RELMBUSS BILJERS FANDA

Systems in Between

A Mixed-Methods Study Developing and Using a Local Pharmaceutical System Approach in Indonesia

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Relmbuss Biljers Fanda

The research for this dissertation was conducted at Erasmus School of Health Policy and Management (ESHPM), Erasmus University Rotterdam. The research received financial support from the Indonesia Endowment Fund for Education Agency – Lembaga Pengelola Dana Pendidikan.

Cover design by Suci Erika Nataliyani (Instagram: @sucierika_n)

Systems in Between:

A mixed-methods study developing and using a local pharmaceutical system approach in Indonesia

Systemen ertussenin:

Een mixed-methods studie naar de ontwikkeling en toepassing van de farmaceutische systeembenadering in Indonesië.

Thesis

to obtain the degree of Doctor from the

Erasmus University Rotterdam

by command of the

rector magnificus

Prof.dr.ir. A.J. Schuit

and in accordance with the decision of the Doctorate Board.

The public defence shall be held on

Friday, 06 March 2026 at 10.30 hrs

by

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born in Kupang, Indonesia.

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Introduction

> "Achieve universal health coverage, including financial risk protection, access to quality essential health-care services, and access to safe, effective, quality and affordable essential medicines and vaccines for all."

The above passage is taken from Sustainable Development Goal target 3.8, which identifies access to essential medicines as a global health concern, especially for countries aiming to achieve universal health coverage (UHC). Lack of access to these medicines affects nearly two billion people, most of whom live in low- and middle-income countries (LMICs) [1]. The issues of low availability, affordability, poor quality, and safety are nothing new when it comes to medicines and continue to hamper access to and the quality of health services.

Availability of essential medicines is also unequally distributed within some larger countries, with variations being reported in the literature. In India, availability differed from one province to the next, ranging from 43% in Bihar to 88% in Tamil Nadu [2]. In China, health facilities in the east reported a higher availability of essential medicines than those in the central and western regions [3]. In Brazil, the average availability of essential medicines in the north and northeast was reported to be lower than in the southeast, with differences of up to 14% [4].

Variations in regional capacities pose challenges to the national government's efforts to develop and bolster policies that balance the conflicting interests of all actors in ensuring access to medicines. The value for money achieved in medicine procurement differs from one sub-national region to another, depending on their budgets and health programme priorities. For example, in India, 2% of the public health expenditure on medicines in one state may be equivalent to 17% of that of another [5]. Districts with limited purchasing power attempting to keep costs low may still overrun their public budget [6]. The variation in public expenditure is one of the socioeconomic and geographical factors influencing access to medicines, which are often interconnected [7]. Such variation may prevent a national policy based on a single design from working well for all districts, because each district has different needs and capacities.

Existing frameworks to ensure access to medicines rarely focus on the organisation of medicine supply at more local levels within a country. Although existing frameworks presented by the WHO Collaborating Centre for Pharmaceutical Policy and Regulation, Management Science for Health, and Wirtz et al. have contributed valuable knowledge, they are limited in their ability to improve and assess the national pharmaceutical system [8–11]. These top-down approaches might not be suitable for some larger countries, such as India, Indonesia, and Brazil, because their standardised approach does not take regional variation into account. They further ignore layered policymaking, even though many countries have decentralised health systems, with local and regional governments organising medicine supplies.

One exception is the framework put forward by Bigdeli et al., who suggested a complex adaptive systems approach to improving access to medicines in LMICs [12]. Their framework addresses multiple structures of the pharmaceutical system and advises starting the analysis at the individual or community level and working up to cross-sectoral policies and the international context. Still, this framework does not take into account variations in the health system, including health facilities and local governance.

There is thus a need for an approach that allows for the layered nature of medicine supply, local and regional variations in resources, and geographical conditions, as well as reactions from the local healthcare system. In this thesis, I aim to understand how local systems operating within a national system work to ensure equal access to medicines for all the citizens of the country. Equal access means everyone receives the medicines they need. I also examine which elements and outcomes of a local pharmaceutical system could ensure access to medicines. Evidence from this study can be used as guidance for countries with a three-tier governance structure—national, local, and health facilities—to strengthen the local government as a critical link in the health system. This empirical and analytical approach can aid in understanding and addressing local differences in access to medicines and the functions of pharmaceutical systems, for example, by helping countries determine to what extent they can adjust their standards and governance mechanisms.

For my research, I selected Indonesia to test our approach due to the suitability of its healthcare landscape. Most Indonesian health and policy implementation programmes, including those related to medicine provision, are managed at the local level. Over 500 local governments are responsible for ensuring that more than 10,000 primary health centres are adequately stocked with the medicines required by their communities. Variations in local contexts—such as demographics, socioeconomic conditions, and health development status—pose significant challenges for the national government in designing a one-size-fits-all policy. These local differences, combined with the involvement of multiple actors within Indonesia's health and pharmaceutical systems, have given rise to complex system dynamics and interactions.

Understanding these variations and local system behaviours is critical to supporting Indonesian policymakers in their efforts to achieve health equity through tailor-made local efforts. The benefit of such an approach is that it ensures that all local governments can work towards achieving national health development targets while accounting for local variations. It also supports Indonesia's National Agenda for Health System Transformation, ensuring that every aspect of this system promotes equal access to healthcare nationwide.

In this introductory chapter, I set out the background to my study. I discuss prior evidence regarding access to medicines in Indonesia and other countries with similar features, e.g., LMICs and countries with multilevel governance structures. I begin by examining the scale of the problem of global access to medicines and the complexity involved in managing medicines. I then discuss existing approaches to improving pharmaceutical systems within a country. This knowledge informs our case for focusing on the local system perspective. Because my proposal to define a local pharmaceutical system is new, I then turn to the core of my argument, which presents various theoretical angles that can be used to understand complex systems and local system performance. This theoretical section is followed by an explanation of my methodology and an outline of the thesis. In the final section, I explain the Indonesian setting of the health and pharmaceutical systems that ensure access to medicines.

Lack of access to essential medicines as a global health concern

Access to essential medicines has long been a worldwide concern, and many publications have been devoted to disseminating knowledge about this subject. A quick search in the PubMed database shows that the first paper discussing the "access to medicines" theme was published in 1979, and the number of similar publications has increased in recent years, as Figure 1 shows.

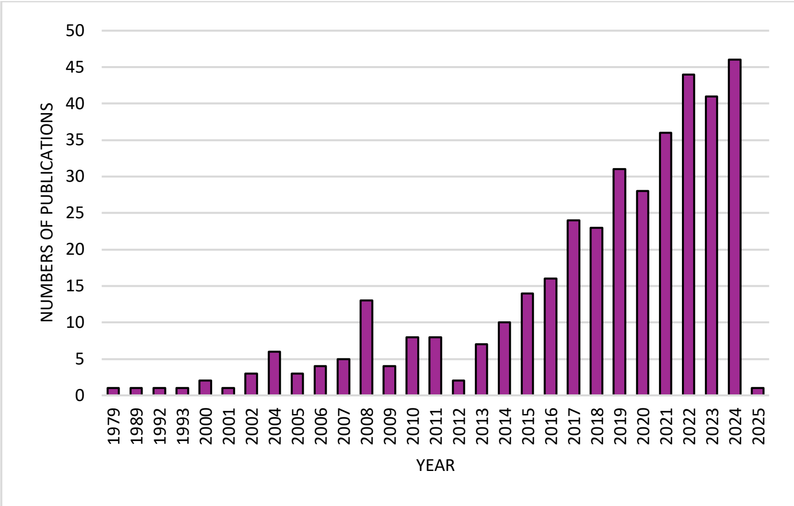

Figure 1. Number of academic publications in PubMed addressing access to medicines (accessed 6 January 2025).

One example is the current debate about what medicines should be listed in the WHO's Essential Medicines List (EML). First published in 1977 and continuously updated, the WHO EML has offered 150 countries successful guidance [13]. The first edition defines essential medicines as those that meet the most basic healthcare needs of a population. More recently, in the 2022 edition, essential medicines refer to those that can satisfy the priority healthcare needs of the population, which should be based on their value in relation to the country's disease prevalence, public health relevance, and purchasing power [14]. The updated definition underscores the core problem of the WHO EML: to what extent is it appropriate for every country in the world, given that countries vary in terms of their national health priority agenda and political direction? The long-standing tension between high-cost medicines with better efficacy and national budgetary problems remains unsolved [15]. Depending on their financial capacity, some countries may classify medicines for rare diseases as essential, whereas these same medicines might be out of reach for other countries.

Another example is the debate about including pembrolizumab, an immunotherapy drug, in the WHO EML [16]. This medicine can cost EUR 143 or more per infusion vial, but its cost-effectiveness remains unclear. Despite a price reduction, it remains unaffordable for many LMICs. Including it on the EML may compel some countries to procure it, potentially leaving LMICs with a sense of injustice and a feeling of being left behind as they witness other WHO member states prescribing this medicine for their patients.

While the discussion about the list's contents is unresolved, prior studies show that public health facilities in LMICs continuously struggle with the availability of essential medicines listed on the WHO EML. A systematic review in 2009 stated that the availability of essential medicines in these countries' public sectors was as low as 46% [17]. More recent empirical studies reported that the availability of medicines remained low in such countries as the Philippines (30.1%), Pakistan (35%), and India (41.3%) [18–21]. While the private sector may afford some access to essential medicines, the associated out-of-pocket payments are often too expensive for people with limited financial capacity [22]. In the private sector, the same essential medicines may cost 25 times more than the international list prices [17]. The promise that UHC would tackle financial constraints in access to healthcare, including medications, has not been fulfilled.

One of many consequences of a lack of access to quality medicines is that people receive suboptimal treatment at healthcare services, or no treatment at all. Low medicine availability or stockouts lead to practitioners reducing dosages, prescribing the wrong medicines, and postponing treatments. For certain disorders, such as cardiovascular diseases, lower medicine availability and affordability are associated with major adverse cardiovascular events, even leading to higher mortality rates [23].

Factors impacting access to medicines within a complex national pharmaceutical system

As discussed earlier, significant variation exists within countries regarding the availability of essential medicines. In my thesis, I focus on identifying the factors that contribute to this variation within a country, in particular the pharmaceutical system. Many countries are attempting to improve their national health performance, but they rarely have a complete understanding of the way in which their pharmaceutical system functions in ensuring access to medicines [24, 25]. There are multiple complicating factors at work here. One is that improving access to quality medicines involves a complex relationship between all the actors and domains within that system [12]. The following paragraphs discuss the complexity of this system based on prior studies.

The performance of a country’s national pharmaceutical system is intertwined with its national health priorities. A pharmaceutical system's primary function is to ensure an adequate medicine supply chain using the country's national EML. However, LMICs often lack the capacity to manage their medicine production locally and rely on imported pharmaceutical products [10, 26]. The role of the national health system in ensuring fairer medicine prices is critical to the sustainability of the pharmaceutical supply chain in LMICs [27].

One critical dimension of pharmaceutical performance is the proper functioning of human resource elements, in this case, the pharmacists. Pharmacists’ availability and performance, in turn, impact the performance of supply chains in delivering medicines to public health facilities [28]. In Saudi Arabia, the distribution of pharmacists tends to vary between less urbanised areas such as Albaha and Bish, which have 4.6 pharmacists per 10,000 population, and urban areas such as Jeddah and Riyadh, which have 9.8 pharmacists per 10,000 population. Extreme shortages of highly qualified pharmacists in remote rural areas have also been found in Kenya, raising concerns about effective public health interventions [29].

The roles and responsibilities of each actor, including pharmacists, medical doctors, and other stakeholders, within a national health system are also complex because they are connected and influence one another [30]. For example, a pharmaceutical company operating a pharmaceutical service in eastern Indonesia developed a system of profit-sharing that assigned the role of medication manager to medical specialists instead of pharmacists [27]. The medicine supply gatekeeper is, therefore, the medical specialist, but the official regulations and the rules governing medical professional competence assign this role to the pharmacist [31]. An actor seen as external to the local pharmaceutical system – i.e., the pharmaceutical company as a national pharmaceutical actor – has distorted that system's operation. Such interactions between actors and elements within the health system are common and make it more challenging for governments in LMICs to ensure access to medicines.

Another crucial factor in ensuring access to medicines is geographical accessibility. For example, difficulties posed by distance and transport systems are described as a barrier to accessing health services in Latin America [32]. Geographical circumstances combined with cultural factors may also play a role; for example, regarding access to chronic medicines in Cape Town, South Africa, people over the age of 45 prefer waiting six hours in a clinic rather than accessing other health service points within a one-kilometre radius [33]. In low-income countries such as Malawi, Uganda, Jordan, and Ghana, as much as 35% of communities must travel long distances because they have no health service provider within a 15-minute travel time range [34–36]. Geographical factors, such as poor roads, limited transport options, and long travel times, continue to play a role worldwide in hindering access to medicines [37].

Existing analytical approaches for understanding a pharmaceutical system using systems thinking

The need to use system approaches to medicine availability is not new and remains relevant to many countries, including LMICs. The first framework to be developed was the Management System for Health in 1995 (Management Sciences for Health, 1995). Scholars worldwide subsequently worked to conceptualise pharmaceutical system performance in ensuring access to medicines, and several pharmaceutical system frameworks have been developed [9, 11, 39–42]. Two frameworks have made a significant contribution by employing complex systems thinking.

The first was a framework developed by Bigdeli et al (2013). This framework addresses access to medicines in a multilevel health system, starting at the individual level and moving on to households, communities (including health service delivery), the health sector, public policies cutting across sectors, and ending at the level of international policies. This grand design has three important features: 1) it takes a complex perspective on demand-side constraints, 2) it allows for multiple and dynamic relationships within the health system based on its six building blocks, and 3) it calls attention to leadership and governance within local, national, and international contexts [12].

The main criticism of the Bigdeli framework is its practicality in the field. While this framework identifies and considers the demand- and supply-side barriers to access and their interactions with the building blocks throughout the various health system levels, it is mainly a conceptual work and has had no empirical follow-up. Hafner et al. (2017) found no further definition of the pharmaceutical system in this framework and subsequent publications [40].

A second attempt to delineate a pharmaceutical system approach was developed by the research group Management Sciences for Health [9]. Drawing on their research, a pharmaceutical system can be defined as "the structures, people, resources, processes, and their interaction within the broader health system that aim to ensure equitable and timely access to safe, effective, quality-assured pharmaceutical products and related services that promote their appropriate and cost-effective use to improve health outcomes" [40]. This group has developed a Pharmaceutical System Strengthening (PSS) framework to measure pharmaceutical systems worldwide.

The PSS framework aims to support stakeholders in LMICs in their efforts to enhance their national pharmaceutical systems and, ultimately, improve both access to and use of medicines. The framework draws on relevant literature, including the WHO Access Dashboard and the Lancet Commission on Essential Medicines Policies [10, 11], and synthesises insights into seven critical system components, taking into account system resilience and performance. A comprehensive list of performance indicators has been developed for these system domains [9]. For example, the % availability across a basket of medicines is an indicator of the performance of the pharmaceutical system, especially its function of ensuring pharmaceutical products and related services. This framework can be used to direct health investments and efforts to problematic domains that need interventions.

The PSS framework simplifies the system of performance indicators and erases the multilevel system perspective. While the first version of the PSS tool encompassed a comprehensive and detailed selection of system domains, the new version, called PSS Insight v2.0, reduces the number of indicators from 117 to 38, recognising that the original number was overly burdensome for LMICs [9]. Soucy Brown et al. (2021) also argue that the pharmaceutical system could be made less complicated by combining system levels 2 to 5 (health service delivery, health sector level, public policies cutting across sectors, and international and regional) into one level, that of the supply-side system.

Although I appreciate the MSH team's effort to make the framework a more practical tool for measuring a country's performance, I question whether this is an oversimplification and suitable for the real practice of pharmaceutical systems. More particularly, the latest PSS framework views a pharmaceutical system as a linear system and removes the complex thinking elements, such as multiple and dynamic system relationships. The conceptual framework of access to medicines developed by Bigdeli et al. (2013) from a health system perspective reflects the system interactions within a national pharmaceutical system, which is more realistic given the actual interactions seen in pharmaceutical systems.

Moreover, neither the PSS nor the Bigdeli framework takes into account the specific problems related to unequal access to medicines *within* a country. The nature of a pharmaceutical system is that it is resource-intensive and involves multiple actors. Implementation assessment and interventions to strengthen pharmaceutical performance at the national level are especially complicated for larger countries because there are more independent entities operating at decentralised levels. Insights that could be gained from regional variations and local pharmaceutical systems within the national system may be overlooked in these frameworks. In the remainder of this thesis, I make a case for taking a holistic view of the local pharmaceutical system. This approach is crucial, especially for larger countries with decentralised systems – such as Afghanistan, Brazil, China, India, Indonesia, Russia, and Tanzania – that need to monitor sub-national performance in medical access. This requires a closer examination of local system performance, such as at the municipal, district, or provincial level. To our knowledge, little is known about the complexity of this local pharmaceutical system. To explore these issues empirically, I selected Indonesia as my case study.

Research gap and question

From a public health perspective, the main objective of this thesis is to improve our knowledge of pharmaceutical systems in order to help stakeholders provide better access to medicines. This effort requires us to better understand a pharmaceutical system's performance in guiding the practical work of health workers. Focusing on the smallest system in the public sector and investigating the other related systems helps us analyse the system's performance. Including local contexts—such as the pharmaceutical system, other health systems, and socioeconomic characteristics—allows us to gain a comprehensive understanding of how these factors interact and shape primary healthcare's performance in delivering medicines to patients. This study seeks to conceptualise the definition and architecture of the local pharmaceutical system, contextualise these to Indonesia's setting, and analyse the system's performance. Based on these arguments, the main research question of this thesis is: **"How do insights into the functioning of the local pharmaceutical system in Indonesia lead to a better understanding of efforts to improve access to medicines?"**

For practical considerations, I have developed three sub-questions to structure this thesis:

1. *How can we conceptualise and assess local pharmaceutical systems from a complexity perspective?*

This first sub-question explores the definition and scope of local pharmaceutical systems. It aims to develop our analytical thinking, informing our knowledge about this local system, including its key features, indicators, and system dynamics.

2. *How does the local pharmaceutical system in Indonesia perform, and how can we explain variations in medicine availability?*

This second sub-question appraises the performance of all Indonesian Primary Health Centres (PHCs) in providing medicines. It seeks to investigate what essential medicines are available at all PHCs, what local and regional variations can be detected in access to essential medicines, and what factors drive better outcomes for the local pharmaceutical system across districts.

