework method and applied a systems thinking lens to evaluate data on supply chain processes and challenges [14,15]. Table 1 provides a brief summary of data elements. Full details of the data collected are available separately [12]. We collected experiences and perspectives from semi-structured key informant interviews from program partners at the international, national, provincial, and zonal levels of the administrative hierarchy who were involved at various stages of the procurement, storage, and distribution of iCCM commodities. We conducted focus group discussions with ReCo supervisors at the health facility, ReCos, and caregivers of children in participating communities. Finally, we performed a document review of key policy and program documents relating to supply chain processes and products. Data were charted, coded, and indexed according to an emergent code frame guided by the supply chain categories in MaxQDA. We developed a process map detailing the iCCM supply chain scheme and its agents, and assessed challenges across its areas. The results of this study will be used to inform a causal loop analysis of the supply chain of iCCM.

Table 1. Summary of data collection.

Data Source	No. Conducted/ Items Retrieved	Description of Participants or Items
Focus group discussions	12 groups 101 participants	ReCos, supervisors, caregivers
Key informant interviews	28 participants	Ministry and iCCM program staff at various administrative levels
Document review	13 documents	iCCM and child health program policies, manuals, guidelines, and protocols; national and provincial supply chain policies and procedures

3. Results

Demographic results of the interview and discussion participants and the document review are published separately [12]. The following results detail (i) the program and policy actors involved at various steps in the supply chain of the iCCM intervention; (ii) a process map of the program's supply chain; and (iii) participant experiences, perspectives, and gaps according to select categories of the supply chain and commodities health systems domain.

3.1. Process Mapping of Procurement and Distribution of iCCM Medical Products

3.1.1. Primary Actors, Administrative Organizations, and Their Roles in iCCM Supply Chain Processes

DRC's supply chain structure is complex and comprises multiple agents across its organizational hierarchy. At the highest echelon, the National Drug Supply Program (Programme National d'Approvisionnemet en Médicaments, PNAM) is the administrative body expected to regulate all national medicine and commodity supply chains. PNAM is responsible for implementing the public supply chain system of DRC, the National Essential Medical System (Système National des Médicaments Essentiels, SNAME). SNAME as a service body controls the procurement of drugs and commodities appearing on the country's essential medicine list. It carries out this mandate through a centralized pharmaceutical procurement system through a nonprofit association called the Federation of Central Purchasing Centers for Essential Medicines (Fédération des Centrales d'Achat des Médicaments Essentiels, FEDECAME), which is tasked with lobbying, purchasing, and distributing essential medicines at the national level. Under FEDECAME are two sub-national purchasing agencies, or Bureau Centrale d'Achats (BCAF), one in Kinshasa (managing the western provinces) and the other in Goma (managing the eastern provinces). These BCAFs are responsible for organizing the commodity requests of each province and managing tenders for the national essential medicines program. The BCAF responsible for

eastern DRC is the Association Régionale D'Approvisionnement en Médicaments Essentiels (ASRAMES). After the acquisition has taken place, BCAFs must coordinate distribution to 16 provincial warehouses or Central Regional Distribution of Drugs (CDR). The CDR coordinates, stores, and distributes drugs designated for all public health structures in the province. The CDR specific to Tanganyika Province is the Centrale d'Achat et de Distribution de Médicaments Essentiels du Tanganyika (CADMETA). CADMETA is not considered its own legal entity; rather, it operates under the direct provincial jurisdiction of the Division Provincial de la Santé (DPS), where purchases and quality assurance are undertaken by the BCA operating under FEDECAME.

The DPS acts as the senior governmental body that manages health activities in the province. While coordinating with the national health system, they oversee all zonal hospitals and health offices (Bureau Centrales de Zones, BCZ) and their corresponding health teams (Equipe Cadres de Zones, ECZ), who in turn manage lower-tier health facilities. The DPS's decentralized nature allows them to operate with near-complete autonomy within the country. The DPS liaises directly with the CDR (CADMETA) for commodities. Together, these structures constitute the primary bodies that control the quantity and flux of mediciens in and out of the province.

In Tanganyika Province, CADMETA is responsible for supplying the General Reference Hospitals (HGR) of the zones and ensuring the availability of drugs. For the Tanganyika iCCM program, the partnering NGO for iCCM implementation was wedged between the DPS and CADMETA and acted as the primary point of contact between the zones for the procurement of iCCM commodities. At the zonal level, an NGO-based iCCM focal person (FP) was positioned in each zone and worked directly with the ECZ, whose members include the Chief Zonal Doctor (MCZ), the BCZ pharmacist, and the designated BCZ iCCM FP, among other zone team members. Some zonal headquarters are merged due to the dearth of facility structures.

Each zone is divided into administrative units called aires de santé (health areas), where an infirmière titulaire (IT) acts as the director of the area's health facility, as well as the overseer of all health activities within the health area. They are direct supervisors to a designated group of ReCos, who are the CHWs that deliver care directly in communities within the iCCM framework. ITs submit monthly data to the zone for the procurement of drugs and supplies intended for distribution amongst their group of ReCos. Site Management Committees (COGESITE), Community Animation Committee (CAC), and Aire Development Committee (CODESA) represent lower-level local development committees providing communal oversight of iCCM implementation.

3.1.2. System Overview

The supply chain processes of iCCM products operated as a combined push–pull system. This is contrasted with common supply chain distribution systems of DRC, which are primarily pull, meaning that lower levels request commodities based on need, rather than receiving regular shipments based on a predetermined schedule or long-term projections of demand. The process begins with international product procurement. Commodities were acquired from two sources: at the onset of the program, the NGO requested commodities from European suppliers, where midway through implementation this was shifted to procuration directly from the country's eastern purchasing agency, the BCAF in Goma via the provincial purchasing and distribution agency (CADMETA). Once commodities arrived in the province, they were centrally stored at CADMETA. All zones were expected to request iCCM supplies quarterly directly via the NGO; otherwise, interim emergency orders were placed if forecasted stock levels were low. The BCZ pharmacist, BCZ iCCM FP, and NGO FP were expected to compile requests based on estimated commodity consumption reported by ITs in the zone. This data was validated and sent to the NGO at the provincial capital. Typically, this information would go directly to the DPS, which would then request stocks via CADMETA. However, the implementing partner acted as a stand-in for the DPS. The NGO subsequently confirmed requests, triggering CADMETA to deliver the stocks to

the zones. Once CADMETA had the necessary stocks, they transported the drug shipments by land or by boat.

Once shipments arrived in the zones, the BCZ FP, NGO FP, and BCZ pharmacist would run inventory and stock supplies. A BCZ FP notifies ITs of the shipment, who are expected to fetch these at the zone headquarters. Once at the health facility, medicines are recorded in the iCCM registry. The IT notifies their ReCos, who are expected to retrieve these supplies at the facility. Typically, ITs and ReCos restock medicines monthly, while the BCZ is expected to maintain a six-month stock provision Health facilities are expected to receive one month's worth of stocks plus a one-month security stock, with health centers over 150 km from the BCZ receiving a three-month stock provision, along with a one-month security stock. Figure 3 depicts the flow of medical products in the iCCM package, detailing procurement and distribution levels, key agents, and reasons for delays.

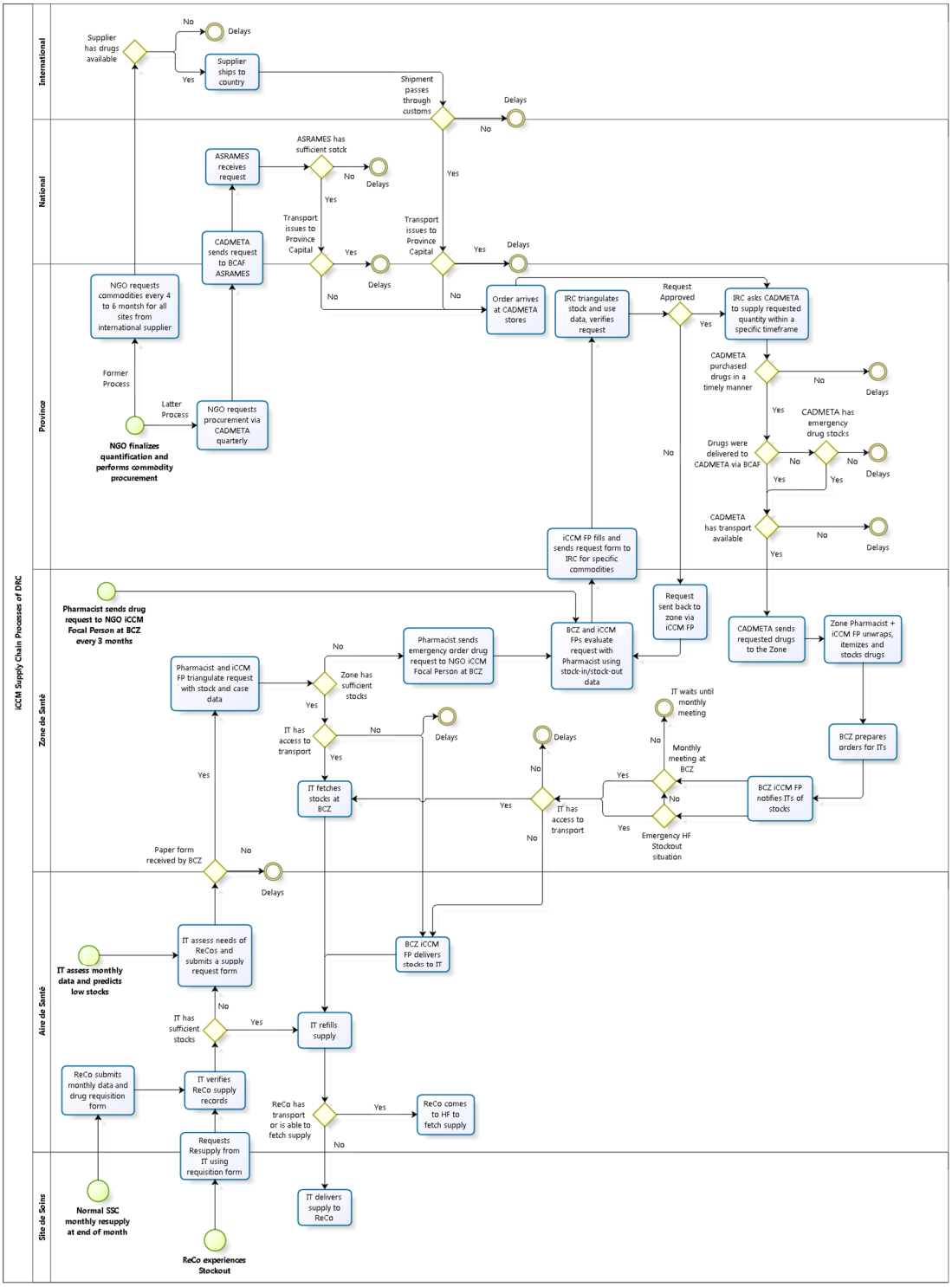

Figure 3. Process map of iCCM supply chain procurement and distribution pathways, gateways, and obstacles from local stockout to international procurement in Tanganyika Province, DRC. Abbreviations: ASRAMES—Association Régionale D'Approvisionnement en Médicaments Essentiels, Regional Association of the Procurement of Essential Medicines; BCAF—Bureau de Coordination des Achats FEDECAME; Central buying unit; BCZ—Bureau central zone de santé, central office of the health zone; CADMETA—Centrale d'Achat et de Distribution des Médicaments Essentiels dans le Tanganyika, Central Purchasing and Distribution of Essential Medicines in Tanganyika; DPS—Division Provincial de la Santé; HF—health facility; IT—infirmière titulaire, registered nurse; FP IRC—International Rescue Committee; NGO—nongovernmental organization; ReCo—Relais communautaire; SSC—site de soins communautaires, community health site.

3.2. Supply Chain Thematic Areas

This section details categories of the supply chain thematic domain as they relate to processes and program agents. Figure 4 summarizes the primary bottlenecks identified across the administrative hierarchy of iCCM.