3. *How do actors in the local pharmaceutical system deal with predictable and unpredictable system dynamics in the Primary Health Centres' medication management?*

This last sub-question attempts to understand the actual practice of health workers in managing the availability and accessibility of essential medicines. It investigates the actual complexity of medicine supply management practices, including the quantification, procurement, distribution, and dispensing of services in the context of national policies and the health workers' response in the field.

Understanding the nature of complex systems thinking and system complexity

A typical feature of both health and pharmaceutical systems is their complexity, as they involve multiple entities with diverse interests and levels of authority, each working and making decisions independently but interacting with one another. One way to understand complexity in local pharmaceutical system performance is to deal with the complexity itself using the complexity science approach. Complexity science offers an appropriate means towards understanding how health system properties behave or function in a non-linear and interdependent manner, and with a system characterised by fuzzy boundaries. Complexity science can be used as a "grey" science to understand "stuff in between", and referring to the epistemology of complexity thinking requires a high-level conceptual approach to explore various perspectives [43]. One of the theoretical angles that we can use to understand system behaviours is that of a complex adaptive system, defined as **"**a set of multiple individual agents with the freedom to act in ways that are not always totally predictable, and whose actions are interconnected so that one agent's actions change the context for other agents**"** [44]. When analysing pharmaceutical systems as complex adaptive systems, three features are important. We describe them below.

The first is that the system can itself be part of another system, and may have its own sub-systems [45], thus exhibiting fuzzy boundaries between (sub-)systems. Healthcare systems are conceptualised as systems encompassing all entities—including people, materials, organisations, and their relationships—that function to promote, restore, and maintain health [46], while a pharmaceutical system aims to provide better access to medicines for the community. The pharmaceutical system can be treated as a sub-system within the broader health system; however, it is also connected to other systems, such as industrial and economic systems. While each of these systems functions independently to some extent, they are also interrelated and dependent on one another. Importantly, complex adaptive systems have the ability to self-organise, thus responding to internal and external changes.

The second feature of the complex adaptive system approach is that it emphasises interdependencies between system elements. The more independent entities a system has, the more complex the interactions within the system. One insight gleaned from three systematic reviews is that variations in medicine availability are associated with multiple factors. Pharmaceutical and health system determinants that affect medicine availability are health facility level, medicine procurement mechanisms, the presence of medicines on national essential medicines lists, a lack of human resources, poor inventory management, the mechanism of consumption forecasting, and inefficiencies in drug registration processes [47]. Socioeconomic and demographic factors such as the size of populations, the community's ability to pay, the cost of medication distributions on the market, international funding programmes, and trade-related aspects of intellectual property rights agreements have also been found to be important [28, 48]. These elements, both within and outside pharmaceutical systems, are interconnected and support or hinder one another in their functions. Because both the demand and the supply side of these elements are complex and interconnected, access to medicines should be tackled from a health system perspective and consider access constraints at the six different levels (individual; household and community; health service delivery; health sector; public policies cutting across sectors; and international and regional).

The third and final feature of the complex adaptive system approach is its emphasis on non-linearity, which means that a change in the system may lead to unexpected or more worrying chaotic situations or system drift [49]. Complexity science takes the self-organising ability of local practices as a starting point, meaning that central policies will also have unexpected and often unintended effects on the wider system. The interdependent and linked elements within complex adaptive systems often blur the boundaries within and between health and pharmaceutical systems, making it challenging to understand and delineate each element's contribution as an independent output [12, 44]. The concept of system boundaries in a complex healthcare approach can be problematic because fixed boundaries do not exist [43]. Instead, system boundaries are perceived as something temporary that needs to be studied empirically. The complexity across multiple domains also makes the system outputs less predictable, controllable, and amenable [50]. Looking at the interactions between system components helps us understand the variety better than if we were to take a linear approach, as it makes us aware of local variations and how these create new conditions and interactions [51]. Changing a complex adaptive system is, therefore, never simple, as it involves making changes at multiple levels and in different directions simultaneously.

Local systems in a complex health system

In this thesis, I argue that, although a local pharmaceutical system approach may help in understanding how the pharmaceutical system works in most larger countries, what we actually need is a better concept of the local health system. I believe that the term "local" refers to more than a mere spatial delineation; it encompasses a broader system of relationships between component elements, including their interactions, interconnections, and interdependencies. In the context of a health system, these relational and dynamic features can vary significantly from one local system to another [52]. Local wisdom—shaped by specific contexts—is crucial for understanding how health policies, interventions, and programmes are perceived and how they support the work of all the actors, especially those on the front lines in a complex healthcare system [51]. While certain components—like national regulations and central funding—originate at the national level, their influence on local system performance forms an integral part of local system dynamics.

It is essential to explore how local system interactions are shaped in practice and how they interact with actors at other levels. Figure 2 shows the interactions [presented as arrows] among all actors within a national governance system in countries with multilevel governance. Governance systems are layered in the sense that central (i.e., national) policymaking influences resources and decision-making powers at "lower" levels; in multilevel systems, this includes different decision-making centres with their own resources and possibilities. The "lowest" level is usually where policies are implemented in clinical practice. However, governance systems are not unidirectional, and implementors can connect and communicate directly with national stakeholders. Moreover, decision-making is never linear, because lower levels of government can exercise discretion, something often unforeseen by national policymakers.

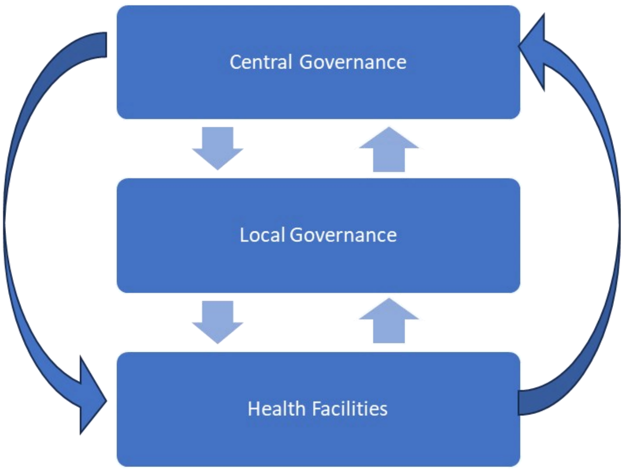

Figure 2. Interaction between actors in a multilevel health system (source: authors)

In a health system context, variation among local systems is also influenced by external health system factors, such as the availability of financial and non-financial resources, cultural values, and other social contexts. For example, it has been found that community health workers' motivations and job satisfaction are associated with their target community's income level, local social and cultural norms, logistics and supplies of health products, and health policies and practices [53]. In the case of sub-national and district governance, the local context may encompass—but not be limited to—political geography, rural areas and districts, the wealth index of the area, public and private health facility developments, and local epidemiological health problems [54–58]. Health facility characteristics may include ownership (public or private), type and number of health workers employed, and the level at which the facility operates, such as primary, secondary, or tertiary [59–61]. The combination of factors differs across local systems, producing local, context-specific characteristics. In this thesis, I focus mainly on the ground-level system, i.e., the health facility, but include relevant relationships with actors at provincial and district levels.

A glance at Indonesian health and pharmaceutical systems

Indonesia, a country situated at the confluence of the Pacific Ocean, the Malacca Straits, and the Indian Ocean, with over half of all international shipping passing through its waters, has the largest pharmaceutical market in Southeast Asia. Indonesia ranks 16th globally in terms of total gross domestic product (GDP), which has been growing steadily over the past two decades. In the last ten years, Indonesia's healthcare industry has doubled in size, reflecting the country’s significant growth and development. In 2022, its health expenditure was estimated at around USD 47.1 billion (3.7 % of GDP). Indonesia has a population of more than 270 million, making it the fourth most populous country in the world. Its population is spread out over five million square kilometres, equal to the distance from London to Tehran or a third of the entire European continent.

Ensuring access to medicine is an integral part of universal health coverage in Indonesia[62]. In 2014, the country introduced a national health insurance scheme for Indonesian citizens*, Jaminan Kesehatan Nasional* (JKN), which does not cover out-of-pocket spending on health care [63]. The JKN incorporates an agenda of equitable medicine distribution and affordability across the country that was embedded in its national medicine policy in 2006. By 2023, after nine years of JKN implementation, 95% of the Indonesian population was enrolled in this social insurance system [64]. As a result, access to quality health services, including access to medications, has become an implicit right for all Indonesians.

Recently, this upper-middle-income country in Southeast Asia has been striving to transform its national health system comprehensively, including by improving the performance of its pharmaceutical system and the resilience of its health system. In 2022, the Indonesian Ministry of Health backed the vision of former President Joko Widodo to ensure equitable access to healthcare for all citizens. Six domains have been addressed in the transformation agenda: primary healthcare, referral care, health resilience, health financing, human resources, and technology. More details can be found in Figure 3. This agenda builds and improves on ongoing efforts to achieve universal health coverage, a goal pursued since 2004[62]. The intention is to ensure that all citizens, regardless of their location, have access to all necessary treatments, including the medications they require, without facing any financial barriers.

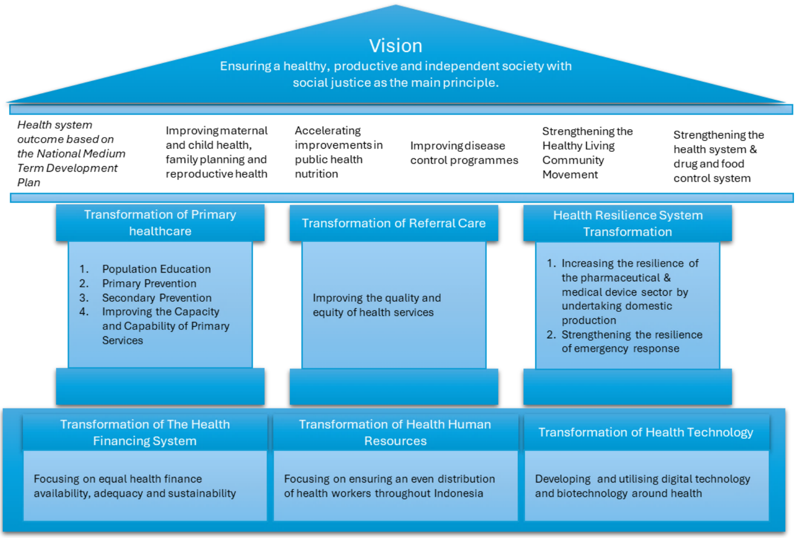

Figure 3. The Indonesian Health System Transformation Agenda

The exceptional context of Indonesia delivers benefits for and poses challenges to its national health and pharmaceutical system, one being the variation in sub-national contexts and capacity. More than 80% of Indonesia's landscape is covered by water, making it the largest archipelago in the world and resulting in profound variations in population density, fiscal capacity, and access to health services. The population is not evenly distributed; more than 50% of Indonesians reside in the Java and Bali region, the most developed region, consisting of only 23 of Indonesia's more than 17,000 islands [65]. Financially, districts located in Java and Bali generally have greater fiscal capacity than those located in other regions (as shown in Figure 4a).

This financial disparity is also reflected in healthcare accessibility, including access to Primary Health Centres (PHCs). As one of the main building blocks in the transformation agenda, over 10,000 PHCs play a crucial role as the backbone of the national health system [66, 67]. PHCs are the most accessible health service point for the population, and for this reason, a sub-district always has one or more PHCs. In the UHC scheme, almost everyone on a limited income is registered at a PHC as their first-level health provider, the hope being that the PHC can address their basic health issues before they need a hospital referral [68]. PHCs are more densely distributed across Java and Bali, whereas access remains a major challenge in some larger districts in Papua, Sumatra, and Borneo (see Figure 4b). Even more concerning is that many PHCs in Papua and other disadvantaged districts outside Java and Bali lack pharmacists, limiting access to essential medications, as illustrated in Figure 4c.

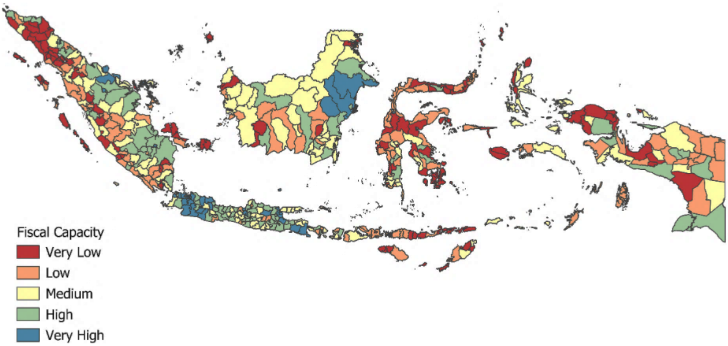

Figure 4a. Map showing the fiscal capacity rating of the 514 districts in Indonesia, measured in 2019

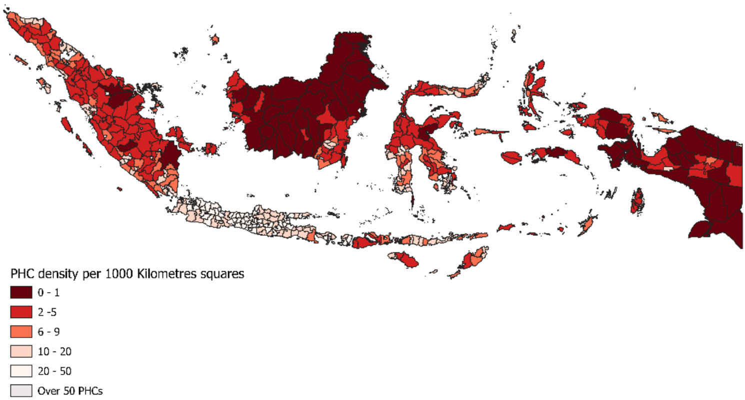

Figure 4b. PHC density per 1000 square kilometres in all districts in Indonesia in 2019

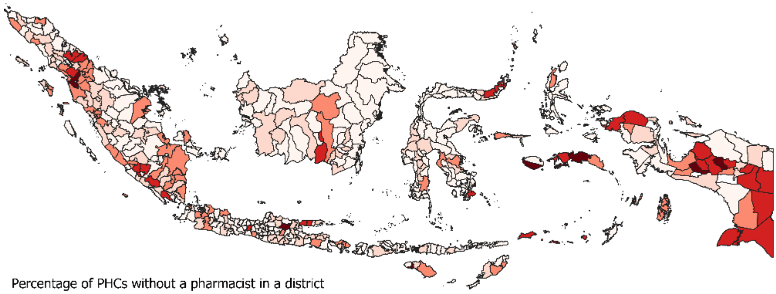

Figure 4c. Percentage of PHCs without a pharmacist available in all districts in Indonesia in 2019

Medicine provision in the Indonesian public sector and its complexity

Previous reports have charted remarkable progress in making medicines available in Indonesia's public sector. The Indonesian Ministry of Health reported a high availability of essential medicines at PHCs, at 93.6% [69]. However, the most recent National Health Facility Survey reported conflicting findings. In 2004, the average availability of medicines at PHCs was only 46% [70]. This disparity raises a critical question about the extent to which progress can be effectively achieved within a complex health system, and whether the figures accurately reflect the actual situation.

Smaller studies also cast doubt on the overall progress in medicine availability in the public sector by reporting lower figures. Recent case studies in large cities in Java, where 90% of the country's medicine manufacturers and national distributors are located, have highlighted ongoing issues with medicine shortages. In the capital city of Jakarta, a third of PHCs ran out of essential hypertension medications for over a year [71]. In Yogyakarta, the availability rate for fifty essential medicines at public facilities was 76.6% [72]. Additionally, a study focusing on Surabaya found that stocks of one in four essential medicines at PHCs were below required levels [73]. A 2017 study in the Keerom district located on Papua Island found that, of the 35 prioritised medicines, 29% were out of stock, and 7% of the available medicines had expired [74].

The provision of medicines at PHCs is, moreover, complicated by the structure of the mixed medicines market. The market has more than 200 registered manufacturers that produce more than 30,000 medicinal products and 2,211 wholesalers or distributors. Private retail pharmacies, numbering around 30,000, are perceived as a threat but can also be beneficial in supporting PHC performance [75]. For example, some private pharmacies provide free medicines under a returned-referral programme (PRB) for chronic patients with non-communicable diseases. Multiple actors have their own interests, and this adds to the complexity of medicine procurement and supply across the country, with multiple relationships based on procurement types in the pharmaceutical system.

The complexity of medicine procurement is closely tied to the intricacies of the supply chain and variation in the pricing of medicines. Some prices listed on the national e-catalogue platform appear significantly lower than the international list prices. For instance, 39% of the medicines registered in this national procurement system have had their retail price reduced by up to 70%, with some medicines priced up to 134 times lower than the lowest price point in the public sector [76, 77]. This dramatic price reduction has led to negative profit margins and a lack of financial incentives for suppliers, resulting in their refusing orders from the public sector. It is simply not profitable for them to serve PHCs in areas where the cost of distribution is high, especially in the case of low-priced medicines [27]. Although the e-catalogue has made essential medicines more affordable, setting prices nationally fails to account for district-level variations. As a result, the benefits of the lower prices accrue disproportionately to districts in the Java and Bali region, while those in more remote areas continue to pay more due to logistical challenges and supply chain constraints. Even more concerning is that these areas remain underserved within the national medicine procurement system, highlighting that a single, centralised policy cannot address the diverse needs and realities of medicine procurement across Indonesia.

To understand the effects of this complexity and variation, we need information about the more localised government system and how medication availability is managed at the PHC level. Access to medicines was impacted by health system decentralisation to the district level when, in 2001, the central government transferred power and authority to district governments to develop and implement most of its public health programmes. The 514 District Health Offices (DHOs) are therefore vital in managing medicines for the more than 10,000 PHCs [78]. A DHO establishes medicine purchasing plans, procures medicines, and oversees logistics and utilisation for a whole district [63]. While their financial capacity, local political agenda, and governing capacity varies, the districts are nevertheless responsible for public sector performance, including the DHOs in providing medicines for the PHCs [78].

Methodological approaches

In this thesis, I employ a comprehensive, sequential, mixed-method approach consisting of an integrative review, quantitative and qualitative research, and data collection using methods that include a systematic search of literature reviews, policy document reviews, secondary analysis of nationally representative data, panel data reviews, and interviews. Below, I describe my research approach in more detail.

The first phase of my research was crucial in shaping the subsequent phases. It involved a comprehensive review of the academic and grey literature. I focused on documents that presented a framework or policy direction using a systems thinking approach. The result of this phase, our proposed analytical framework, was then reviewed by external experts **(Chapter 2)**.

The second phase involved contextualising the local pharmaceutical system approach to the Indonesian setting and identifying the factors that matter to medicine availability. After studying the Indonesian pharmaceutical system that provides medicines in the public sector, I specifically zoomed in on medicine availability at the PHC level. I analysed the problem of medicine availability based on multiple national datasets and charted the progress made in the delivery of essential and problematic medicines, and in problematic districts **(Chapter 3)**. During my research, I noted all possible covariates that potentially matter to medicine availability at PHCs and tested a total of 65 covariates for their association with the system outcome **(Chapter 4)**.

In the final phase, I carried out interviews with health workers in two districts about how they managed their medicines. I started by collecting their medicine stock reports on ten selected essential medicines for basic health services at the PHCs, such as maternal and child health, tuberculosis, and non-communicable diseases. I explored the reasons for stock fluctuations over a four-year period. The Bantul district in the Java and Bali regions and the Kupang district in Eastern Indonesia were selected to represent districts with advantages and disadvantages based on their PHC performance in medicine availability **(Chapter 5)**.

Thesis outline

This thesis consists of one review chapter, three empirical chapters, and one concluding chapter. More details are outlined below:

Chapter 2 – Assessing the performance of the local pharmaceutical system: An analytical approach to improve – conceptualises an analytical framework for defining a local pharmaceutical system (LoPhaS) and identifying its goals, scope, and main features. The chapter describes how we built the architecture of the LoPhaS based on the existing literature addressing access to medicines and improvements to the pharmaceutical system.

Chapter 3 – The availability of essential medicines in Primary Health Centres in Indonesia: Achievements and challenges across the

Archipelago – examines the availability of essential medicines in PHCs across Indonesia, why medicines are unavailable, and the extent to which communities have access to alternative dispensaries. The chapter focuses on describing progress and success in making essential medicines available at PHCs.

Chapter 4 – Local Systems, Local Solutions: Which factors drive essential medicine availability in public health facilities across Indonesia? – identifies the determinants of medicine availability using the LoPhaS approach across the entire population of PHCs in Indonesia.

Chapter 5 – Managing medicines in decentralisation: Addressing discrepancies between national policies and local practices in primary healthcare settings in Indonesia – reports our investigation into the discrepancies between national policies and local practices, shedding light on coping mechanisms employed in each phase of medicine management within PHCs.

Chapter 6 – General discussion of the four chapters – highlights the main findings from the integrative reviews and empirical studies and reflects on their implications for complexity theory and practices in healthcare and pharmaceutical systems. The chapter also gives recommendations for building knowledge and improving the current performance of the LoPhaS in Indonesia.

Chapter 2:
Assessing the performance of Local Pharmaceutical Systems: an analytical approach to improve access to medicine

This chapter was published as:

Kok, M. O*., Fanda, R. B*., Lubbers, R. U., van Gurp, M., Ravinetto, R., & Probandari, A. (2025). Assessing the performance of local pharmaceutical systems: an analytical approach to improve access to medicine. The Journal of Medicine Access, 9, 27550834251371502.

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Abstract

Well-functioning pharmaceutical systems are crucial for ensuring universal access to medicines and their appropriate use. While existing frameworks for analysing pharmaceutical systems generally focus on the national level, in many countries, the core functions are often managed locally within a broader national framework. Despite this local focus, there has been no effort to conceptualize a 'local pharmaceutical system' as a distinct entity with its own goals, functions and operational components. A method for analysing and comparing the performance of local pharmaceutical systems (LOPHAS) within a country is still lacking. We aim to develop an analytical approach and framework to assess the performance of LOPHAS and guide improvements in access to essential medicines. We conducted an integrative literature review and consulted with purposively selected experts. We systematically searched for existing approaches for conceptualizing or assessing pharmaceutical systems and empirical studies in which these were applied and combined this with insights from 23 reviews and guidebooks suggested by experts to develop the LOPHAS approach and framework. We identified 13 existing frameworks and 16 studies that had applied these frameworks to analyse pharmaceutical systems. Building on these findings, we propose that a LOPHAS has six core functions: (1) local governance, (2) managing product supply, (3) financing, (4) developing human and physical resources, (5) appropriate dispensing and use of medicines and (6) monitoring performance. For each function, we defined operational components and indicators. The primary outcomes of a LOPHAS are access to medicine and appropriate use of medicine. The LOPHAS framework provides a practical tool for assessing and comparing the performance of LOPHAS. By identifying areas for improvement, it can guide policymakers, healthcare providers and local administrators in strengthening systems to ensure that essential medicines are accessible and used appropriately, supporting broader health goals.

Plain Language Summary

Developing an Approach to Assess the Performance of Local Pharmaceutical Systems and Improve Access to Medicine

Why was the study done? Access to medicines is essential for public health, and well-functioning pharmaceutical systems play a critical role in ensuring that medicines are available, affordable and used appropriately. Most existing frameworks for assessing pharmaceutical systems focus on the national level, but many key functions, such as medicine distribution and use, are managed locally. Despite this, there has been no clear way to define or evaluate 'local pharmaceutical systems' as unique entities. This study aimed to fill this gap by developing a method to assess local pharmaceutical systems (LOPHAS) and identify ways to improve their performance. What did the researchers do? The researchers conducted a comprehensive review of the scientific literature to identify existing methods for analysing pharmaceutical systems and consulted experts to gather additional insights. Using this information, they developed an analytical framework, named the LOPHAS approach, that defines the key functions and indicators needed to evaluate LOPHAS. What did the researchers find? The researchers identified 13 existing frameworks and 16 studies that had applied these frameworks to analyse pharmaceutical systems. Building on these findings, they proposed six core functions of a LOPHAS: governance, supply management, financing, human and physical resource development, appropriate dispensing and use of medicines and performance monitoring. For each function, they outlined specific operational components and measurable indicators. How is this useful? The LOPHAS framework provides a practical tool for assessing and comparing the performance of LOPHAS within a country. By identifying areas for improvement, it can guide policymakers, healthcare providers and local administrators in strengthening systems to ensure that essential medicines are accessible and used effectively.

Introduction

Around the world, countries struggle to ensure access to safe, quality-assured, and affordable medicines for their populations. In many low- and middle-income countries, the average availability of medicines falls well below the 50% threshold in public facilities and below 70% in the private sector [79, 80]. Access to medicines also varies widely within countries [37, 81]. Studies consistently reveal significant disparities in medicine availability across districts, provinces, and regions—differences that are often obscured by national averages [37, 82, 83]. These local disparities exacerbate inequalities, as medication availability tends to be higher in affluent urban areas and lower in rural and remote areas, where residents typically have lower incomes and less access to health services [84–87]. Limited access to medicines and high prices pose serious risks to patients' health by increasing the likelihood of non-treatment, inadequate treatment, and catastrophic health expenditure. Moreover, poor availability in public facilities and licensed pharmacies drives patients to seek medications from unregulated outlets, heightening the risk of encountering costly, expired, and substandard or falsified medications [88, 89].

Ensuring access to quality-assured and affordable medicines and promoting their appropriate use requires a well-functioning pharmaceutical system [90]. Drawing upon work by Hafner et al., [91] we define a pharmaceutical system as the people, practices, structures, and resources and their interactions within the broader health system that aim to ensure equitable and timely access to safe, effective, affordable, and quality-assured pharmaceutical products and related services that promote their appropriate use to improve health outcomes. While it can be useful to describe a pharmaceutical system as a set of components, the mutual dependencies and interconnected practices and structures together make it function as a system [12, 46, 91]. Even when pharmaceutical systems are not deliberately designed or centrally organized, they do emerge as de facto systems through the patterns of actions and interactions of those who procure, store, distribute, prescribe, and use medicine within the larger world in which they are embedded [92]. Like most systems involving humans, pharmaceutical systems are complex, contingent, and locally specific and co-evolve with the larger societal structures in which they operate, such as the health system, pharmaceutical market, and political economy [12, 25]. Several pharmaceutical system frameworks have been developed [39, 41, 42, 91, 93] and empirical studies have demonstrated their utility in guiding analyses of national pharmaceutical systems [94–97].

While the national level may seem the logical focus from a policy perspective, many countries have decentralized the organization of core functions of their pharmaceutical system that directly affect access to medicines to a more local level. For instance, in Indonesia, the local authorities in each of the 514 districts are responsible for forecasting local medicine needs, procurement and distribution [84, 98]. These districts operate relatively autonomously as local systems, with large variations in terms of medicine availability, affordability, and accessibility [72, 99]. Comparable decentralized systems are in place in several other, often larger, countries like Brazil, India, the Philippines, and Nigeria [19, 100, 101]. In this article, we present a strategy for assessing the performance of local pharmaceutical systems and exploring the underlying causes of disparities in access to medicine across different regions.

Core functions of a pharmaceutical system that are typically organized at the local level include forecasting medicine needs, procuring, storing, and distributing medicines to facilities [82]. Local organization of these functions offers notable advantages, allowing for tailored medicine supply to meet local needs and circumstances and accountability to local communities [102, 103].

Even in countries with decentralized systems, certain functions remain centralized at the national level, such as regulating market authorization, vigilance, trade, and taxation of pharmaceutical products [91]. Furthermore, establishing rules and regulations regarding medicine pricing, distribution, and prescription practices is commonly managed at the national level [82]. Although the national level holds formal authority, local authorities and stakeholders may still wield significant influence over these functions, as they are often tasked with interpreting and enforcing policies and regulations within their local contexts [100, 104]. There are also system functions organized at both the national and local levels, such as the financing of publicly procured medicines, which is often sourced from national and local budgets [96, 105, 106].

In addition to the local organization of system functions, local circumstances can significantly influence the supply, pricing, and accessibility of medicines [107, 108]. Challenges like poor infrastructure, distance to suppliers, and local insecurity can complicate and escalate the cost of medicine supply in both the public and private sectors [37, 100, 109–111]. Considering these local conditions is essential for understanding the disparities in access to medicines across different regions within a country.

While many core functions of pharmaceutical systems primarily operate at the local level, there is presently, to the best of our knowledge, no dedicated analytical framework designed to evaluate the performance of a local pharmaceutical system (LOPHAS). Such an approach and framework have the potential to offer a standardized method for mapping and comparing the performance of local sub-systems within the same country, facilitating learning from variations in how local systems operate, perform, and develop over time. Additionally, it may offer guidance when designing and testing interventions to enhance pharmaceutical system performance.

The aim of our study is to develop an analytical approach and framework for measuring, analysing, and comparing the performance of local pharmaceutical systems. To achieve this, we conducted an integrative review, synthesizing pharmaceutical system frameworks, empirical studies, and insights from purposively selected experts [112]. Drawing upon these insights, we present a local pharmaceutical system as a mixed, nested, complex adaptive systems, that should be analysed using a holistic perspective, taking into account the dynamic relationships between medicines, other components of the health system, and markets at multiple levels. To guide analyses and comparison of local pharmaceutical systems, we defined the functions and operationalized components of LOPHAS, which we then linked with relevant indicators. As an analytical strategy, we propose assessing disparities among local systems within a country, integrating performance metrics with data about how local systems are organized, and supplementing quantitative evaluations with qualitative investigations into actual practices and interactions among system components and levels.

Methods

We developed the Local Pharmaceutical System approach and framework in three stages. We started with conducting an integrative review to identify existing system approaches and frameworks that conceptualize and describe a pharmaceutical system. We chose to conduct an integrative review since it allows for the inclusion and integration of insights from a variety of both theoretical and empirical literature to understand a phenomenon of concern more fully [112]. Next, we searched for empirical studies in which these frameworks are used, and empirical analyses that explicitly use a systems approach to analyse the functioning of a pharmaceutical system or supply chain. In the second stage, we read, analysed and compared the identified system frameworks, assessed the main domains and functions described in each framework, and summarized the insights from the empirical studies that were relevant to the operation and performance of local pharmaceutical systems. Using the constant comparative method of analysis, we synthesized these insights into a first draft of an analytical framework that describes the main functions of a LOPHAS. We continued by formulating indicators for each of these core functions. In the third stage, we shared the description of the LOPHAS framework and its functions and indicators with seven purposively selected experts and asked them to provide feedback and suggestions for improvement. In the results section, we describe the framework and the core functions, which result from the integrative and interpretive development process.

Literature search

The search strategy is depicted in Table 1 with search terms and databases. Searches were conducted in PubMed and Google Scholar. Our study had the following in- and exclusion criteria:

- Explicitly using a systems perspective
- English literature
- 1990 until the end of June 2024
- Peer-reviewed research articles
- Grey literature, which is explicitly based on empirical research

An iterative process was employed, using the results and bibliographies of relevant studies to guide subsequent searches. The search was considered saturated when no noticeably new publications emerged. The snowball method was applied by consulting the bibliographies of key studies and identifying studies that cited them to uncover additional relevant research.

Relevant studies were independently searched by three authors, and the titles and abstracts were screened for relevance. Studies that met the criteria were compiled into a CSV file in Excel. Studies were included if they assessed the functioning or strengthening of a pharmaceutical system using a systems approach. Once search saturation was reached, the CSV file was screened for duplicates, which were then removed. The relevant studies were organized in Zotero [113] and reviewed by two authors. Articles that met our inclusion criteria were included in the final review and analysis.

Data evaluation

Since an integrative review allows for the inclusion of many different types of research, we used the Mixed Methods Appraisal Tool (MMAT) to appraise the quality of studies [114, 115]. Developed to evaluate qualitative, quantitative, and mixed methods research, the MMAT is specifically designed for reviews that include diverse study designs. It enables the appraisal of five categories of studies: qualitative research, randomized controlled trials, non-randomized studies, quantitative descriptive studies, and mixed methods research. Each category includes five specific methodological quality criteria. In our study, two authors independently appraised the selected articles, then compared their assessments and resolved any discrepancies through discussion to reach consensus. Articles deemed of insufficient quality by both reviewers were excluded from further data analysis.

Table 1. Search terms and databases

Databases	Search terms
PubMed Google Scholar	Pharmaceutical systems Access to Medicine(s) Access to Pharmaceuticals Framework Strengthening Sub-national District State Province Decentralized Local

Search Strategy				
Subject		**Concept**		**Context**
Pharmaceutical Systems OR Access to Medicine(s) OR Access to Pharmaceutical(s)	**AND**	Framework OR Strengthening	**AND**	Sub-national OR District OR State OR Province OR Decentralised OR Local

Data analysis

The following information was extracted from all included studies: PMID/DOI, title, authors, year of publication, and the journal. Additionally, frameworks and their descriptions were extracted, along with any data related to the functioning of pharmaceutical systems at the local level. The critical components, functions, and goals of these frameworks were analysed and compiled into a table (supplementary file). The empirical studies were thoroughly reviewed to highlight important insights on the functioning of local pharmaceutical systems, which were also extracted. Three authors conducted the data analysis and developed the framework.

Expert consultation and validation

In the third stage, we shared the initial LOPHAS approach and framework with seven purposively selected experts. The expert consultation was designed to provide an additional layer of critical reflection and empirically grounded feedback to strengthen the development of the LOPHAS approach and framework. We set out to select experts who had extensive practical experience in strengthening pharmaceutical systems at both national and local levels across a variety of country contexts. Diversity in geographic and institutional background was a key consideration in our selection process. We followed a purposive sampling approach and continued inviting new experts until we reached saturation and their contributions confirmed the robustness of the approach, framework and functions. The consulted experts have contributed to systems strengthening efforts across all continents and have held relevant senior positions in prominent national and international organizations. We asked these experts to carefully assess the approach and framework and provide feedback and suggestions for improvement.

A key suggestion of these experts was not only to include publications that explicitly used a systems approach but also to draw upon the broader literature on access to medicine. Based upon the expert consultation, we identified 23 review articles and two handbooks [82, 116] that provide further empirical insights into improving access to medicines. After gathering feedback from all experts and carefully reviewing the articles and handbooks, we compared and triangulated the core elements of the LOPHAS approach. We discussed differences and suggestions until a consensus was reached and the approach and framework were finalized.

Results

Included publications

Our systematic search strategy resulted in 29 studies for our integrative review. 13 studies provide some sort of framework to analyse the functioning of a pharmaceutical system (table 2). A detailed comparative analysis of the critical components, functions, and goals of a pharmaceutical system is available in Appendix 1. We identified 17 empirical studies that explicitly used a systems perspective (supplementary file 2). There were three types of studies: analyses of a pharmaceutical system's situation at a specific point in time, studies that evaluate barriers and enablers to accessing medicines, and studies that assess pharmaceutical system interventions using a system approach. We found two studies that provided a novel framework and empirical data. None of the studies specifically aimed to describe local functions within a national system. The consultation with experts resulted in an additional 23 reviews and two handbooks, which were used to develop, enrich, and triangulate our approach further. The 13 frameworks, empirical studies, and reviews provide a rich mosaic of insights, based upon concrete experiences in dozens of countries, on all continents, relevant to analysing pharmaceutical systems.

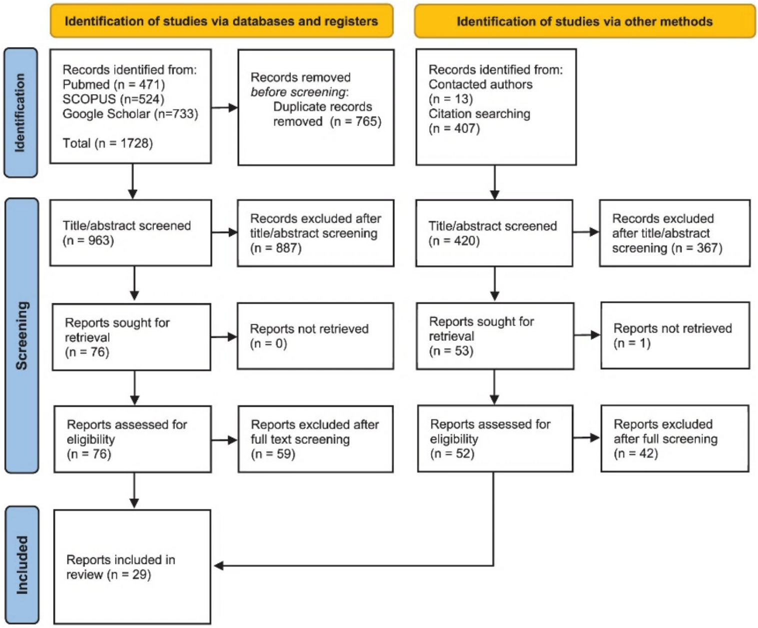


Figure 1. PRISMA flowchart of included studies

Table 2. Existing pharmaceutical system frameworks/assessment tools.