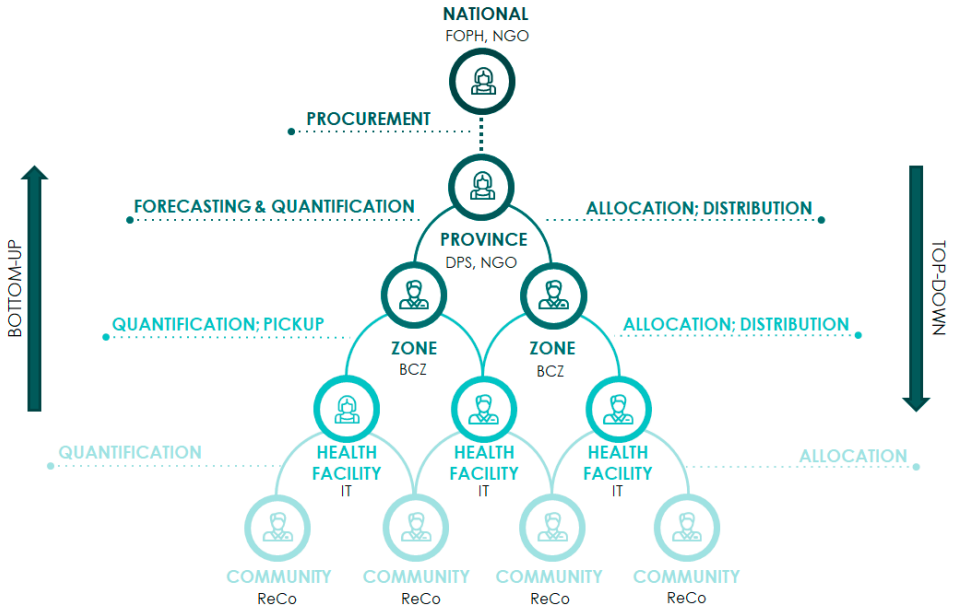

Figure 4. Summary of identified primary supply chain bottlenecks, their locations, and their direction across administrative strata. Abbreviations: BCZ—Bureau central zone de santé, central office of the health zone; DPS—Division Provincial de la Santé; FOPH—Federal Office of Public Health; IT—infirmière titulaire, ReCo supervisors; NGO—Non Governmental Organization; ReCo—Relais communautaire, community health worker.

3.2.1. Drugs and Commodities, Quality, and Sustainability

The drugs and diagnostic tools that comprised the iCCM commodity package were (i) a timer; (ii) malaria rapid diagnostic tests (RDT); (iii) 50 mg and 135 mg tablets of artemisinin combination therapy (ACT) for children ages 12 to 59 months; (iv) amoxicillin 250 mg dispersible tablet; (v) paracetamol 100 mg tablet; (vi) zinc 20 mg tablet; (vii) low osmolarity oral rehydration salts (ORS); and officially (viii) rectal artesunate suppository (RAS) 50 mg and 200 mg. Zone staff reported that RAS was no longer appearing among the collection of commodities and had been stocked out for at least 7 months up to the date of data collection [1].

Products were well received by communities, with high self-reported acceptance and use. Quality assurance of iCCM products was ensured by initial procurement from select international vendors before this was changed to the local purchasing agency. Commodities were described by caregivers as high-quality and efficacious, where they claimed that rapid visible changes in their children encouraged preference for iCCM products over traditional medicine and in some cases even those at the health facility. Caregivers, ReCos, and some ITs strongly felt that more commodities should be encompassed within the service delivery package to better match community demand. The lack of community availability of RAS was lamented among zonal staff due to its use as emergency pre-referral treatment.

The continued procuration of the original commodity brands used during the program was not likely after the program handover to the ministry, according to the DPS. Rather, the commodities expected to be procured post-partner exit would rather be those that are ordered via ASRAMES, the regional purchasing agency.

3.2.2. Quantification and Allocation

Quantification procedures in the program were non-standardized, requiring different data elements and calculations at varying administrative levels, while omitting critical measures defining product need. Additionally, allocated product quantities rarely matched the requested stock volume. ITs and ReCos were expected to ultimately drive calculated quantities projected for provincial procurement, but much of their data was not incorporated into upstream requisition calculations that determined procured stock volume. This resulted in a feedback loop of substandard quantification, which drove inadequate supply and underestimated need, further compounding insufficient procurement.

Official policy on quantification processes was conflicting. Some ministry documents stated that an initial allocation for ReCos was calculated using 30% of the average monthly consumption per IT's ReCo group. Other documents specified that the quantity is expected to be equivalent to a two-month supply evaluated using the ReCo catchment population, 50% of the consumption rate of products at the ReCo's site, expected incidence rates, and the doses necessary for treatment per case. However, different zones used different calculations, where none of the above indicators were taken into account aside from use. Rather, the quantity of drugs that the IT provides to the ReCo is based on an average one-month supply of consumption based on a period of six months, in addition to a one-month security stock.

At the community level, ReCos conduct a semi-annual calculation known as the "calcule moyenne mensuelle" (CMM), averaging the total consumption over two quarters. This informs the monthly order quantity "quantité à commander" (QAC) for each commodity, calculated as twice the CMM minus the remaining stock after a physical inventory. Despite ReCos providing their calculated needs to their supervisors, requisitions submitted by ITs loosely aligned with these requests. Most ReCos reported consistent stockouts and inadequate quantities to meet patient demand across all three commodity groups.

Formula 1. Quantification formula for a monthly order of commodities for SSCs according to Manuel de l'Encadreur, PCIME Communautaire.

$$QAC = \left\{ \left(\frac{6\ month\ consumption}{6} \right) \times 2 \right\} - Remaining\ Stock \quad (1)$$

At the health facility level, the quantification process conducted by ITs appeared inconsistent, influenced by various factors such as irregular ReCo requests, stock utilization, ReCo distance, and remaining quantities at the end of the month. ITs also considered the ReCo caseload, leading to cyclical misrepresentation of demand as ReCos reported advising caregivers to seek assistance elsewhere during stockouts instead of documenting cases. Catchment populations exhibited poor accuracy and failed to consider patients outside the catchment area. The utilization of these data for needs calculation in health facilities was limited. Notably, seasonality was not considered in determining ReCo needs according to IT practices.