Framework	***Aim(s)***	***Method to develop framework***
Rapid pharmaceutical management assessment: an indicator-based approach (Management Science for Health, 1995) [38]	To present an indicator-based approach for rapidly assessing pharmaceutical management systems and programs	1. Recommendations from panel 2. Filter 200 indicators to 33 3. Expert Consultations. 4. Conduct a field test
Improving access to essential medicines - a framework for collective action (WHO, 2004) [90]	To guide and coordinate collective action on access to essential medicines	No Information
Functional components of a pharmaceutical system framework (Barillas, 2005) [117]	To ensure the effective and efficient functioning of the pharmaceutical system within the context of health sector reform	No Information
Using indicators to measure country pharmaceutical situations (WHO, 2006) [42]	To summarise and provide a picture of the situations of different pharmaceutical sector components and the current status of national drug policies	Tested in 2003 and 2006 in 146 countries
The regional framework for action on access to essential medicines in the Western Pacific 2010-2015 (WHO, 2009) [118]	Multiple, including; Respond to country needs and challenges in development and implementation of activities, based on expressed principles and grouped under the following components: Policy and access to essential medicines, Quality assurance, Rational selection and use	Expert consultations and in-depth reviews
Pharmaceutical supply management framework (Management Science for Health, 2012) [119]	The aim of the framework is to assess the functioning of the supply system of a pharmaceutical system	Unclear

ATM from a health system perspective: a conceptual framework (Bigdeli et al., 2013) [12]	The aim is to embed ATM in the wider health system strengthening debate, as a systems approach to improving ATM seeks to ensure that policies are more effective and generate longer-term equitable and sustainable results.	Literature review
SIAPS PSS framework (SIAPS, 2013) [120]	To depict a comprehensive set of dynamic relationships among five health systems building blocks, with a medical product building block overlay representing SIAPS' technical focus on strengthening pharmaceutical systems and services within a health systems context, aligned with partner country strategic plans and USG/USAID health related goals.	Unclear
Lancet commission progress indicators (Wirtz et al., 2017) [10]	To present indicators to assess the progress on essential medicine policies	An expert commission
PSS measurement framework (SIAPS, 2018) [121]	To have created a measurement framework and corresponding indicators for determining whether investments in pharmaceutical systems strengthening are contributing to the development of stronger, more sustainable pharmaceutical systems	Literature review and expert consultations
Action-oriented pharmaceutical sector strengthening cycle (Oteba et al 2018) [122]	To depict prioritized action areas, levels and goals of a pharmaceutical system to strengthen them	Unclear (based on a USAID framework)
Access to medicines framework (Afzali et al., 2019) [39]	The aim of this study was to collect and compile applicable indicators and impart a comprehensive framework for assessing access to medicine	Literature review, focus groups and a Delphi study
Analytical framework for qualitative evaluation of access to medicines from a health systems perspective (Joosse 2024) [8]	To develop a framework specifically designed to identify barriers, facilitators and drivers to access to medicines from a country's health system perspective.	Not specified. Presented as by product of a study on the barriers and facilitators to medicines in South Africa.

Three types of pharmaceutical system perspectives

Careful analysis of the 13 system frameworks shows that they are grounded in three different system perspectives, which can be referred to as 1) mechanistic, 2) teleological, and 3) complex adaptive system (CAS) perspective. Before laying out our analytical approach and the LOPHAS framework, we first characterise these three types of system perspectives.

The first type of framework to analyse a pharmaceutical system is rooted in a mechanistic systems perspective. These mechanistic frameworks emerged from the basic idea that enhancing access to medicines necessitates the consideration of diverse actors and factors operating in concert as a system [90]. In these frameworks, analysts outline these components and their functions within the system [123]. A mechanistic perspective views a system as a relatively static entity consisting of several parts with defined functions and structures. The empirical studies that use this perspective tend to break down the pharmaceutical system into smaller, more manageable parts. Cause-and-effect relationships are often perceived in a linear manner, assuming that changes in one part of the system directly lead to direct effects in other parts.

A second type of pharmaceutical system approach starts from a teleological perspective. An early example is the Rapid Pharmaceutical Management Assessment approach, published in 1995 [38]. A teleological perspective refers to a way of understanding systems by focusing on their purpose, goals, and outcomes. Pharmaceutical systems are viewed as purposeful entities that are designed to achieve specific objectives, such as providing access to medicines [121]. Teleological systems analysis emphasises the goals or desired outcomes that a system is designed to achieve. Systems are seen as exhibiting purposeful behaviour directed toward achieving their goals. A teleological approach assumes that understanding the goals and processes of a system is essential for effective decision-making and intervention. These teleological perspectives assume that pharmaceutical systems may evolve over time as a result of external influences or deliberate interventions to strengthen system performance.

While teleological approaches can be valuable for analysing a pharmaceutical system, they are not without criticism. One critique is that the emphasis on a predetermined goal or purpose overlooks the ambiguity of goals and the fact that goals may vary among different actors in the system. A second issue is that analyses that use a teleological perspective tend to overlook the emergent properties and behaviours that arise through the interactions of system components. This is illustrated clearly by Bigdeli and colleagues, who show how this can lead to the neglect of unintended consequences, interdependencies, and contextual factors that can have a major influence on access to medicine [12]. A teleological perspective thus risks oversimplifying the complexity of pharmaceutical systems by reducing them to an intended purpose, overlooking the intricacies of their structure, dynamics, and interactions. An additional criticism is that, as goals are unclear and diverse and feedback loops occur, a teleological perspective may struggle to provide accurate predictions about the behaviour of a system. While teleological systems perspectives can be useful, it is important to recognise their limitations and consider alternative perspectives that complement their strengths.

A third perspective on pharmaceutical systems draws from complex adaptive systems (CAS) thinking. Bigdeli and colleagues provide an example of a CAS perspective in their study of how interactions between different health system components influence access to medicine [12]. Complexity theory acknowledges that social systems exhibit emergent properties, non-linear dynamics, and self-organisation. Instead of assuming that pharmaceutical systems are deliberately designed and exist to achieve a predetermined goal, a CAS perspective focuses on the de facto systems that have emerged in practice through the patterns of actions and interactions of those who procure, distribute, prescribe, and use medicine. Following a CAS perspective, a pharmaceutical system comprises numerous interacting and mutually dependent components that adapt and evolve in response to changes in internal dynamics and the environment. Such systems are shaped by non-linear relationships, feedback loops, and unintended consequences, which cannot be fully predicted or explained. A CAS perspective encourages analysts to study the actions of actors, the diverse aims and mechanisms that shape their behaviour, feedback loops, and the role of context in shaping system dynamics. It promotes examining how a system performs in practice and how it is influenced by larger socio-economic, political, and environmental contexts.

Our approach assumes that each of these three system perspectives—teleological, mechanistic, and complex adaptive systems (CAS)—provides valuable insights for analysing and strengthening local pharmaceutical systems. While we primarily focus on the system's purpose and outcomes (teleological perspective), we also describe the system's components (mechanistic perspective) and explore their relationships. Additionally, we conduct in-depth analyses of system properties, dynamics, and how systems emerge and evolve (CAS perspective).

Conceptualising and defining a Local Pharmaceutical System

A Local Pharmaceutical System (LOPHAS) can be viewed as a sub-system nested within a multi-level structure of larger, complex, and evolving systems, such as the health system and the national and international pharmaceutical markets and policies. These systems operate within a broader, national, and international socio-political context. As a subset of these systems, a LOPHAS includes all structures, people, resources, and processes at the local level that contribute to ensuring access to pharmaceutical products and related services. Local pharmaceutical systems emerge when the core functions of the pharmaceutical system are organized and managed at the local level.

Building on this description and existing research, we define a local pharmaceutical system as the people, structures, resources, policies, and interactions that ensure local access to medicines, their appropriate use, and related health services to improve health outcomes.

Our analytical framework of LOPHAS is synthesized in Figure 6. The figure tries to illustrate LOPHAS as one of many sub-systems embedded within the national system, as well as place the LOPHAS into the broader health system and societal context.

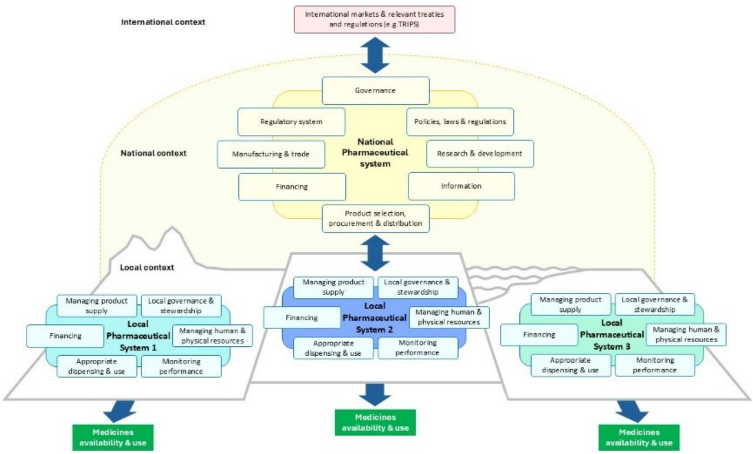


Figure 2. A local pharmaceutical system (LOPHAS) approach

A four-step approach to assessing the performance of Local Pharmaceutical Systems

To leverage the strengths of each system perspective and generate valuable insights, we propose a four-step approach for analysing local pharmaceutical systems.

Step1 Mapping stakeholders and describing the formal organisation of the system

The first step starts with mapping stakeholders and describing the formal organisation of a pharmaceutical system. The purpose of the stakeholder mapping is to identify the entities involved in or impacted by the local pharmaceutical system. In general, one can identify the core stakeholders, supporting stakeholders, and end users. The core stakeholders are all entities directly involved in the pharmaceutical supply chain, such as government agencies, manufacturers, wholesalers, retailers, pharmacies, and healthcare providers. The supporting stakeholders are the organisations that indirectly impact the system, such as non-governmental organisations (NGOs), donor agencies, and community leaders. The end users are the patients and communities who access and use the medicines and related services.

There are significant differences between pharmaceutical systems in different countries. This first step includes identifying which functions are organised at the national level and which are managed locally and clarifying the distribution of roles and responsibilities. To gain insight into a pharmaceutical system, it is also useful to map where medicines are produced (domestic or elsewhere), how they are regulated, how supply chains operate and are overseen, how medicines reach patients, how the system is financed, whether there is a health insurance system, and what role the public and private (either for-profit or not-for-profit) sectors play in this. In some countries, it may also be relevant and possible to describe the informal (unregulated) market.

For this first step, the WHO [90] and SIAPS PSS [121] systems can be used as inspiration, which provide a comprehensive overview of the core components and functions of a national pharmaceutical system.

In this initial stage, it is beneficial to clarify the specific aims of the system analysis (e.g., learning, improvement, accountability) and identify the intended users of the analysis. Engaging these intended users in contextualising the analytical approach and designing the next steps can ensure the analysis is relevant and increases the likelihood the findings are actionable [124, 125].

Step 2 Empirical analysis of the performance of local pharmaceutical systems

The second step is an empirical analysis of how local systems operate and the extent to which intended goals, such as medicine availability and access, are achieved. For this second step, we developed the LOPHAS framework, which includes a detailed description of the functions and goals of the pharmaceutical system at the local level (see Table 3).

The second step involves analysing the relationship between the functioning of local systems and the various dimensions of access to medicine, including availability, accessibility, affordability, and acceptability. Later in this article, we describe the goals and core functions of local pharmaceutical systems in detail, along with several operational components and indicators for each function. These operational components and indicators are designed as suggestions that can be adjusted for specific contexts. Together with stakeholders, an analyst needs to select the specific metrics for evaluating the effectiveness, efficiency, accessibility, and quality of the LOPHAS. This could include indicators based on health outcomes, medicine availability, service quality, patient satisfaction, and affordability indicators. Depending on the situation and the purpose of the analysis, analysts need to consider the broader (political, socio-economical, cultural, infrastructural, and geographical local context, which can influence the functioning of local systems, the specific challenges they face, and the most relevant dimensions of access to medicines.

Step 3 In-depth qualitative analysis

The third step involves studying the actual practices within the pharmaceutical system. In many countries, there is a gap between how a system is supposed to function on paper and what actually happens. Financial incentives, complex supply chains, unclear regulations, poor infrastructure, failing technology, local insecurity, lack of (skilled) human resources, incompetence, and corruption can all lead to medicines being unavailable and patients spending significant amounts on expensive alternatives in private and unregulated outlets [10].

In-depth qualitative analyses are necessary to gain insights into actual practices and understand how the system functions [8, 12]. Through interviews and observations, researchers can discern what actors do, how incentives shape their practices, the feedback loops and unexpected outcomes that arise, how various layers and functions within the health system interact, and how broader structures and dynamics influence these within the context.

Step 4 Integrating insights and develop actionable steps for improvement

In the final stage, analysts can integrate the insights from previous steps to understand how local systems perform and design actionable steps for improvement. The exact focus of this fourth stage depends on the specific goals of the system analysis, such as learning from comparisons, tracing the development of local systems over time, or informing interventions for system strengthening. Engaging intended users and other stakeholders can help validate, interpret, and contextualise findings, leading to the development of relevant and actionable insights.

These insights can inform the design of targeted interventions, such as optimising supply chain processes, expanding access points, or training staff. The data collected in Step 2 can serve as a benchmark and a foundation for a monitoring system that tracks improvement efforts and supports necessary adaptations. This monitoring should be locally tailored, using progress dashboards and feedback loops with frontline healthcare workers and patients to drive better health outcomes.

Key outcomes of a local pharmaceutical system

The goal of the local pharmaceutical system is to ensure access to medicines and appropriate use of medicine. *Access to medicine* within the health sector is most commonly defined as geographical & financial accessibility, availability, and cultural acceptability of quality services and products [41]. The selection, number, and formulations of medicines included depend on each country's national essential medicines list and its policies regarding availability in specific healthcare facilities [126]. Access to pharmaceutical products is commonly measured by the following indicators, which measure key domains of access (another domain is quality, which is not commonly assessed at the local level) [39, 42, 81]:

- Median availability of a basket of essential medicines (%)
- Distance to nearest medicine dispensary (in km, depending on the specific medicine)
- Community perception on access to health care
- Median consumer price ratio of a basket of essential medicines.

Use of medicine is described as prescribing, dispensing, or selling and consumption or end-use by the patient [40]. In line with previous research, we include the fact that the use of medicine should be appropriate and cost-effective. Appropriate since medicine can be prescribed or dispensed inappropriately (wrong substance, dosage, administration route, time period…) and/or consumed *inappropriately* (e.g., wrong self-prescription, incomplete treatment-cycle…), as is a common occurrence [12, 90]. Cost-effective since, in many countries, and/or by specific product, the affordability of medicine is low. A high proportion of dispensed generic medicine indicates better affordability. Based upon the integrative review and expert consultations, we suggest four general indicators for this outcome measure [39, 42]:

- Number of prescribed essential medicine dispensed per 1.000 pop.
- % Medicines prescribed as generics
- % Medicines prescribed from Essential Medicine List
- % (exact or estimate) Population with unmet medicine needs

Key functions of a Local Pharmaceutical System

Our analytical framework outlines six essential functions for a local pharmaceutical system: 1) local governance and stewardship, 2) managing pharmaceutical product supply, 3) financing, 4) developing and sustaining human and physical resources, 5) ensuring quality and promoting appropriate use, and 6) monitoring performance. Table 3 provides an overview of each function, including its operational components.

Table 3. Functions and operational components of a Local Pharmaceutical System

Functions	Operational Components
Local governance and stewardship	- Develop a strategic plan and priority actions to foster ATM - Coordinate with other governmental actors and levels to foster ATM - Map, engage and coordinate with non-governmental and private actors to foster ATM - Contextualise and implement national policies and regulations - Establish local mechanisms for transparency, accountability and responsiveness
Managing pharmaceutical product supply	- Select which products are needed in which health facilities - Establish efficient planning systems and forecast product needs - Procure pharmaceutical products - Store pharmaceutical products and monitoring stock and quality - Distribute pharmaceutical products to dispensing units - Track prices and supplier performance
Financing	- Coordinate and secure sustainable funding for the procurement and contracting of pharmaceutical products, resources and services - Allocate and distribute expenditures to pay for pharmaceutical products and related resources and services - Monitor revenue, expenditures and prices and cost-effectiveness of investments in pharmaceutical products, resources and services
Developing and sustaining human and physical resources	- Develop, manage and support a competent pharmaceutical workforce - Develop, manage and sustain the physical and technological resources needed for pharmaceutical operations

Ensuring appropriate dispensing and use	- Promote appropriate prescribing, dispensing and retail practices and service delivery that supports appropriate use - Contribute to monitoring of practices and quality in the regulated supply chain - Contribute to inspection of retail, marketing and dispensing practices in unregulated outlets and the enforcement of regulations
Monitoring performance	- Monitor appropriate prescribing, dispensing and retail practices and service delivery that supports appropriate use - Monitor availability of pharmaceutical products in dispensing units - Identify and evaluate problems and solutions to improve access and use medicine - Evaluate and monitor ethical standards for pharmaceutical system and access to medicine - Collect and interpret other data relevant for decision-making

<u>Local governance and stewardship</u>

The governance function focuses on the coordination, steering, and oversight provided by local health authorities who are tasked with ensuring that the pharmaceutical system operates efficiently, effectively, and transparently and aligns with national and local health objectives. At the local level, a district or provincial health office (or equivalent function) typically shoulders the responsibility for overseeing the performance of the local system [42, 116]. In most countries, some policy guidance is typically derived from the national level [96, 122, 127]. The local authorities are tasked with crafting a vision and a strategic plan tailored to the local context, coordinating with stakeholders across various levels, and crafting policies concerning the selection, management, procurement, and distribution of pharmaceutical products for public facilities. A well-defined vision guides activities toward the overarching goal of the system: ensuring access to essential medicines and fostering their appropriate use to enhance health outcomes. In line with its priorities, local authorities have to formulate concrete plans to achieve results. Developing these plans requires a thorough understanding of the local situation, health needs, opportunities, obstacles, and their root causes that need to be overcome, as well as awareness of the sphere of influence of the authorities in charge [82].

A key task is coordinating with other national and local actors to foster collaboration and collectively improve pharmaceutical services. Decision-making responsibilities between national and local authorities can vary. Coordination is essential, as local authorities play a vital role in implementing national policies and regulations while providing data and input for national decision-making.

Coordination is also needed with other public and private actors within the local system. This involves scanning and mapping the pharmaceutical landscape - including public, private, and unregulated/informal entities – and having insight into which products and services are provided by whom [116]. Effective engagement with the private sector is needed to achieve public health goals, such as appropriate dispensing of antibiotics. Building relationships with the private sector involves being a reliable partner, fostering genuine engagement and transparent decision-making, and communicating clearly about priorities, regulations, and guidelines [128, 129]. A final component of the local governance of pharmaceutical systems is establishing mechanisms for transparency, accountability, and responsiveness in pharmaceutical operations, financial transactions, and the effective use of resources in coordination with national mechanisms and regulations.

The following indicators could be useful to assess local governance and stewardship:

- Mapping the concerned local stakeholders and their respective roles in the local system
- Local health authorities have developed a vision and a strategic plan for achieving ATM and appropriate use
- Local health authorities have formulated context specific plans to achieve this vision
- Progress reports on local priorities and policy plans are publicly published
- Local health authorities coordinate with relevant governmental and non-governmental actors at local and national level to achieve ATM and appropriate use
- Local health authorities have established explicit mechanisms for transparency and accountability about pharmaceutical operations, financial transactions and use of resources

Managing pharmaceutical product supply

A core function of LOPHAS is to manage the supply of pharmaceutical products. This involves systematically predicting and tracking the demand for pharmaceutical products and selecting, procuring, storing, and distributing these products to dispensing units, along with related services. This core function is interconnected with all other functions and directly contributes to the goals of LOPHAS—ensuring access to medicine and promoting the appropriate use of medicine [38, 121].

The initial selection of pharmaceutical products occurs at the national level, where authorities establish an Essential Medicines List (EML). Local authorities tend to be responsible for selecting which products of the EML are prioritised in the local context and which products will be available in which facilities. Following the selection of pharmaceutical products, local authorities play a key role in forecasting, procuring, storing, and distributing products to dispensing units. Any issues in the supply chain, whether due to inaccurate forecasting, incorrect procurement, inadequate storage capacity, or insufficient distribution, can result in medicine shortages. The operationalised components of procurement, storage, and distribution are underpinned by various supporting functions, including the availability of adequate human, physical, and financial resources, effective local governance and stewardship, quality assurance, and continuous monitoring and, if necessary, targeted actions to strengthen the performance of the system [40].

The operationalised components of forecasting and monitoring local pharmaceutical product needs are critical and unique functions of LOPHAS. In some countries, local health authorities forecast medication needs (for the public sector) for a given period, typically one year, which are then compiled by national authorities responsible for providing the required products to local authorities [76]. In other countries, medicines for public facilities are procured locally, or there is a mix of central and local procurement. Poor forecasting can result in stock-outs or oversupply and expired medicines. Estimating the local medication needs depends on up-to-date data on medicine use, stocks, and disease incidence and prevalence [82, 95], and accurate knowledge of the contribution of other stakeholders, such as NGOs or other implementers. Monitoring medication stocks can help to refer patients to facilities with adequate stocks, thus improving access [12, 95].

Indicators are essential for measuring the components of forecasting, procurement, storage, and distribution of medicines to assess the pharmaceutical product supply.

The following indicators could be useful to assess the local management of product supply:

- Mapping of different actors involved in supply and procurement across sectors
- Local authorities list which medicines are essential and should be available in which facility
- Reliable local data on medicine needs and use exists
- Reliable local data on medicine stocks exists
- System in place to align procurement with up-to-date disease prevalence and incidence
- Organisation to forecast has adequately trained human resources to forecast medicine
- % of medicines procured from EML
- % of medicines procured that are registered or authorised with the NRAs (this should be 100%)
- Adequate facilities to store medicine
- Organisation tracks medicine prices and monitors supplier performance
- % of medication expired, damaged or stolen of a basket of essential medicines
- Mean % availability of a basket of essential medicines

Financing: securing and allocating funds

The financing function involves managing resources to ensure adequate and sustainable funding for purchasing pharmaceutical products, covering related services, supporting human resources, and meeting other costs essential to the local pharmaceutical system [105, 130, 131].

Financing for pharmaceutical products in public facilities typically originates from various channels. Often, national governments allocate funds to local authorities, which then combine these with local resources to procure medicines [94]. In addition, there are specific medications that are procured nationally and distributed to public facilities. Besides the public system, most countries also have a vibrant private market, where private healthcare providers, pharmacies, and other medicines outlets acquire medicines. Financing in this sector usually stems directly from patients and health insurers and sometimes from other sources such as charities and donors [132].

A core component of this function is coordinating and securing funding for procuring and contracting pharmaceutical products, resources, and services. The authorities in charge need to pool, allocate, and distribute resources, purchase pharmaceutical products, and pay for related services and resources [133, 134]. Transparent monitoring of revenue, costs, and prices is crucial to controlling spending, supporting decision-making, and promoting accountability in financial transactions and resource use.

The following indicators could be useful for assessing the local financing function:

- Mapping of the concerned local stakeholders and financing flows
- Medicine expenditure per person by public sector
- Back-up funding from national or local government is available
- Out-of-pocket expenditure on pharmaceuticals as a percentage of total pharmaceutical expenditure
- % of people enrolled in insurance scheme
- System in place to monitor revenue, expenditures and prices across sectors
- Adequacy and transparency of mark-ups

Developing and sustaining human and physical resources

Developing, supporting, and sustaining a competent pharmaceutical workforce is essential for a well-functioning pharmaceutical system at all levels. A skilled pharmaceutical workforce is critical for the selection, procurement, and management of medicine and for providing pharmaceutical services and promoting the appropriate use of medicine [122, 132, 135].

Normally, policies and regulations for training new health professionals, including pharmacists, pharmacy technicians or pharmacy assistants, as well as administrators in health systems, are set at the national level. National governing bodies are tasked with accreditation of training programs and ensuring that training is provided in accordance with accepted norms, guidelines, standards, and regulations [39]. In some countries, local governments also invest in training new staff by co-funding and supporting local universities and training programs. Additional training is often delivered through short courses, in-service programs, and continuous education to enhance pharmaceutical skills and competencies [136]. However, in many countries, companies attempt to influence medicine provision through such training. Local authorities must ensure that healthcare professional training prioritises evidence-based prescription criteria and, ultimately, patient health.

Local healthcare authorities play a vital role in managing the pharmaceutical workforce by recruiting, hiring, deploying, and supporting pharmacy professionals, as well as monitoring and evaluating their performance. Insight into the ratio of pharmacy professionals per inhabitant offers a valuable measure to evaluate the human resource capacity of the local pharmaceutical system. This data can inform strategies for the development and distribution of pharmacy professionals.

The following indicators could be useful to assess the local development of human resources:

- Number of pharmacists per 10.000 pop.
- Number of pharmacy practitioners per 10.000 pop.
- Number of pharmaceutical technicians/assistants per 10.000 pop.
- % of dispensing facilities in which a pharmacist is present
- The relative distribution of pharmacist – considering aspects such as public or private sector and rural and urban areas

Physical resources are vital for pharmaceutical operations, including the adequate storage, distribution, and proper dispensing of medicines, which are essential for ensuring access to medicine. Inadequate access to dispensing facilities can force people to travel long distances, resulting in the loss of time and money to obtain medication. Authorities overseeing LOPHAS are responsible for ensuring an adequate number of licensed pharmacies by developing, supporting, and maintaining public pharmacies, as well as licensing private pharmacies and other outlets. In remote and underserved areas, unlicensed dispensing units, such as informal drug vendors and midwives, also provide medicines [137]. Local authorities need to determine if such outlets truly fill a gap, and can try to engage them through training, upgrading and licensing constructively.

The following indicators could be useful to assess the physical resources involved in pharmaceutical operations:

- Number of pharmacies per 10.000 pop. (specified for public and private)
- Number of licensed pharmacies per 10.000 pop.
- Number of unlicensed dispensing units per 10.000 pop.
- Distance to nearest pharmacy (from communities)
- Distance to nearest dispensing unit (from communities)

Ensuring appropriate dispensing and use

Local health authorities need to ensure the adequate use of pharmaceutical products and services, which includes promoting adequate storage and distribution practices and appropriate use of medicines.

Ensuring the quality of medicines is primarily the responsibility of national regulatory authorities, which establish and enforce safety, efficacy, and quality standards [97, 122, 132]. Manufacturers, distributors, and pharmacies must comply with these standards, regulations, and guidelines across manufacturing, distribution, and pharmaceutical practices [138]. Unregistered, expired, and substandard or falsified products may become more prevalent in countries with limited regulatory enforcement and unmet demand [139–141]. Local health authorities can support regulators by reporting suspected or expired products, assisting with inspections, regulatory enforcement, and monitoring prescription, marketing, and retail practices (73).

The following indicators could be useful to assess local quality assurance:

- Regular inspection of good storage and distribution practices
- Regular reporting of expired, unlicensed and suspected products
- % of licensed establishments and % of licensed personnel
- % of dispensing units inspected in a year

Local health authorities can take several measures to promote the appropriate use of medicine, ensuring that medications are prescribed and used to maximise their health benefits. Local authorities can disseminate guidelines to healthcare providers and promote their integration into clinical practice [142]. This needs to be combined with continuing education programs and training sessions for health professionals on rational prescribing, medication safety, and adherence-promoting strategies [143]. Regular monitoring can help to gain insight into prescribing patterns, medication adherence rates, and medication-related outcomes. In addition, local authorities need to collaborate with the organisation that is responsible for enforcing regulations and policies related to pharmaceutical marketing, promotion, and prescribing practices to prevent inappropriate use of medication.

The following indicators could be useful to assess appropriate use at the local level:

• % of prescriptions that align with diagnosis and treatment guidelines • % of patients receiving counselling on medication use, potential side effects, and adherence • % of patients who adhere to prescribed medication regimens • Over-the-counter (OTC) sales of antibiotics and injections • Assessment of patient-reported outcomes related to medication efficacy and use • Educational interventions offered to healthcare providers reduce medication errors

Monitoring system performance

A robust monitoring and evaluation system is essential for generating the data and insight needed for informed decision-making in local pharmaceutical systems. Adequate forecasting, planning, budgeting, and other operations require reliant local information systems that are managed by adequately trained staff [116]. The information gathered about pharmaceutical products and services at the local level provides valuable data for national health strategies and policies, but it is also crucial for local decision-making. Multiple studies indicate that by routinely analysing and utilising data to inform decision-making and planning in pharmaceutical operations, local authorities can optimise resource allocation, improve operational efficiency, and enhance the delivery of pharmaceutical services to communities [95, 122, 127, 132, 135].

Reliable and timely publicly shared data is an important part of any attempt to improve transparency, accountability, and responsiveness in pharmaceutical operations, including financial transactions and the effective use of resources [82, 144]. Ethical standards are important to ensure the integrity of professional behaviour. Clarifying and monitoring adherence to these standards is important for tackling corruption and improving efficiency, credibility, and public trust in government institutions.

Indicators to measure this function need to assess the existence of monitoring systems that routinely measure data to identify problems and the use of this data to inform decision making.

The following indicators could be useful to assess the local monitoring of system performance:

- Local authorities routinely collect, analyse and share data about medicine availability, access to medicines and pharmaceutical services
- Local authorities indicate and oversee ethical standards for professional conduct and monitor compliance
- Local authorities routinely collect, analyse and share medicine revenue and expenditure data
- Local authorities routinely analyse and use data to inform decision-making and planning of pharmaceutical operations and policies

Local factors influencing medicine access and availability

The local availability and accessibility of medicines are influenced not only by the organisation of the pharmaceutical system but also by the local situation, including health needs and socioeconomic, cultural, logistical, geographical, and security factors.

A key feature of the local situation is the health-seeking behaviour of individuals, households, and communities, influenced by their health status, preferences, economic situation, and social, physical, and cultural factors, all of which trigger demand for medicines and related services. Health status, needs, and socioeconomic conditions, such as health insurance coverage, income levels, and poverty rates, directly influence this demand.

Community members are not passive consumers but act as stewards of the system by demanding services and accountability and expressing their (dis)satisfaction with services and products. Historical experiences, cultural beliefs, and practices also play a significant role; for example, preferences for traditional medicine, household spending priorities, or mistrust of certain pharmaceuticals can impact which medicines are stocked and how they are used [145].

Logistical factors, including the accessibility of health facilities, infrastructure quality, mark-ups, and supply chain efficiency, influence medicines prices and the timely delivery and availability of medicines. Additionally, the local security situation can significantly affect medicine availability, as conflict or instability can disrupt supply chains, limit access to health facilities, and deter pharmaceutical companies from operating in certain areas.

When assessing and comparing the performance of local pharmaceutical systems, it is important to consider the influence of local circumstances. The purpose of the analysis and the specific context will determine which local factors to focus on, as these can vary significantly across different regions within a country.

Below, we list six key aspects of the local context that could be considered in an analysis of LOPHAS performance. For most aspects, relevant indicators and data are routinely available.

- Health and demographic factors (e.g. population density, health needs, disease prevalence)
- Socioeconomic conditions (e.g. health insurance coverage, income levels, employment)
- Historical experiences, cultural beliefs and practices (e.g. traditional medicines practices, health beliefs, perceptions)
- Transportation factors (e.g. distance to facilities, producers and distributors, transportation cost)
- Geographical factors (e.g. physical barriers due to topography and terrain, weather conditions)
- Security situation (e.g. security incidents, violence, law enforcement, political stability)

Discussion

The aim of our study was to develop a systematic approach to analysing the performance of local pharmaceutical systems. We began developing the LOPHAS approach after observing significant regional variations in medicine availability within countries and recognising that many key functions of pharmaceutical systems are co-managed or fully managed at the local level. The LOPHAS approach is designed to systematically learn from these local variations, generating insights to improve performance and access to medicines. This approach is particularly relevant for large, diverse countries with decentralised health systems.

Based on our integrative review and consultations with experts, we propose a four-step analytical approach supported by a framework of six core functions, each with operationalised components and indicators. By linking insights into the performance of local systems with key outcome metrics and contextual factors, we aim to facilitate learning through comparisons of local systems within a country, both cross-sectionally and over time. We expect this approach will help identify best practices and gaps and provide valuable insights that can be used to inform targeted actions for improving access to medicines.

In developing the LOPHAS approach, we drew upon various studies, frameworks, and tools designed to measure various aspects of pharmaceutical systems. We noticed that the existing frameworks are grounded in three different types of system perspectives (mechanistic, teleological, and complex adaptive systems). These different types of system perspectives contain different ideas of what a system is and how systems emerge and evolve. We believe each perspective can offer valuable insights for analysing and strengthening local pharmaceutical systems.

The existing approaches and frameworks tend to focus on operations, policies, and regulations at the national level. The LOPHAS approach specifically targets the subnational level, emphasising the factors leading to healthcare access disparities within countries. While focusing on the national level, several frameworks recognise that operations, structures, and dynamics at multiple levels are relevant to the performance of pharmaceutical systems [12, 40]. This is most evident in Bigdeli et al.'s approach, where the authors distinguish between stakeholders at five levels, including communities, service delivery stakeholders, the national policy and regulatory environment of the health sector, and the national and international contexts [12]. While we fully acknowledge the influence of national and international markets, regulations, and dynamics, our focus is on the local level, where significant disparities exist that require targeted analysis and may offer opportunities for focused action.

Access to medicines is influenced not only by the functioning of the pharmaceutical system but also by local factors such as geographical barriers, logistical challenges, capacities and resources, poverty, and insecurity. When analysing and comparing the performance of local pharmaceutical systems, it may be relevant to consider these local circumstances.

In two studies, where we tested elements of the broader LOPHAS approach, we analysed the influence of various local circumstances. In a study in Indonesia, we found that the availability of essential medicines was lowest in primary health facilities in sparsely populated areas in the relatively poor districts in the east of the country, where the average distance to health facilities and medicine manufacturers was greatest [146].

A recent study using the LOPHAS approach in Afghanistan found that the local security situation had little impact on medicine availability [111]. Instead, availability was significantly influenced by the type of organisation managing the provincial health system. Provinces where health services were contracted to not-for-profit private organisations showed much higher availability of essential medicines compared to those managed directly by local governments. These findings underscore the value of analysing local differences to gain actionable insights that can inform the development of targeted policies and effective practices.

When applying the LOPHAS approach, analysts need to identify the most appropriate local level for their analysis. One way to do this is by mapping the subnational level at which key aspects of the pharmaceutical system are formally organised. This will likely depend on the structure of the health and pharmaceutical system. The relevant level may also differ depending on the type of medicine, as some products are distributed through national programs while others are locally sourced and provided. Another potential method for determining the most relevant local level and concerned local stakeholders is to analyse the geographical clustering of pharmaceutical outcome measures, such as medicine availability or affordability.

A key feature of the LOPHAS approach is the integration of quantitative analyses, which assess local variations in outcome measures (step 2), with in-depth qualitative studies that uncover actual practices in local pharmaceutical operations (step 3). This third step was introduced in response to empirical studies showing that diverse local dynamics and factors can unexpectedly affect the availability and accessibility of medicines, as well as the performance of local pharmaceutical systems [48, 109, 147]. Where formal qualitative research capacities are limited in some local systems, strengthening these capacities or exploring alternative methods to gather and integrate qualitative feedback into the analysis can be beneficial.

An intriguing trend is the rapid digitalisation of pharmaceutical supply chains and healthcare facilities. With sufficient focus on harmonisation, this digital transformation could greatly enhance the availability of data for analysing the performance of LOPHAS (71). While these data offer new opportunities, relying solely on routine data may lead to a skewed understanding of how these systems operate, as there is often a gap between how a system is supposed to function on paper and what actually happens in practice. Integrating these routine data with qualitative analyses is essential for understanding how systems function, as well as how various layers, incentives, and practices interact. This understanding is crucial for designing effective interventions.