Discrepancies in calculation procedures were observed between health facilities and the zone, particularly for outgoing quantification for the province and allocated quantities to supervisors. BCZ pharmacists' reports varied on indicators used, such as ReCo caseload, community-level demand, site distance, number of ReCos, IT distance from the BCZ, and available conservation space. However, no interviewed ITs mentioned using a formula incorporating this information or receiving products based on these criteria. Moreover, zonal actors lacked access to much of this information when analyzing IT stock requests. Procurement requests at the BCZ were triangulated using ReCo case data aggregated by the IT, stocks on hand, and drugs dispersed, with limited consideration of geospatial information. Supervisors were considered best-positioned to assess ReCo needs, and only some pharmacists reported training on iCCM drug quantification. Multiple national and international partners' involvement in health programs led to a surplus of certain products in zonal warehouses, complicating product allocation to ITs.

Quantities requested from the zone were aggregated and electronically transmitted to the province. Provincial-level quantification occurred at the NGO partner, where quantities

for the next procurement level were supposed to be determined based on requisitions from zones, the number of functional sites, and pricing. However, quarterly quantification estimates revealed a fixed expected number of cases per ReCo, documented as CMMs but in fact representing blanket averages across all ReCos and zones. Table 2 illustrates trimestral estimations at the provincial level and the basis for product calculations.

Table 2. Example of provincial quarterly requisition estimates based on average caseload, May 2017.

Commodity Requisition	Expected New Cases per ReCo
RDT	40 cases per month
Paracetamol	40 cases per month
Rectal artesunate	0.5 cases per month
Amoxicillin	10 cases per month
ORS	10 cases per month
Gloves	40 cases per month

CADEMTA procurement orders occurred quarterly. Quantification of iCCM products in collaboration with the provincial ministry (DPS) was limited, and was typically conducted at the NGO provincial headquarters. The NGO reported strong general collaboration between itself and the DPS in program implementation; however, resource constraints led to the division of program activities.

3.2.3. Ordering and Procurement

Emergent and contradictory systems behavior was observed when major changes in provincial procurement temporarily strengthened local systems, but did so at the expense of ministry involvement. Initially, the NGO sourced iCCM commodities from European suppliers, causing substantial delays due to mandatory bulk orders. With a growing number of iCCM sites and a requisition of at least a six-month supply to satisfy demand, ordered quantities were continuously high, thus increasing waiting periods for shipments. Recognizing severe stockouts resulting from this approach, the NGO transitioned to local procurement through the provincial purchasing agency (CADMETA). CADMETA would receive order quantities from the NGO and source these via the regional purchasing agency (ASRAMES). Critically, the DRC MoH did not purchase iCCM commodities for any province, which were procured independently without national oversight.

The use of CADMETA for local procurement offered advantages by sourcing commodities through an established national institution, reducing resupply delays, reinforcing local capacity, and providing a funding source enabling public health facilities to acquire other products. However, this approach risked undermining efforts to strengthen the existing supply chain, as the NGO acted as an intermediary between zones and CADMETA instead of facilitating direct ordering between zones and the CDR. Despite an emphasis on tracking and verifying product requests, the process required zonal pharmacists to resubmit requisition forms to the NGO, which placed orders on behalf of the zone. This introduced two additional steps between zones and the purchasing agency, deviating from the regular zonal procurement process.

Zonal actors raised concerns about CADMETA's effectiveness, pointing to significant stockouts in late 2016. The handover of procurement responsibilities to CADMETA and leadership changes in international oversight coincided with this drop in supplies. The initial attribution of stockouts predominantly to CADMETA may have failed to consider handover delays or issues at ASRAMES, rather than deficiencies in the CDR or changes in technical leadership. Despite challenges, stockouts of other drugs somewhat stabilized post-handover.

This transition also posed challenges for zonal procurement. When the pharmacist and the zone NGO FP managed orders quarterly, requisition requests were instead directed straight to the NGO, circumventing CADMETA. This introduced a parallel requisition operation that was no longer based solely on zonal calculated need and upon request

(pull system). This was further complicated by the non-involvement of the provincial government (DPS) in product procurement, combined with near-exclusive zone reliance on international health program partners for drugs. Few of these used the local system to procure or deliver supplies. This subtracted the zone from the ordering process and bypassed the DPS.

Supply requests between ReCos, ITs, and the zone were submitted monthly via a paper-based system. Order frequency increased during stockout periods, which was particularly challenging for ITs, who often traveled long distances of up to 200 km to reach their zone headquarters. Both ITs and ReCos faced financial challenges, with inadequate stipends for ITs to undertake all iCCM activities (USD 20) and no reimbursement for ReCos, making travel to health facilities financially burdensome and physically taxing. After the program handover to the ministry, the continuity of iCCM procurement processes relies on BCZ FPs, shifting the responsibility from the NGO to the state. This poses challenges for sustainability as zone financing and oversight have not been designated for this role. All zonal actors emphasized the need for a replacement program partner to ensure continued iCCM commodity procurement post-partner exit.

3.2.4. Transmission, Distribution, and Reception

One of the primary bottlenecks in the supply chain was identified as the distribution of products, notably between the province and zone, and the zone and health facility. Distribution mechanisms were dynamic and evolving, introducing unpredictable product delivery and availability. Constraints affecting commodity delivery across all levels included intersecting cross-system issues related to consistent financing, infrastructure, climate, human resources, ethnic violence, and access to transport.

Upon amassing sufficient stock, the purchasing agency (ASRAMES) would transport goods 700 km for storage at CADMETA. Subsequently, CADMETA, upon receiving a mandate from the NGO (or DPS), used land or water transport to deliver products to the zones. At the zone, a member of the ECZ or the NGO FP notified ITs of the shipment for pickup. Depending on timing, ITs might await the monthly zone meeting for drug collection, while those facing urgent stock needs often traveled immediately, sometimes by bicycle or on foot. Zone actors underscored the importance of direct supply delivery to ITs at the facility due to distance and limited IT resources. Tracking pickups is the responsibility of the BCZ FP, without a standardized procedure. ITs sign a zonal registry upon receiving supplies. Once iCCM supplies reach the health facility, ReCos are notified for retrieval, confirming reception upon collection. ITs consider this confirmation process crucial to validate drug delivery.

Province-to-zone distribution faced challenges due to inconsistent financing. The NGO's shift to stock procurement via CADMETA improved delivery speed to the province. However, zone delivery speed remained contingent on the ready availability of vehicles, boats, and fuel. CADMETA initially faced transport difficulties due to the closure of some secondary zonal warehouses. The iCCM program offered sporadic financing for this distribution structure. Provincial managers anticipate ongoing challenges post-partner exit, as the internal public zone delivery system relies entirely on external funding.

The ReCo requisition process was described as complicated. ReCos submitted a request form in duplicate, requiring IT validation before presenting it to the pharmacist for retrieval. ReCos often waited to retrieve drugs if the IT was absent, which was considered common in some zones. In some cases, ITs would deliver products directly to ReCos at significant distances. ReCos would often go to the health facility by foot or bicycle; however, most described their bikes provided by the project as being broken down or unusable.

Supervisors highlighted the dedication of CHWs to maintaining a liquid supply. Stockouts were attributed not to ReCo's inability or unwillingness to collect products, but mainly to health facilities running out of iCCM supplies. Actors at all levels emphasized that the most significant distribution gap was from the zone to health facilities.

3.2.5. Inventory and Storage

Despite regular inventory practices across all cadres, effective product tracking was impeded by poor data systems. At the provincial and zonal levels, this was further challenged by the oversight of multiple programs, inadequate space, and disorganized stocking systems.

iCCM commodities destined for Tanganyika Province are stored at ASRAMES warehouses in Goma, which maintained well-structured storerooms implementing inventory software. CADMETA's provincial warehouses, however, faced challenges with insufficient space to house all needed medical products for the province, affecting procurement quantities. Inventory is conducted with limited staff and outdated technological systems, relying on the National Health Information System (SNIS) for stock-flow monitoring. This provides little to no visibility of actual product on hand.

Zones stocked supplies at their local BCZ, usually located at the regional hospital (HGR). Storerooms were described as often cramped and uncooled, posing challenges especially where two zone capitals were shared between one hospital building. Inventory practices varied, where pharmacists conducted inventory checks monthly or quarterly. Many had developed their own systems to identify and retrieve drugs but struggled with product tracing due to paper-based systems or the absence of tracking tools. Zonal pharmacists stressed the difficulty of tracing stock flows without software, impacting stock management, forecasting and quantification, and data utilization. BCZ pharmacists unanimously called for stock management software to enable them to perform their functions effectively.

At the health facility, ITs conduct monthly inventory based on reported ReCo consumption and track product outflow. iCCM drugs are stored separately for community use, with generally acceptable storage conditions, though concerns about space and security were raised. supervisors and ReCos are expected to verify stocks in communities monthly using informal paper or iCCM-specific forms. ReCos were provided with drugboxes for storage, but not all have received them.

3.2.6. Stockouts and Emergency Orders

Provincial and national stakeholders openly addressed stockouts in community sites, attributing them to challenges in transporting commodities between the zone and health facilities. In cases of provincial stockouts, the DPS mitigated gaps by substituting malaria commodities from other programs. Stockouts showed stabilization after CADMETA took over drug procurement, except for amoxicillin and RAS, which exhibited significant fluctuations. Late 2016 amoxicillin stockouts were attributed to the handover of the procurement mandate to CADMETA.

Zonal actors faced stockouts primarily due to insufficient commodity distribution. At the health facility level, ITs believed stockouts sometimes resulted from difficulty reaching the zone for pick-up, but were largely due to poor allocation during retrieval and stockouts at the zone. In stock-out scenarios, ITs sought supplies from nearby supervisors before contacting the central office.

Nearly all ReCos experienced stockouts at different frequencies across zones Some sought supplies from neighboring sites or directed patients elsewhere, submitted emergency orders, or retrieved the product for caregivers at the facility. Stockouts also held implications for the way certain medicines were used. In instances of simple malaria and ACT stockouts, some ReCos administered RAS if available and sought alternative products at the facility, increasing the chances of its use as a monotherapy.

4. Discussion

In this paper, we mapped the supply chain processes and actors involved in an iCCM program implemented in Tanganyika Province, DRC, assessing bottlenecks at different administrative strata and across select thematic areas of the supply chain.

Our study found critical challenges within the procurement, quantification, and distribution processes at specific administrative levels that encumbered iCCM supply chain health (Figure 4). Stockouts were a common occurrence in communities and were considered by each agent group from the zone to the community to be the result of insufficient quantities available at the antecedent level. Some of the greatest gaps identified in this study that propelled inferior stock availability were (i) procurement processes between the national and province level; (ii) challenges in product distribution between the province, zones, and their facilities; and (iii) quantification and product allocation processes which did not account for critical data elements to appropriately forecast adequate stock volume.

Various quantification procedures outlined in different policy guidelines referred to inconsistent criteria to calculate necessary stock quantities for different program agents, while no trimestral estimates at any administrative level incorporated this information into their calculations. Resultant top-down calculations undercut actual needs. This difference grossly undermined requested stock orders and introduced a domino disconnect, resulting in miscalculations that aggregated and compounded to the highest level, requested quantities that were not respected, and true commodity demand that was almost never met.

Similar challenges have been documented extensively in SCM studies of community health programs in LMICs, including Ethiopia, Mozambique, Malawi, Rwanda, Uganda, and DRC [19–27]. This is worrisome considering the increased amount of product in the hands of CHWs globally, whose expansion in some countries is increasing faster than any other health cadres [28]. Program manuals and government guidelines should be updated and standardized to ensure consistent forecasting and quantification formulas with required elements that extend from the national to community level, that account for the usual necessary data for logistics management as well as contextual factors including population and season [19,29]. This should be extended to data registries and forms for essential data elements to calculate needs. Controls should also be introduced to ensure effective downward allotment of these products, and that requested quantities are checked against allocated amounts.