The LOPHAS approach, framework, and associated indicators are not intended as a fixed blueprint but as a rudimentary framework that needs to be operationalised and contextualised to make it useful. When adapting and applying the approach, the specific purpose of the system analysis, the needs of stakeholders, and local circumstances need to be taken into account. As others have emphasised, a pharmaceutical systems framework is intended to be a tool that inspires, guides, and focuses analyses [148]. It should offer direction and help to structure thinking while allowing for creativity and adaptation based on the specific context or needs of the analysis

The LOPHAS approach appears particularly valuable for analysts, policymakers, and other stakeholders in larger, more diverse countries that could benefit from a decentralised organisation of pharmaceutical operations. For instance, our recent observations in Indonesia revealed that national regulations governing the financing and supply of medicines were effective in some regions but hindered access in others [147]. These local variations underscore the need for a more decentralised, context-specific strategy to enhance access to medicines. The LOPHAS approach is expected to support the development of such strategies.

Systematic local data collection on medicine availability, as emphasised in the LOPHAS approach, is also vital for monitoring progress toward achieving SDG 3.8, which prioritises equitable access to essential medicines [149]. Currently, the SDG indicator 3.b.3, designed to measure access to medicines, is at risk of being discontinued due to insufficient data coverage [150]. Enhancing local data collection efforts and integrating this information with broader health system performance metrics can help bridge these gaps, ensuring that progress toward this critical goal can still be effectively evaluated.

Strengths and limitations

A strength of our study is that it builds upon an empirically grounded and comprehensive body of literature, combined with the rich experience of the consulted experts. We have included both grey and scientific literature based on studies in diverse countries that encompass a variety of perspectives. The included frameworks offer important conceptual insights into the components of pharmaceutical systems, while the empirical studies, reviews, and expert consultations provide further evidence and experience with different empirical methodologies.

A limitation of this study is the lack of evidence specifically addressing local pharmaceutical systems within the broader context of national pharmaceutical and health systems. None of the included studies aimed to define a local pharmaceutical system or assess the differences between the national and local dimensions. While local operations were mentioned, often indirectly, in several empirical studies, the limited focus on the local level highlights the importance of beginning each analysis with a comprehensive mapping of the local situation and applying the approach in a careful and reflective manner.

A second limitation results from the trade-off between complexity and pragmatism. Our analysis revealed numerous frameworks with extensive lists of stakeholders, components, and overarching principles. We recognise that pharmaceutical systems are inherently complex and diverse and believe that it is not possible to encapsulate this complexity in a single framework. We have tried to develop an approach that incorporates the most relevant elements while being practically useful.

Conclusions

In many countries, core functions of the pharmaceutical system are largely organised, delegated, or co-managed at the local level. The LOPHAS approach and framework offer a structured tool for assessing and comparing these local pharmaceutical systems. Our four-step analytical approach recommends evaluating both the performance of local pharmaceutical systems and the contextual factors that influence access to medicines, combining quantitative analyses with in-depth qualitative studies of actual practices. Beyond its practical application, the LOPHAS framework holds scientific relevance as a means to systematically study local pharmaceutical systems—an area that remains understudied despite its growing importance, particularly in countries that have decentralised their health systems. We anticipate that such integrated studies and comparisons will yield valuable insights and inform concrete actions to improve access to medicines and, ultimately, advance universal health coverage.

Supplementary materials

- sj-docx-1-map-10.1177_27550834251371502.docx
- sj-docx-2-map-10.1177_27550834251371502.docx

Chapter 3:

The availability of essential medicines in primary health centres in Indonesia: achievements and challenges across the archipelago

This chapter was published as:
Fanda, R.B., Probandari, A., Yuniar, Y., Hendarwan, H., Trisnantoro, L., Jongeneel, N. and Kok, M.O., 2024. The availability of essential medicines in primary health centres in Indonesia: achievements and challenges across the archipelago. *The Lancet Regional Health-Southeast Asia*, *22*.

Abstract

Background

Indonesia is making significant strides toward achieving universal health coverage, which involves providing free access to essential medicines. This study examines the availability of essential medicine in primary health centres (PHCs) across Indonesia, the reasons why medicines are unavailable, and the extent to which communities have access to alternative dispensing points.

Methods

Enumerators visited each of the 9831 PHCs in all 514 districts to assess the availability of 60 essential medicines and identify reasons for any absent medicines. We correlated the results with the national village census to assess the relationship between availability, poverty, and access to alternative dispensing points.

Findings

Medicine availability varied greatly. The median availability for 17 priority medicines was 82%, while 58% of the broader selection of 60 essential medicines was present. The availability of maternal and childcare medicines was highest (73%) and lowest for mental health (42%). The main reasons for absence were that medicines were deemed unnecessary (46%) or not supplied (38%). The Java/Bali region had the highest medicines availability, and rural areas in Eastern Indonesia had the lowest. In these districts, the population is financially struggling, most dependent on free medicines from public providers, and has the least access to alternative dispensing points.

Interpretation

The availability of priority medicines in PHCs is relatively high, while public-paid prices are low by international standards. To improve availability of all essential medicines, the government should prioritise areas with the highest need, increase funding for PHCs in remote areas, and implement transparent monitoring of medicines availability.

Funding

Indonesian Government.

Keywords: medicine availability, pharmaceutical system, access to medicine, primary health centres.

Introduction

The provision of essential medicines is an integral part of universal health coverage (UHC) [10, 12]. Access to free medicine plays a vital role in maintaining and improving the health of individuals, while also protecting the most vulnerable populations from catastrophic health expenditures due to high out-of-pocket costs.

Indonesia, the world's fourth most populous nation, is striving to achieve UHC care [63]. In 2014, the government introduced a national health insurance scheme, *Jaminan Kesehatan Nasional* (JKN)[62]. At the start of 2023, the JKN scheme has registered over 253 million participants, representing 93% of the population. The government pays the premiums for economically disadvantaged people, and state employees, currently some 70 percent of registered participants [64]. Nevertheless, the limited availability of healthcare services, especially in the parts with more people financially struggling, means that registration of participants may not translate into effective 'coverage'[65].

Providing access to quality health services poses a formidable challenge in this vast island nation. Indonesia is exceptionally diverse. Some 150 million people are squeezed into the island of Java, just 6% of the land mass. The other 120 million Indonesians are scattered across some 7,000 other inhabited islands, spread out over a distance of more than 5000 kilometres. Population density ranges from 1400 /km2 in West Java to 10/km2 in North Kalimantan and Papua provinces. Income, health needs, and access to services are similarly diverse. While in central Java, 4% of the population lives below the local poverty line, poverty rates in Papua province are nearly 10 times higher. In the Java and Bali region, 94% of the villages have easy access to a hospital, in contrast with only 27% in Malukus, Nusa Tenggara, and Papua [151]. The most pressing challenge in improving health coverage lies in the eastern part of the country, where poverty rates and healthcare demands are highest, and accessibility to health facilities is most limited [65, 152].

The national health insurance scheme provides comprehensive coverage to all participants, including free access to the entire list of over 300 essential medicines [153]. Primary Health Centres (PHCs) play a crucial role in delivering health services and medicines. There are over 9900 PHCs that are strategically located throughout the archipelago, including rural and remote areas [75]. These PHCs offer a wide range of primary healthcare services, including maternal and child health services, family planning, immunisations, basic diagnostics, treatment of common illnesses, and management of chronic diseases. Since the majority of the population relies on PHCs as their first and primary source of free healthcare, it is crucial to ensure that essential medicines are available at these centres [67].

Previous studies into the availability of medicines in public facilities offer a mixed picture. In 2020, the Indonesian Ministry of Health reported that a selection of 17 most needed essential medicines was available in 93.6% of PHC, as indicated by a self-reported survey completed by staff from 85% of the PHC[69]. Smaller studies, whereby researchers visited facilities and looked for specific medicines paint a more worrying picture. Three recent studies in public facilities in large cities on Java, the island where most medicines producers and distributors are based, found that even in the most developed parts of the country, medicine is frequently out of stock, leading to reduced treatment for patients. A study in 2019 in the capital Jakarta found that one in three PHCs were without essential hypertension medicine for over a year[71]. In Yogyakarta, the availability of 50 essential medicine in public facilities was around 76,6% [72] and a study in Surabaya found that one in four essential medicine were not sufficiently available in PHC [73].

There are signs that the problems with the availability of medicines may be even greater in the more remote regions. In 2017, a study of 6 PHC in Keerom district in Papua showed that, of the 35 most essential medicine, 29% was not available, and 7% of the available medicine were expired [74].

Little is known about the reason why some medicines are not available. Studies from other countries indicate that shortages in the public sector often stem from underbudgeting, inefficient purchasing practices, and inadequate stock management. A recent qualitative study in Indonesia suggests that low prices may also contribute to medicine shortages [154]. To be able to afford UHC, the Indonesian government has tried to bring down the prices of publicly procurement medicine by introducing a single-winner auction system. For each province, bidders have to pitch their prices below a fixed ceiling level and promise to fulfil orders up to the demand forecast by the Ministry of Health. Local health authorities have to procure essential medicines through the public procurement system, known as the e-catalogue. If medicines are not being supplied, public facilities may source them directly from the market [155]. The implementation of the auction system has effectively fostered competition between manufacturers and pushed down medicine prices, often to levels below the international reference price [76]. Low prices have made medicines more affordable, but have also put pressure on the profit margins of manufacturers, leading some companies to withdraw from the market, and making them less inclined to fulfil orders to remote regions that incur higher supply costs [154].

Patients end up paying the price, as medicine shortages in public facilities force them to purchase their own medications from private outlets or go without treatment. This is especially problematic for economically disadvantaged patients who live in areas with restricted access to alternative medicine outlets, such as pharmacies or drug stores, where prices can be relatively high [27].

While Indonesia has made significant progress in covering its population with health insurance, it remains unclear which essential medicines are actually available, why some medications are not available, and to what extent people have access to alternative dispensing points. Insight into the availability of essential medicines throughout the country is essential to formulate policies to improve access, reduce inequalities and allocate resources to the areas where they are needed most.

This study aims to assess the availability of essential medicines in all PHCs throughout Indonesia, the reasons why medicines are unavailable, and the extent to which communities have access to alternative dispensing points, such as pharmacies and drug stores. Enumerators visited each of the 9831 PHCs across Indonesia to document the availability of 60 essential medicines and determine reasons for any unavailable medicines. We analysed the availability of both these 60 essential medicines, and a more focused set of 17 medicines prioritised by the Indonesian government, and explored the relationship between district fiscal capacity, percentage of limited percentage of economically disadvantaged people, accessibility to alternative dispensing points, performing independent financial management system and the 60-medicine availability.

Methods

Study design and setting

In this article, we present the results of the *Riset Fasilitas Kesehatan (Rifaskes)* study, a national health facility survey for which data about the functioning of all primary health centres in Indonesia was collected, including the availability of essential medicine [156]. The Rifaskes study was funded by the Government of Indonesia and was led by the authors of the present study (HH and YY), working at the Indonesian National Institute of Health Research and Development (*Balitbangkes*) with technical advice and support from academic experts (LT and RF).

Study population and inclusion criteria

Data were gathered on site from all Primary Health Centres (Pusat Kesehatan Masyarakat) and district health offices in all 514 districts in Indonesia. PHCs were included in the survey when they were listed as active PHCs at the start of 2019 (n=9909) and were functioning as PHCs when reached by the enumerators. PHCs were excluded when they were not active when visited by the enumerators or the function of the facility had changed (e.g. transformed into a hospital). Of the total of 9909 PHCs that were listed, 9831 PHCs (99.2%) were included in the survey and dataset.

Data collection

Preparation for the study started with a pilot of the questionnaire and data collection procedures in Cirebon District, West Java. The structured questionnaire was developed by a team of Balitbangkes. The structure and most questions and themes were inspired by the Service Availability and Readiness Assessment (SARA, developed by WHO in collaboration with USAID). The SARA instrument was adjusted to the Indonesian context by the research team, in close consultation with experts from the Indonesian government and academia. The main adjustment was that more questions were added regarding the performance PHCs and the district health offices [157]. The instrument that was used in the study is available at https://dataverse.harvard.edu/dataverse/Medicines_Indonesia.

Data were collected in each of the 514 districts by four local data collectors and one field coordinator. The field coordinators were staff members of Balitbangkes. The 2056 data collectors were hired locally, had at least a bachelor degree related to health, and received a one-day training to ensure the quality of the data collection process.

Data collectors used a paper-based structured questionnaire. Data were collected on-site between April and July 2019. The data collectors visited the PHC and interviewed the responsible staff members, including the head of the PHC, the treasurer, and the pharmacists or other staff members responsible for managing the PHC medicines.

Data Management

The data collectors handed the paper questionnaires to the field coordinators, who double-checked their completeness and entered the data in the RedCap online platform. The electronic data was stored at the data management unit at the National Institute for Health Research and Development. Data were ready to be used in 2020. Data management and analysis were done using IBM SPSS Statistics version 27.0.

To analyse the relationship between medicine availability, access to health providers and alternative dispensing points, and health insurance coverage, we merged the data from the Rifaskes study with two other national surveys to the district level.

The first is a national census of villages or *Survei Potensi Desa* (PoDes) 2019, a census of all villages in Indonesia: 94573 village records. The second dataset comes from Sismonev JKN, an online platform from the National Social Security Council (DJSN), which provides demographic data about health insurance coverage per district (Sismonev JKN 2019). The three datasets were merged at district level without weighting, as all three datasets contain information based upon a total sample.

Data analysis

Continuous variables were reported as averages, or as median values with interquartile ranges when the variable was skewed. Normality assumptions were checked by inspecting the distribution of the residuals of the continuous outcome variables. We performed univariable and multivariable linear regression analyses to assess the relationship between the availability of 60 selected medicines and district's characteristics (type of district, fiscal capacity, percentage of JKN subsidised participants, access to other medicine dispensing points, medicine availability at the District Health Office, and population density) and independent financial management at the PHC.

Ethics Approval

Ethical approval for this study was received from the Health Research Ethics Committee, National Institute of Health Research and Development (HREC – NIHRD) with reference number LB.02.01/2/KE.011/2019.

Variables and Measures

Availability of essential medicines

Data collectors visited all PHCs and checked, together with the responsible officials at the PHC, the availability of 60 essential medicines. According to Ministerial Health Decree HK.01.07/Menkes/688/2019, these 60 medicines should be available in all PHCs. This decree describes the Indonesian Essential Medicine List (EML) and states which medicines should be provided at which type of facility. These 60 medicines are listed by the WHOs' Service Availability and Readiness Instrument (WHO SARA) as indicator medicine for essential medicine availability [157]. In our analysis, we also assess the availability of a smaller sub-selection of 17 medicines that are prioritised by the Indonesian Ministry of Health as 'most essential' medicines (marked with (M17) in Figure 1). The data collectors checked whether a medication was available and did not distinguish between different strengths or variations of that medication.

Reasons why medicines were unavailable

If a medicine was not available, the responsible official at the PHC was asked why it was absent. Possible answers were: 1) not supplied to the PHC, 2) not needed at the PHC, 3) substitutable by another medicine, and 4) management difficulty and other. Additional data pertaining to the response category 'management difficulty and other' was not collected.

Districts and four regions

We followed the official division of districts in 'rural districts' *(Kabupaten)* and 'urban districts' *(Kota)* and five levels of district fiscal capacity (very low, low, middle, high and very high). In line with previous studies, we grouped Indonesia's 34 provinces into four regions that demonstrate similar economic characteristics, as shown in Table 1 and mapped in online supplementary material file (3). From west to east, these four regions are 1) Sumatra and the western islands; 2) Java and Bali; 3) Borneo, West Nusa Tenggara (NTB), and Sulawesi, and 4) Eastern

Indonesian (East Nusa Tenggara (NTT), Maluku and Papua). Supplementary Figure 1 showed the four regions in Indonesia's map.

Population and insurance status

Using the data from Sismonev JKN 2019, we calculated insurer-reported coverage by dividing the number of registered participants (subsidised and non-subsidised) by district population. In our analysis, we focus on the participants with subsidised JKN health insurance. This is the most relevant segment for our analysis, as these Indonesians are considered economically disadvantaged by the Indonesian government. While health insurance coverage tends to be high in almost all districts in Indonesia, there are significant differences between districts in the percentage of participants with subsidised JKN health insurance (6). This is both the most resource-limited segment of the population and the group that is most in need of free essential medicines from public facilities.

Access to health service providers and alternative medicine dispensing points

We constructed a proxy for physical access to health service providers and medicine dispensing points at the district level using data from 94573 villages recorded. In PoDes 2019, village heads were asked whether various health services were present in the village, and if not, how easy it was to reach. We classified each health service as accessible if the service was present in the village, or 'easy' or 'moderately easy' to reach. We classified access as 'restricted' if the nearest facility was reported as 'hard' or 'very hard' to reach. The health services included are PHCs, hospitals, private clinics, general practitioners and midwives. In a similar way, we constructed a proxy for access to alternative medicines dispensing points at the district level, for which we included pharmacies, hospitals, and drug stores. Drug stores were included as a medicine dispensing point, as studies show that they often sell a variety of 'prescription only' medicine.

Results

Characteristics of the study population

Table 1 shows Indonesia's diversity in terms of population, availability of medicines, health service providers and medicine dispensing points, and insurance coverage across four different geographical regions.