Poor data recording, use, communication, and visibility were determined to be the root causes of many iCCM supply chain deficiencies. This notion is reinforced by the fact that disaggregated CHW data are rarely integrated into country health data systems, and their reports are seldom used to inform forecasting [30,31]. This is exacerbated by the fact that the current health information system (SNIS) is disjointed and considered an important source of inadequate planning and supply. Another factor that can affect the supply chain but was not verified by our study was the deviation of drugs from the public to the private sector. Transparent end-to-end access to granular, real-time stock information, including product on hand, quantity dispensed, and geolocation, and linking these with cases and other data elements could vastly improve forecasting and inventory while streamlining allocation and distribution processes and preventing product loss [32]. Simple programmatic provisions for telephone communication could also facilitate the exchange of information relatively inexpensively, where calls could be organized to crosscheck stock information and emergent challenges. While common infrastructural and financial concerns about the implementation of SCM software in LMICs are well-founded, some scalable solutions have been proposed [33]. The quality of supply chain systems could be reinforced by linking an HMIS system to inform product needs based on cases and spatio-temporal epidemiology data [34]. Blockchain-based supply chain solutions may also be able to answer challenges through the use of smart contracts to track, trace, and improve data quality and visibility at relatively lower costs and increased accessibility [35,36].

Such a trustless system could simultaneously remove the need for expensive third-party centralization and gatekeeping, and improve information flows [36].

International procurement introduced significant delays at the province level due to orders of bulk quantities of stock from disjointed suppliers, which decreased after the change to purchasing through the national system. This shift in the provincial procurement process had the potential to strengthen existing local the local health system, but the exclusion of the provincial ministry and zone health teams undermined this, introducing a parallel sub-process. Additionally, while reports of drug quality during the program were high, the government would not continue to procure the same products after the program handover to the public sector. The use of parallel processes in supply chains and other system processes in health interventions has been noted as a critical gap in sustainability [37]. Efficiency in managing the complexities of many streams, agents, and partners is particularly challenging in light of perishables and cold chain products, and is often leaned on as the reason for the development of alternative procurement or delivery mechanisms that future planners have no intention of sustaining [37,38]. Indeed, some health program managers have historically prioritized achieving targeted objectives with an "at-all-costs" mentality, which can come at the expense of the development of the local system [39,40]. Some community-based programs have been found to use external suppliers throughout the duration of their programs, while others introduced a private distribution mechanism that funneled products directly to communities, both with mixed results [41,42]. The DRC program benefitted from the use of existing distribution mechanisms, but future efforts should focus on building local capacity for managing procurement practices with the ministry and zone teams to promote seamless handover and uninterrupted supply.

The success of the supply chain was found to be nearly completely reliant upon last-mile distribution, where supervisors and CHWs were expected to absorb the programmatic and opportunity costs of drug pickup and delivery. Irrespective of these challenges and the critical nature of their role in the supply chain, the community level had little to no ostensible effect on stockouts experienced during the duration of the program. Rather, distribution between the province and zones and zone to health facility were identified as some of the strongest gaps. Similarly, distribution problems were the most frequently reported challenge in a recent systematic review of supply chains in community health programs [43]. This can also be because distribution is a more visible challenge for individual providers, often assumed by them. Relying on supervisors to channel products from the district headquarters to facilities is common in CCM programs [25,41,44]. The extent to which this added to the supervisor's work burden was commonly reported in our study. However, the ethics of assigning more responsibilities to providers to not simply reduce but subsume program costs, and the extent to which supervisors should be expected to undertake these tasks temporarily and in the long term, should be strongly reconsidered by planners when designing robust supply chains for their programs. At minimum, adequate financing for consistent transport commensurate with true costs for supervisors and CHWs, or the provision of such transport would likely help support better supply chain fitness. Lastly, programmers should also be wary to not circumvent this challenge by direct product delivery to supervisors or CHWs outside of established health system processes, as has also been documented across a number of CCM programs [41,45–48]. This introduces provisionary supply pathways, which serve the purpose of meeting short-term program goals at the expense of genuine health systems strengthening.

5. Conclusions

Healthy supply chains are more than simple product delivery systems; they comprise an ecosystem of partners that exchange information on demand and consumption. The emergent phenomena observed in DRC's community case management supply chain described were the result of various system interdependencies. Scaleable solutions for community-based supply chains in LMICs should concentrate on addressing the causes of bottlenecks, such as data visibility and use to procure sufficient product quantities and

allocate them effectively; earmarked financing for or designated development of timely delivery systems; and the use of existing systems instead of the development of parallel processes; rather than patching their symptoms.

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Notes

[1] While all of the medicines listed in this study were technically included as items within the country's national essential medicines list (2010) [16], only some formulations were listed as actually being available at or procured for health facilities or general hospitals. While rectal artesunate (100 mg suppositories) is included in WHO's Model List of Essential Medicines [17] and Model List of Essential Medicines for Children as of 2017, it was not yet a part of DRC's most recent Essential Drug List at the time of this study. Only from 2017 onwards was quality assured RAS was available on the market [18].

References

1. Yadav, P. Health Product Supply Chains in Developing Countries: Diagnosis of the Root Causes of Underperformance and an Agenda for Reform. *Health Syst. Reform* **2015**, *1*, 142–154. [CrossRef] [PubMed]
2. Dowling, P. *Healthcare Supply Chains in Developing Countries: Situational Analysis*; DELIVER PROJECT, Task Order 4; USAID: Arlington, VA, USA, 2011.
3. Bennett, S.; Glandon, D.; Rasanathan, K. Governing multisectoral action for health in low-income and middle-income countries: Unpacking the problem and rising to the challenge. *BMJ Glob. Health* **2018**, *3*, e000880. [CrossRef] [PubMed]
4. Fanelli, S.; Salvatore, F.P.; De Pascale, G.; Faccilongo, N. Insights for the future of health system partnerships in low- and middle-income countries: A systematic literature review. *BMC Health Serv Res.* **2020**, *20*, 571. [CrossRef] [PubMed]
5. World Health Organization. *Improving Health System Efficiency: Democratic Republic of the Congo: Improving Aid Coordination in the Health Sector*; World Health Organization: Geneva, Switzerland, 2015; Available online: https://apps.who.int/iris/handle/10665/186673 (accessed on 8 December 2022).
6. Senge, P.M. *The Fifth Discipline: The Art and Practice of the Learning Organization*; Doubleday/Currency: New York, NY, USA, 1990.
7. Antonacci, G.; Reed, J.E.; Lennox, L.; Barlow, J. The use of process mapping in healthcare quality improvement projects. *Health Serv. Manag. Res.* **2018**, *31*, 74–84. [CrossRef] [PubMed]
8. De Savigny, D.; Blanchet, K.; Adam, T. *Applied Systems Thinking for Health Systems Research: A Methodological Handbook*; McGraw-Hill: London, UK, 2017.
9. Antonacci, G.; Lennox, L.; Barlow, J.; Evans, L.; Reed, J. Process mapping in healthcare: A systematic review. *BMC Health Serv. Res.* **2021**, *21*, 342. [CrossRef] [PubMed]
10. NHS Institute for Innovation and Improvement. *Improvement Leaders' Guides*; Series 1: Process mapping, analysis and redesign; Department of Health: London, UK, 2005.

11. Karim, A.; de Savigny, D.; Awor, P.; Muñoz, D.C.; Mäusezahl, D.; Tshefu, A.K.; Ngaima, J.S.; Enebeli, U.; Isiguzo, C.; Nsona, H.; et al. The building blocks of community health systems: A systems framework for the design, implementation and evaluation of iCCM programs and community-based interventions. *BMJ Glob. Health* **2022**, *7*, e008493. [CrossRef]
12. Karim, A.; de Savigny, D.; Ngaima, J.S.; Mäusezahl, D.; Cobos Muñoz, D.; Tshefu, A. Assessing Determinants of Programmatic Performance of Community Management of Malaria, Pneumonia, and Diarrhea in Children in Africa: Protocol and Data Collection for a Mixed Methods Evaluation of Integrated Community Case Management. *JMIR Res. Protoc.* **2022**, *11*, e33076. [CrossRef] [PubMed]
13. Langston, A.; Wittcoff, A.; Ngoy, P.; O'Keefe, J.; Kozuki, N.; Taylor, H.; Lainez, Y.B.; Bacary, S. Testing a simplified tool and training package to improve integrated Community Case Management in Tanganyika Province, Democratic Republic of Congo: A quasi-experimental study. *J. Glob. Health* **2019**, *9*, 010810. [CrossRef] [PubMed]
14. Gale, N.K.; Heath, G.; Cameron, E.; Rashid, S.; Redwood, S. Using the framework method for the analysis of qualitative data in multi-disciplinary health research. *BMC Med. Res. Methodol.* **2013**, *13*, 117–124. [CrossRef]
15. Karim, A.; Cobos Munoz, D.; Mäusezahl, D.; de Savigny, D. A systems approach to assessing complexity in health interventions: An effectiveness decay model for integrated community case management. *Glob. Health Action* **2020**, *13*, 1794106. [CrossRef]
16. *Liste Nationale des Médicaments Essentiels*; Révision Mars 2010; Ministre de la Santé de RDC: Kinshasa, Democratic Republic of the Congo, 2010.
17. *WHO Model List of Essential Medicines*; World Health Organization: Geneva, Switzerland, 2017.
18. Lengeler, C.; Burri, C.; Awor, P.; Athieno, P.; Kimera, J.; Tumukunde, G.; Angiro, I.; Tshefu, A.; Okitawutshu, J.; Kalenga, J.-C.; et al. Community access to rectal artesunate for malaria (CARAMAL): A large-scale observational implementation study in the Democratic Republic of the Congo, Nigeria and Uganda. *PLOS Glob. Public Health* **2022**, *2*, e0000464. [CrossRef]
19. Chandani, Y.; Andersson, S.; Heaton, A.; Noel, M.; Shieshia, M.; Mwirotsi, A.; Krudwig, K.; Nsona, H.; Felling, B. Making products available among community health workers: Evidence for improving community health supply chains from Ethiopia, Malawi, and Rwanda. (Themed Issue: Current scientific evidence for integrated community case management (iCCM) in Africa: Finding. *J. Glob. Health* **2014**, *4*, 020405. [CrossRef]
20. Rao, V.B.; Schellenberg, D.; Ghani, A.C. Overcoming health systems barriers to successful malaria treatment. *Trends Parasitol.* **2013**, *29*, 164–180. [CrossRef] [PubMed]
21. Chandani, Y.; Noel, M.; Andersson, S.; Ombeva, A.; Shieshia, M.; Heaton, A.; Felling, B.; Mugeni, C. Improving community level supply chain performance using team-led, data driven solutions in Malawi and Rwanda. *Am. J. Trop. Med. Hyg.* **2013**, *89*, 327–328.
22. Miller, N.P.; Zunong, N.; Al-Sorouri, T.A.A.; Alqadasi, Y.M.; Ashraf, S.; Siameja, C. Implementing integrated community case management during conflict in Yemen. (Research Theme: Community health in emergencies). *J. Glob. Health* **2020**, *10*, 020601. [CrossRef]
23. Henriksson, D.K.; Fredriksson, M.; Waiswa, P.; Selling, K.; Peterson, S.S. Bottleneck analysis at district level to illustrate gaps within the district health system in Uganda. *Glob. Health Action* **2017**, *10*, 1327256. [CrossRef] [PubMed]
24. USAID. *Mozambique: Strengthening the Community Health Worker Supply Chain*; Deliver Project. Final Report; USAID: Arlington, VA, USA, 2014.
25. Global Fund; WHO; UNICEF. *Integrated Community Case Management (iCCM) in Sub-Saharan Africa: Successes & Challenges with Access, Speed & Quality Thematic Review Report*. 2018. Available online: https://www.childhealthtaskforce.org/resources/presentation/2019/thematic-review-iccm-success-challenges-access-speed-quality-e-shargie (accessed on 3 February 2024).
26. Altaras, R.; Montague, M.; Graham, K.; Strachan, C.E.; Senyonjo, L.; King, R.; Counihan, H.; Mubiru, D.; Källander, K.; Meek, S.; et al. Integrated community case management in a peri-urban setting: A qualitative evaluation in Wakiso District, Uganda. *BMC Health Serv. Res.* **2017**, *17*, 785. [CrossRef] [PubMed]
27. VillageReach. *Exploring New Distribution Models for Vaccines and other Health Commodities Adapted to the on the Ground Realities of the Equateur and Tshuapa Provinces, Democratic Republic of Congo*; VillageReach: Seattle, WA, USA, 2015.
28. Javanparast, S.; Windle, A.; Freeman, T.; Baum, F. Community Health Worker Programs to Improve Healthcare Access and Equity: Are They Only Relevant to Low- and Middle-Income Countries? *Int. J. Health Policy Manag.* **2018**, *7*, 943–954. [CrossRef] [PubMed]
29. John Snow, Inc. *Quantification of Health Commodities: A Guide to Forecasting and Supply Planning for Procurement*; John Snow, Inc.: Arlington, VA, USA, 2017.
30. John Snow, Inc. *Baseline Assessment for Cstock*; John Snow, Inc.: Boston, MA, USA, 2018.
31. Vledder, M.; Friedman, J.; Sjöblom, M.; Brown, T.; Yadav, P. Improving Supply Chain for Essential Drugs in Low-Income Countries: Results from a Large Scale Randomized Experiment in Zambia. *Health Syst. Reform* **2019**, *5*, 158–177. [CrossRef] [PubMed]
32. Lufesi, N.N.; Andrew, M.; Aursnes, I. Deficient supplies of drugs for life threatening diseases in an African community. *BMC Health Serv. Res.* **2007**, *7*, 86. [CrossRef]
33. John Snow, Inc. *Information Systems for Supply Chain Management: The Case for Connecting Separate and Interoperable Technology Applications for Logistics Management Information System and Health Information Management Systems Data*; John Snow, Inc.: Arlington, VA, USA, 2017.
34. Sant Fruchtman, C.; Mbuyita, S.; Mwanyika-Sando, M.; Braun, M.; de Savigny, D.; Cobos Muñoz, D. The complexity of scaling up an mHealth intervention: The case of SMS for Life in Tanzania from a health systems integration perspective. *BMC Health Serv. Res.* **2021**, *21*, 343. [CrossRef]