Table 1. Study population characteristics by region and types of districts

	Region				*Type of districts*		*National*
	Sumatra	**Java and Bali**	**Borneo, NTB and Sulawesi**	**Eastern Indonesia**	**Rural**	**Urban**	
Population (in million people)	59·3	162·4	42·5	15·0	206·9	72·5	279·4
Population density	10864	110741	8242	3693	9495	293389	15038
Districts	154	128	147	85	416	98	514
District fiscal capacity [n]							
Very high	6	31	6	0	24	19	43
High	22	44	18	7	77	14	91
Middle	32	38	38	18	105	21	126
Low	42	14	43	29	104	24	128
Very low	52	1	42	31	106	20	126
Availability of Essential Medicine in PHC (out of 60) [mean sd]	34·4 (6·3)	36·3 (5·3)	35·0 (6·1)	32·3 (8·2)	35·0 (6·3)	35·0 (5·3)	35·0 (6·3)
Availability of Most Essential Medicine in PHC (out of 17) [median IQR]	14·0 (2·0)	14·9 (1·7)	14·3 (1·9)	13·2 (2·8)	14·3 (2·1)	14·6 (1·7)	14·3 (2·0)
Primary Health Centres	2547	3696	2373	1215	8131	1700	9831
Primary Health Centres with independent financial management	582	2138	345	174	2422	817	3239
Hospitals	711	1466	437	177	1583	1208	2.91

Private pharmacies	5611	14647	5203	1227	17283	9405	26688
Drug stores	3933	10952	1828	147	12684	4176	16860
Villages	25621	25988	18996	13332	78691	5246	83937
% of villages with easy to moderate access to any type of health facility *[M]	97%	100%	92%	66%	97%	100%	97%
% of villages with easy to moderate access to any other dispensing point**[M] (excluding PHC)	96%	100%	82%	37%	87%	100%	93%
Percentage of population with JKN coverage	73%	79%	86%	80%	76%	88%	79%
Percentage of JKN participants that are subsidised	47%	45%	55%	62%	51%	38%	48%

NTB: West Nusa Tenggara; JKN, *Jaminan Kesehatan Nasional*; PHC, Primary Health Centres; M, Median; IQR, Interquartile range

*Included facilities: primary health centres, pharmacies, private clinics, general practitioner practices and hospitals

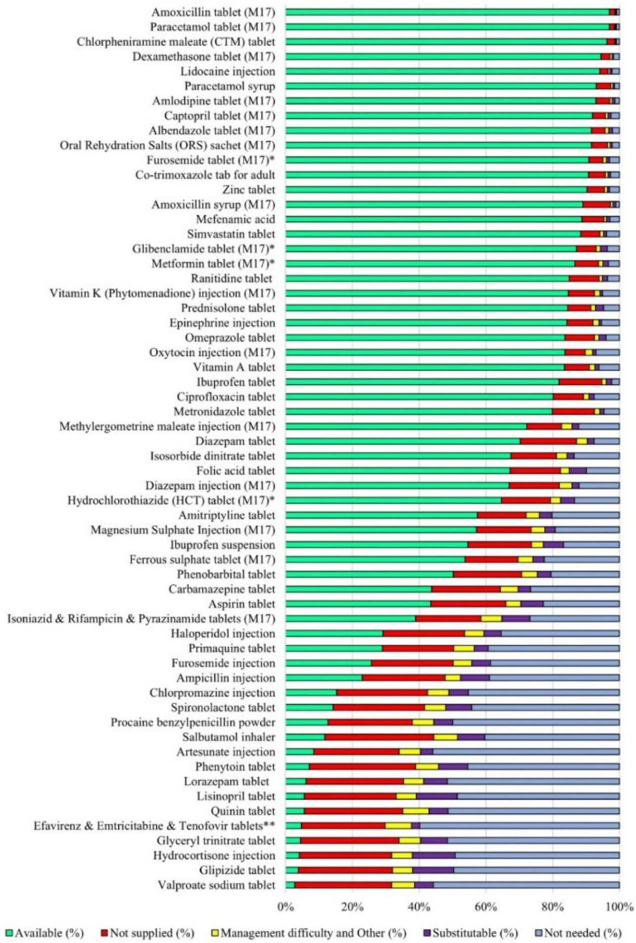
**Included medicine providers are pharmacies, hospitals and drug stores.

The Java and Bali region is the richest, most populous and has the highest number of facilities offering health services and medicines, including pharmacies and drug stores. In contrast, Eastern Indonesia is the most resource limited and least populous region and has the lowest number of healthcare facilities and medicine providers.

While most facilities are concentrated in the Java and Bali regions, the sparsely populated Eastern Indonesia boasts approximately four times more PHCs per citizen. The eastern region has the lowest percentage of villages with access to healthcare while having the highest percentage of subsidised JKN participants. Eastern Indonesia has a much lower number of drug stores (147) compared to the other regions in the country, such as the Java Bali region (11952).

The availability of 60 essential medicines

Figure 1 shows the availability of each of the 60 essential medicine in all PHCs across Indonesia. Medicine availability varied greatly. Thirteen out of 60 essential medicines (22%) were available in more than 90% of the PHCs. The majority (33 out of 60) of the medicines were available in less than 80% of the PHCs. Twenty out of 60 medicines were available in less than 30% of the PHC.



M17 = Indonesian priority medicines. *= For the calculation of priority drugs (M17)· the availability of glibenclamide tablet can be substituted for metformin tablet· and Furosemide tablet can be substituted for HCT tablet. **= Tenofovir + Emtrisitabin + Efavirens tablets (HIV medicinzes) can be substituted by the combination of Tenofovir + lamivudin + Efavirens tablet

Figure 1. The availability of 60 selected essential medicine in PHCs

The reason that medicines were not available

When a particular medicine was not available, the responsible staff at the PHC were asked why it was out of stock. The most common response was that medicines were deemed 'not needed' (46%). The second most common reason, accounting for 38% of stockouts, was that medicines were not supplied to the PHC. Additionally, some medicines were unavailable due to being 'substitutable' (8%) or due to 'management difficulties' (8%). Surprisingly, half of the PHCs considered a quarter of the 60 essential medicines as 'not needed'. However, the other half reported that these fifteen medicines were neither substitutable nor supplied to them. Supplementary Figure 2 shows the distribution of the average availability of the 60 essential medicine in PHCs. On average, 58% of the essential medicine were available.

The availability of the 17 priority essential medicines

Given the frequency with which PHC staff identified multiple medicines as 'not needed' or 'substitutable', we also analysed the availability of the 17 medicines prioritised by the Ministry of Health as the 'most essential medicines' (marked with (M17) in Figure 1). 82% of these 17 priority medicines were available (Supplementary Figure 3 shows the distribution of the average availability). Six of the 17 most essential medicines were available in less than 80% of the PHCs. These six medicines were methylergometrine maleate injection (72%), diazepam injection (67%), hydrochlorothiazide (HCT) tablet (65%), magnesium sulphated injection (57%), ferrous sulphate (54%), and adult anti-TB medicines (39%).

Since a previous study suggested that medicines were less likely to be supplied to more remote areas, we also assessed the average availability of medicines in PHCs per district. Figure 2 shows the average availability of the 17 most essential medicines across all 514 districts in Indonesia. Availability ranged from 6.9 (41%) in the district with the lowest availability, to 17 (100%) in the best-performing district. Overall, there was a small difference in mean availability between rural (84%) and urban (85%) districts. However, when comparing urban and rural districts within each of the four regions individually, the differences were much larger.

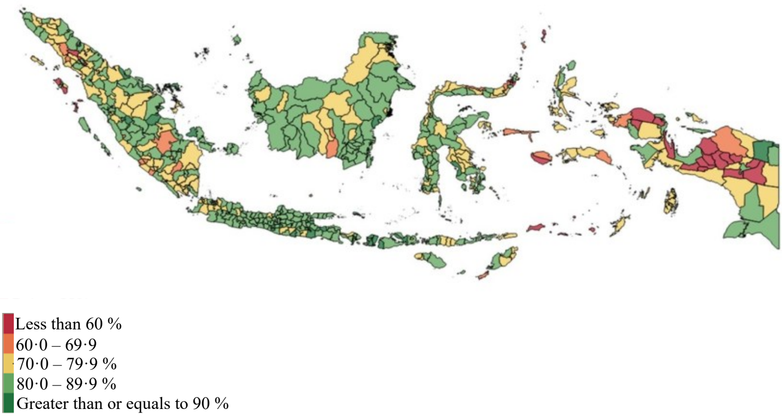


Figure 2. Average availability of 17 most needed essential medicines in PHCs at the district level.

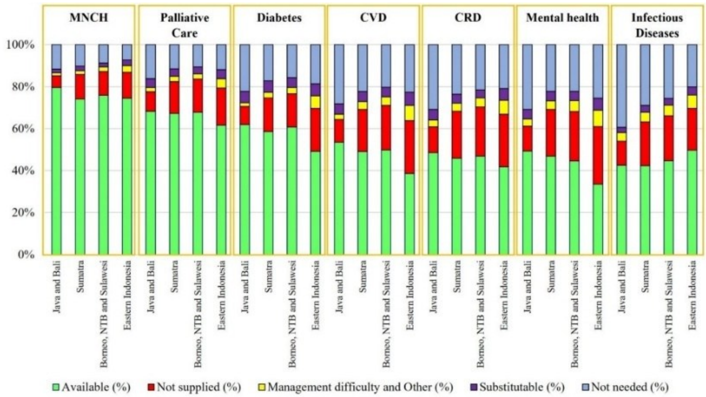
Reasons for medicine absence per district

We assessed the main reasons for the absence of the 17 priority medicines in PHCs, comparing urban and rural districts within each region (Supplementary figure 4). In rural areas in Eastern Indonesia, as well as in the Borneo, NTB, and Sulawesi regions, the unavailability of priority medicines is predominantly attributed to supply problems, accounting for 46% and 48% respectively. In contrast, in urban districts of the Java and Bali regions, supply problems are less frequently cited as the cause for medicine unavailability (16%). Regardless of the region, the most common reason for the absence of the 17-priority essential medicine in rural districts is the failure to supply them, accounting for 44% of cases, compared to 32% in urban districts.

The availability of medicines based on treatment categories.

The 60 essential medicines in our study are categorized in different treatment categories, which include: 1) Maternal, Neonatal, and Child Health (MNCH), 2) palliative care, 3) Diabetes, 4) cardiovascular diseases (CVD), 5) Chronic Respiratory Diseases (CRD), 6) Mental Health and Neurological Diseases, and 7) Infectious Diseases.

Figure 3 shows the median (M) availability of medicines for each treatment category, per region and district type. There were large differences in availability between the categories. Medicines needed for maternal, neonatal, and child health services were most available (80%), while the availability of medicines for mental health was much lower (35%), with a notable scarcity in Eastern Indonesia (33%).



MNCH: Maternal, Neonatal, and Child Health, CVD: Cardiovascular Diseases, CRD: Chronic Respiratory Diseases

Figure 3. The availability of 60 essential medicines, for each of the service categories, per region

Access to health service providers and alternative dispensing points

We continue to identify access to the providers of health services and present the results in Supplementary Table 1. In urban districts throughout Indonesia and rural areas in the Java and Bali regions, 100% of the villages reported good access to a PHC (characterised as easy or moderately easy to reach). In rural areas in the other three regions, the percentage of villages with good access to a PHC was lower, with 92·3% in Sumatra, 89·3% in Borneo, and 63·2% in Eastern Indonesia.

When medicines are not provided by a PHC, patients must obtain them from another provider. This is especially problematic when people are financially struggling and access to other medicine dispensing points is restricted. Supplementary Table 1 shows that the percentage of the JKN subsidised participants is the highest in rural Eastern Indonesia (as indicated by the 81·7% who have subsidised health insurance). While people in these districts are most dependent on free medicines provided by the PHC, access to PHCs is most restricted (63.2%) and they have less access to other dispensing points (34·9%), including pharmacies (31·8%), hospitals (24·1%) and drug stores (6·4%), compared to other regions (Supplementary Figure 5 shows the maps with access to community pharmacies, hospitals and alternative dispensing points per district).

Regression analysis

Table 2 displays our regression analyses. It shows that in districts with more resource-limited populations (higher percentage of people with subsidised JKN), the availability of essential medicines was lower. In districts with less access to alternative dispensing points, the availability of essential medicine was also lower. PHCs which managed their own finances had a higher availability of medicines, compared to PHCs for which finances were managed at the district level. These relations were strongest in Eastern Indonesia, compared to the other regions.

Table 2. The availability of 60 essential medicines, percentage of JKN subsidised participants, access to alternative dispensing points, independent financial management and population density – linear regression model including district fiscal capacity and type of district.

	Unstandardized β Coefficients	95 CI	Standardised β Coefficients	P-value	Adjusted R2 (%)
			Univariable		
Type of districts	0·03	-0·30: 0·35	0·00	0·878	0·00
District fiscal capacity					
Very low	-2·24	-2·58: -1·91	0·13	<.001	0·02
Low	-0·80	-1·11: -0·46	0·05	<.001	0·00
Moderate	1·24	0·95: 1·54	0·08	<.001	0·00
High	0·89	0·60: 1·20	0·60	<.001	0·00
Very high	0·33	0·05 :0·66	0·02	0·036	0·00
Percentage of JKN subsidised participants	-0·03	-0·03: -0·02	-0·08	<.001	0·01
Access to any alternative dispensing points	0·06	0·05: 0·06	0·21	<.001	0·04
Independent financial management	1·63	1·37: 1·90	0·12	<.001	0·02
Population density	-0·00	0·00: 0·00	-0·01	0·381	0·00
			Multivariable		
			All regions		
Type of districts	-1·12	-1·55: -0·69	-0·07	<.001	0·12

District fiscal capacity					
Very low			*Reference*		
Low	0·94	0·54: 1·34	0·06	<.001	
Moderate	2·01	1·61: 2·41	0·14	<.001	
High	1·29	0·88: 1·70	0·09	<.001	
Very high	0·52	0·03: 1·01	0·03	0·036	
Percentage of JKN subsidised participants	-0·02	-0·03: -0·01	-0·05	<.001	
Access to any alternative dispensing points	0·05	0·04: 0·06	0·19	<.001	
Independent financial management	0·93	0·66: 1·21	0·07	<.001	
Population density	0·00	0·00: 0·00	-0·02	0·032	
		Java & Bali Region			
Type of districts	-0·86	-1·47: -0·26	-0·07	0·005	0·04
District fiscal capacity					
Very low			*Reference*		
Low	-1·25	-2·57: 4·75	0·01	0·510	
Moderate	0·92	-0·93: 0·6	-0·01	0·620	
High	-0·36	1·49: 2·52	0·15	0·850	
Very high	-1·09	0·28: 1·17	0·07	0·560	
Percentage of JKN subsidised participants	0·01	-0·01: 0·02	0·02	0·340	

Access to any alternative dispensing points	-0·03	-0·08: 0·02	-0·02	0·250	
Independent financial management	0·80	0·46: 1·15	0·08	<.001	
Population density	0·00	0·00: 0·00	-0·04	0·040	
		Sumatra Region			
Type of districts	-1·77	-2·78: -0·76	-0·10	<.001	0·04
District fiscal capacity					
Very low			*Reference*		
Low	0·32	-0·37: 1·00	0·02	0·366	
Moderate	0·21	-0·52: 0·94	0·01	0·571	
High	0·01	-0·73: 0·75	0·00	0·980	
Very high	0·18	-1·27: 1·63	0·01	0·809	
Percentage of JKN subsidised participants	-0·04	-0·06: -0·02	-0·11	<.001	
Access to any alternative dispensing points	0·03	0·01: 0·05	0·07	0·001	
Independent financial management	1·76	1·16: 2·35	0·12	<.001	
Population density	0·00	0·00: 0·00	0·06	0·054	
		Borneo· NTB and Sulawesi Region			
Type of districts	-0·92	-2·04: 0·21	-0·05	0·111	0·07
District fiscal capacity					
Very low			*Reference*		

Low	1·96	1·29: 2·64	0·14	<.001	
Moderate	3·98	3·28: 4·68	0·29	<.001	
High	3·12	2·27: 3·96	0·18	<.001	
Very high	1·32	0·06: 2·57	0·05	0·040	
Percentage of JKN subsidised participants	-0·02	-0·03: 0·00	-0·05	0·090	
Access to any alternative dispensing points	0·02	0·00: 0·03	0·06	0·010	
Independent financial management	0·10	-0·60: 0·80	0·01	0·786	
Population density	0·00	0·00: 0·00	-0·08	0·005	
Eastern Indonesia Regions					
Type of districts	0·75	-1·89: 3·39	0·02	0·578	0·11
District fiscal capacity					
Very low	*Reference*				
Low	1·20	0·08: 2·32	0·07	0·036	
Moderate	-0·79	-2·08: 0·50	-0·04	0·229	
High	0·45	-1·36: 2·26	0·02	0·626	
Percentage of JKN subsidised participants	-0·16	-0·22: -0·1	-0·24	<.001	
Access to any alternative dispensing points	0·06	0·04: 0·09	0·19	<.001	
Independent financial management	-0·01	-1·28: 1·27	0·00	0·993	

Population density	0·00	0·00: 0·00	-0·10	0·024	

Discussion

Our study for the first time examines the availability of essential medicine in all primary health centres across Indonesia. The results show that medicines availability varies greatly. The median availability of the 17 medicines prioritised by the government as 'most essential' was 82%. On average, 58% of a broader selection of 60 essential medicines was present. The most frequent reason for the absence of medicine is that they were deemed not needed. 38% of the stock-outs were due to medicines not being supplied to the PHC. The availability of medicines varied depending on the type of medicine and the region in which the PHC was located. Medicines for maternal and child health services showed the highest availability, while medicines for infectious diseases and mental health (47%) were the least available. The eastern region of Indonesia, especially the rural areas, had the lowest availability of medicines, and the most districts in which even the 17 priority medicines were poorly available. While at the national level, medicine availability in PHCs seems relatively high, the poor supply of medicines in more remote parts of the country needs attention, as the population in these districts has the lowest income and is most dependent on public health services, where they should receive medicines free of charge.

The results provide insight into both the strengths and weaknesses of medicine availability in Indonesia. Careful interpretation is required. The availability of the 17 most essential medicines at 82% appears notably high, compared to availability data from other large middle-income countries such as the Philippines (30,1%), Pakistan (35%), and India (41,3%), [18–21]. Availability was even higher (85%) in the three most densely populated regions of the country, where a large majority (>95%) of the population lives. The Indonesian government has succeeded in achieving this high availability while bringing down the prices of publicly procured medicines to levels that are low by international standards [76]. The combination of low prices in the public sector and widespread availability of priority medicines to the majority of the population presents an interesting example for other countries striving to attain universal health coverage.

At the same time, our analysis shows that focusing on the average availability of a narrow selection of medicines also has its downsides, as it offers only a partial view. When we examine the larger group of 60 medicines, it becomes evident that several essential medicines were frequently unavailable. Comparing the average availability of this larger selection of medicines with survey results from other countries poses challenges, as our study includes a relatively large number of medicines and draws upon data from all functioning PHCs. We observed large variations in availability among different medicines and between regions within Indonesia. A smaller selection of medicines and a more limited number of sampling locations, as is customary in studies in other countries, can lead to different outcomes. Our detailed analysis shows that, rather than just focusing on average availability, it may be more interesting and useful to look at why medicines are not available and compare different areas. Although medicine availability studies are conducted in many countries, they seldom survey why medicines are not available.