35. Pisa, M.; McCurdy, D. *Improving Global Health Supply Chains through Traceability*; CGD Policy Paper; Center for Global Development: Washington, DC, USA, 2019; Available online: https://www.cgdev.org/publication/improving-global-health-supply-chains-through-traceability (accessed on 9 December 2022).
36. Zhu, P.; Jian, H.; Yue, J.; Xiaotong, L. A Blockchain Based Solution for Medication Anti-Counterfeiting and Traceability. *IEEE Access* **2020**, *8*, 184256–184272. [CrossRef]
37. Lugada, E.; Komakech, H.; Ochola, I.; Mwebaze, S.; Olowo Oteba, M.; Okidi Ladwar, D. Health supply chain system in Uganda: Current issues, structure, performance, and implications for systems strengthening. *J. Pharm. Policy Pract.* **2022**, *15*, 14. [CrossRef]
38. Schell, S.F.; Luke, D.A.; Schooley, M.W.; Elliott, M.B.; Herbers, S.H.; Mueller, N.B.; Bunger, A.C. Public health program capacity for sustainability: A new framework. *Implement. Sci.* **2013**, *8*, 15. [CrossRef] [PubMed]
39. Denyer Willis, L.; Chandler, C. Quick fix for care, productivity, hygiene and inequality: Reframing the entrenched problem of antibiotic overuse. *BMJ Glob. Health* **2019**, *4*, e001590. [CrossRef]
40. Hilton, C. Healthcare poverty-inequality and government quick fixes. *BJPsych Bull.* **2021**, *45*, 68. [CrossRef] [PubMed]
41. Nanyonjo, A.; Counihan, H.; Siduda, S.G.; Belay, K.; Sebikaari, G.; Tibenderana, J. Institutionalization of integrated community case management into national health systems in low- and middle-income countries: A scoping review of the literature. *Glob. Health Action* **2019**, *12*, 1678283. [CrossRef]
42. VillageReach. *Outsourcing Transport to Improve Health at the Last Mile: A Case Study the Long Road to Health*; VillageReach: Seattle, WA, USA, 2016.
43. Olaniran, A.; Briggs, J.; Pradhan, A.; Bogue, E.; Schreiber, B.; Dini, H.S.; Hurkchand, H.; Ballard, M. Stock-outs of essential medicines among community health workers (CHWs) in low- and middle-income countries (LMICs): A systematic literature review of the extent, reasons, and consequences. *Hum. Resour. Health* **2022**, *20*, 58. [CrossRef] [PubMed]
44. Briggs, J. *Procurement and Supply Management for iCCM—Common Challenges. System for Improved Access to Pharmecuticals and Services*; USAID: Nairobi, Kenya, 2016.
45. Keane, E. Integrating Severe Acute Malnutrition into the Management of Childhood Diseases at Community Level in South Sudan Malaria Consortium Learning Paper Series. 2013. Available online: https://www.malariaconsortium.org/media (accessed on 10 December 2022).
46. Wharton-Smith, A.; Counihan, H.; Strachan, C. Implementing Integrated Community Case Management: Stakeholder Experiences and Lessons Learned in Three African Countries. 2014. Available online: https://www.malariaconsortium.org/learningpapers. (accessed on 9 December 2022).
47. World Health Organization and the UNICEF. *Institutionalizing Integrated Community Case Management (iCCM) to End Preventable Child Deaths: A Technical Consultation and Country Action Planning, 22–26 July 2019, Addis Ababa*; World Health Organization and the United Nations Children's Fund (UNICEF): Geneva, Switzerland, 2020.
48. Chandani, Y.; Duffy, M.; Lamphere, B.; Noel, M.; Heaton, A.; Andersson, S. Quality improvement practices to institutionalize supply chain best practices for iCCM: Evidence from Rwanda and Malawi. *Res. Soc. Adm. Pharm.* **2017**, *13*, 1095–1109. [CrossRef]