A remarkable finding is that, as reported by local PHC staff, the most common reason for the absence of medicines is that they are deemed unnecessary. This may be appropriate for some medications, given the vast geographical and disease diversity of Indonesia. Diseases such as malaria are confined to specific districts, thereby requiring medication availability in only select PHCs [158]. Another possibility is that some medications are labelled as unnecessary because the health problems for which they are needed, remain undiagnosed at PHCs, or appropriate care is not provided for other reasons. The frequent claim that medicines for mental health and palliative care are not needed, particularly in rural districts and Eastern Indonesia, raises concerns about the adequacy of care in these areas. This issue deserves urgent attention, especially for populations with limited access to other public health facilities and medicine outlets.

The recurring assertion that certain essential medicines were considered unnecessary in PHCs raises questions about which medicines should be available where and the best way to monitor availability in such a diverse country. Currently, the supply and availability of medicines in the public sector is regulated at a national level. These national regulations state that everyone covered by national health insurance is entitled to free access to over 300 essential medicines from their local PHCs [153].

The results show that there are significant regional disparities in medicine availability. These differences are not necessarily problematic and may even be a strength of the existing decentralised pharmaceutical system. Although East Indonesia exhibited the lowest average availability of medicines, the data shows that it has the highest availability of medicines against infectious diseases. This suggests that local health authorities are strategically allocating their limited budgets to procure the medicines they consider most essential for their local population.

A drawback of these local differences is the lack of clarity for patients regarding the medicines available at their respective PHC. To improve access in practice, it could be beneficial to provide clear information about the specific medicines available at each PHC. This could empower patients to make informed choices decisions about where to seek appropriate care and hold their PHC accountable, while also offering health workers a clear understanding of what they are expected to provide. Ensuring insight into the availability of medicines may also help to convince self-insured Indonesians to continue to pay for their public health insurance, as it shows the benefits of maintaining insurance coverage [159].

The results of our study are also pertinent to the ongoing discussion about the best approach to monitoring medicine availability. In Indonesia, the current monitoring system relies on the self-reported availability of the 17 priority medicines in PHCs. Our findings are about 10% lower than those reported by the Ministry of Health, which may be due to our more complete sample. Our findings also show that the selection of 17 indicator medicines is quite limited. To make medicine monitoring more useful, it may help to expand the number of medicines included in the monitoring framework. There is also merit in considering the monitoring of additional medicines at the sub-national level and the use of a track and trace system [138]. Adopting a combination of national and locally specific indicators offers distinct advantages. It enables performance monitoring and learning from differences at multiple levels within the same framework. Engaging decision-makers at both national and local levels in the selection of their own indicator medicines may also help to enhance ownership, facilitate improvement efforts and promote accountability among national and local health authorities [124].

The primary weakness of the Indonesian approach is that medicines are too often unavailable because they are not being supplied. The lack of supply accounts for 38% of the absence of essential medicines and is the main cause of regional disparities and lower availability in rural and more remote districts, especially in the east. To supply its public health facilities with medical products, Indonesia relies on its competitive and largely domestic pharmaceutical sector. Indonesia has successfully managed to mobilise market forces to push down medicine prices and supply most of its PHCs with priority medicines [160]. The weakness of this same approach is that when it is not profitable to supply a health facility, due to high transportation costs or low volumes, market forces determine that patients are not provided with the medicines they need. This disproportionally impacts to the low-income patients living in sparsely populated and remote districts that are thousands of kilometres away from the manufacturers of medicines. Poor availability of medicines in public facilities pushes patients to private pharmacies and drug shops, where medicines are often sold at relatively high prices, and patients may encounter products from unregulated supply chains, which are more likely to be expired and of poor quality [77, 88, 154].

Until recently, the Indonesian government tried to improve availability in remote areas by offering a premium of up to 20% to incentivise delivery to the most far-flung parts of the archipelago. The lower availability in these remote areas indicates that this premium was not sufficient. Starting in 2023, a new approach was introduced. The consolidated tenders per province were dropped, and now each health facility is free to negotiate directly with manufacturers. While this may work well in the wealthier parts country, where there is sufficient competition between suppliers, it may not be as effective in the low fiscal capacity, least populated, and more remote districts. Fragmentation of demand in these areas could reduce negotiating power and potentially lead to higher prices. Implementing some form of local-level pooled procurement could aid in mitigating these risks[133]. Another concern is that prices paid will no longer be visible to the public, which contradicts WHO recommendations for transparent medicine pricing policies(30,31).

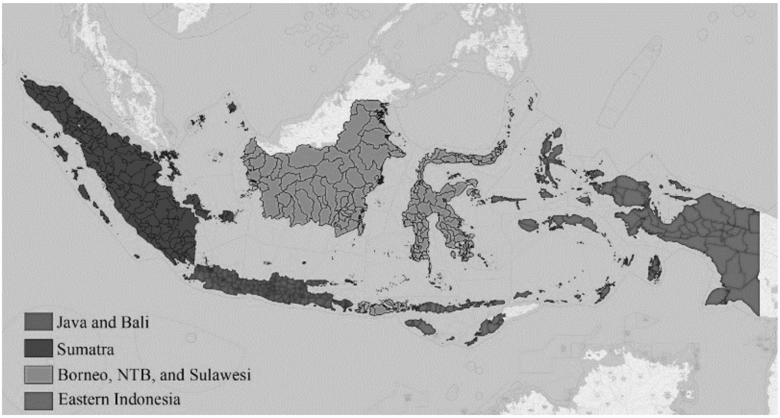
The effects of these changes on the availability and price of medicines in the public health system in Indonesia are difficult to predict. Given the pivotal importance of access to medicines for people's health, it is essential to ensure careful monitoring and in-depth research to assess the impact of this new approach on changes in medicine accessibility and pricing within Indonesia's public health system. The latest government regulation aims to offer the public real-time insight into the availability of medicines in health facilities, contributing to effective monitoring.

Strengths and limitations

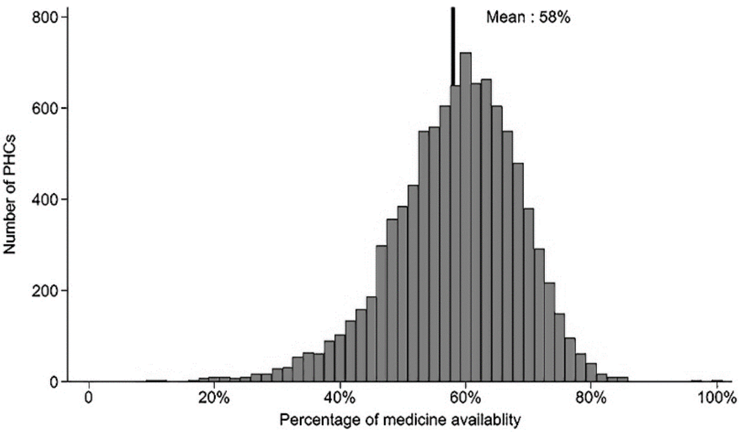
A strength of this study is that it covers data from practically all PHCs in Indonesia, which allows for a unique and comprehensive assessment of medicines availability and regional disparities across one of the largest and most diverse countries in the world. A potential limitation is that the availability of medicines was assessed at only one moment in time. Recent studies in other countries show that medicine availability in public facilities tends to fluctuate over time. While it may be interesting to track availability in specific PHCs, our large sample makes it unlikely that longitudinal tracking would lead to very different outcomes. We also note that there may be more alternative dispensing points than those included in our study, such as physicians, midwives, or small private clinics who also sell medicines. Ideally, the analysis should have as the end goal not the availability of medicines, but patient outcomes.

Overall, this study shows that the availability of prioritised essential medicines in PHCs across Indonesia is relatively high, which is an important finding given the low prices for publicly procured medicines. The average availability of a more comprehensive selection of 60 essential medicines was lower (58%), with some medicines frequently being considered unnecessary by local staff. The availability of medicines was found to be lowest in rural districts, particularly in the Eastern part of Indonesia, where access to other medicine providers is also most limited. These findings unveil both the strengths and weaknesses of medicine availability in PHCs in Indonesia and can be used to guide efforts towards improving access to essential medicine and furthering the goals of achieving universal health coverage.

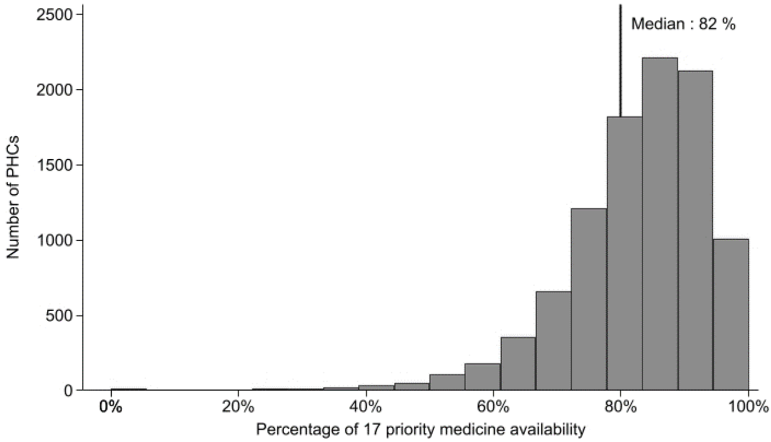
Supplementary materials



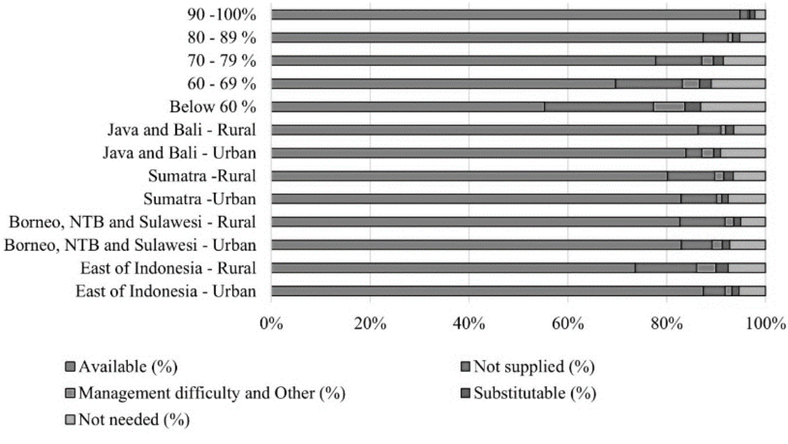
Supplementary Figure 1. Four regions of Indonesia



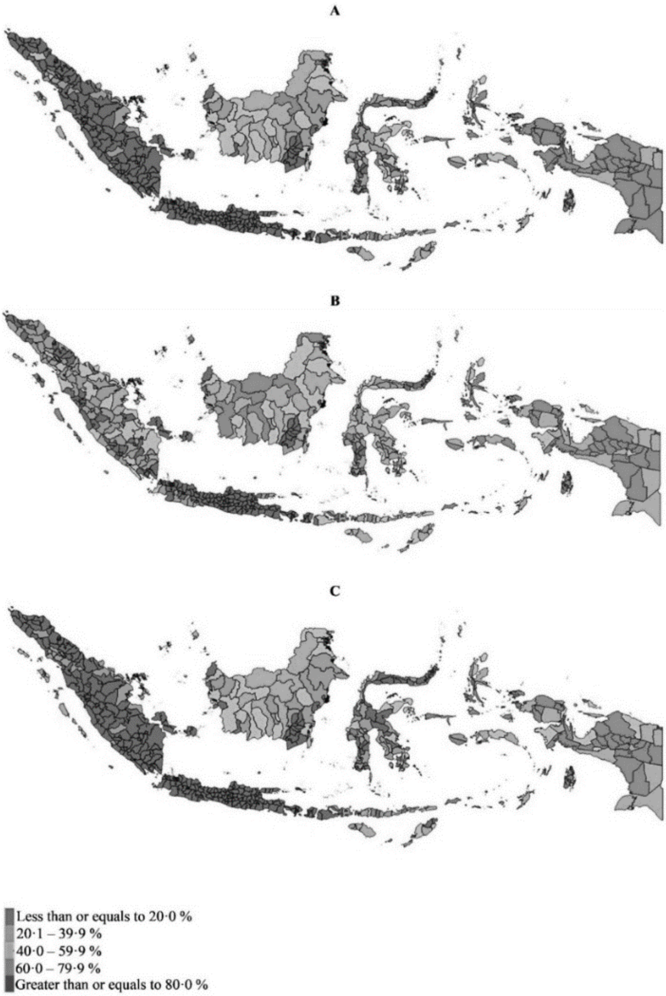
Supplementary Figure 2. The average availability of 60 essential medicines in all Indonesian PHCs



Supplementary Figure 3. The average availability of 17 most essential medicine in PHCs.



Supplementary Figure 4. Reasons that the 17 most essential medicines were not available, comparing urban and rural districts per region.



Supplementary Figure 5. Good accessibility score to a community pharmacy (A), a hospital (B), and other dispensing points (C) based on perspectives of the heads of villages.

Supplementary Table 1. Percentage of villages having easy access to health providers

	Administrative type	Percentage of JKN subsidised participants	Median % of villages with easy access to:				
			PHC	Community Pharmacy	Hospital	Drug stores	Any other dispensing point*
Java and Bali	Rural	71·4	99·5	99·3	98·7	62·5	100·0
	Urban	44·5	100·0	100·0	100·0	81·5	100·0
Sumatra and islands	Rural	68·5	92·2	84·0	73·9	45·8	93·6
	Urban	51·8	100·0	100·0	100·0	69·7	100·0
Borneo, NTB Sulawesi	Rural	75·2	89·3	74·4	58·2	34·6	77·0
	Urban	50·6	100·0	100·0	100·0	72·7	100·0
Eastern Indonesia	Rural	81·7	63·2	31·8	24·1	6·4	34·9
	Urban	59·8	100·0	95·1	95·1	51·8	95·1
National	Rural	73·6	92·2	80·4	69·9	43·3	88·7
	Urban	50·8	100·0	100·0	100·0	74·0	100·0
	Total	70·4	95·2	87·8	79·4	48·6	70·4

M: Median; *included pharmacies, drug stores and hospitals

Supplementary material 1. Research in Context

Evidence before this study

We searched PubMed, Web of Science and Google Scholar for relevant articles without date or language restrictions. The search terms we used were either text word (tw) or Medical Subject Heading terms (MeSH). We included terms for medicines ("medicines" OR "medicines availability" OR "pharmaceuticals" OR "medical products" OR "obat") related terms that could lead to relevant empirical studies ("pharmaceutical system" OR "pharmaceutical supply chain" OR "pharmaceutical management") the name of the country, main islands and region ("Indonesia" OR "Java" OR "Papua" OR "Sumatra" OR "Kalimantan" OR "Sulawesi" OR "Southeast Asia") and facilities ("primary health facilities" OR "puskesmas" OR "hospitals" OR "drug stores" OR "pharmacies" OR "farmasi" OR "apotek" OR toko obat"

We found that very little has been published about medicine availability in public facilities in Indonesia. The five peer-reviewed publications that we identified offer information about only a small number of facilities (<1% of total) and with one exception, focus on public facilities on Java, the most developed island of the country. These studies reveal frequent shortages that hinder patient treatment. Three of these studies were conducted in large cities: in Jakarta a third of the primary health centers (PHC) lacked vital hypertension medicine for a year, in Yogyakarta, around 76% of 50 essential medicines were available in public facilities, and a study in Surabaya reported a quarter of essential medicines were missing in PHCs. A survey in facilities in central Java found that 23% of medicines needed for obstetric care were not available. One small study in six PHCs in Keerom district in Papua indicates that remote areas face worse shortages: 29% of 35 essential medicines was unavailable and 7% expired.

No large-scale studies into the availability of essential medicines in public facilities across Indonesia have been published. There is a lack of surveys investigating the reasons behind medicine stock-outs, no exploration of disparities in medicines access between various regions within the country, and an absence of research into access to medicine outlets throughout the archipelago.

Added value of this study

Our study shows, for the first time, the availability of essential medicine throughout the entire network of primary health centers across Indonesia. The findings reveal significant variations in the availability of medicines. The median availability of 17 priority medicines was 82%, which is relatively high compared to other countries in the region. Out of the broader selection of 60 essential medicines, 58% were present. The primary reason for the absence of medicines was their perceived lack of necessity, accounting for 46% of the stock-outs. Additionally, 38% of the stock-outs were due to medicines not being supplied to the PHCs. The results highlight the variation in medicine availability based on the type of medicine and the location of the PHC. Availability was the lowest in eastern region of Indonesia, especially in the rural areas. These underserved districts are home to the most economically disadvantaged communities in the country and heavily rely on free medicines provided by PHCs. Our analysis reveals that these communities also have the most limited access to alternative medicine outlets.

Implications of all the available evidence

These findings show that the availability of many essential medicines in PHC is insufficient, highlighting the need for improvement to ensure adequate treatment and achieve universal health coverage in Indonesia. In addition to providing a crucial baseline, the results emphasize the necessity for targeted interventions to enhance the supply of medicines in rural and remote areas, particularly within the eastern part of the archipelago.

The observation that certain medicines are occasionally perceived as unnecessary can be attributed, at least partially, to the remarkable diversity of Indonesia and the existence of diseases confined to specific parts of the country. This observation suggests that policymakers must strike a delicate balance between national pharmaceutical regulation and the support of local capacities, practices and structures necessary to ensure the adequate availability of essential medicines at the district and facility levels. This involves medicines prioritization, effective forecasting and inventory management, as well as transparent monitoring of availability and the reasons for shortages.

Despite the challenges, these results from Indonesian offer valuable insights for other nations, as the prices for publicly procured medicines are remarkably low, and the availability of priority medicines is relatively high when compared to data from other middle-income countries.

Chapter 4:
Local Systems, Local Solutions: Which factors drive essential medicine availability in public health facilities across Indonesia?

This chapter is accepted for publication at the BMJ Global Health.

Abstract

Introduction
Ensuring free access to essential medicines is a cornerstone of universal health coverage, yet many countries face persistent local disparities in medicine availability. This study investigates the factors driving variation in essential medicine availability in primary health facilities across Indonesia, focusing on the functionality of local pharmaceutical systems and the influence of socioeconomic and geographical environments.

Methods
Enumerators visited each of the 514 District Health Offices and 9,831 Primary Health Centers (PHCs) to conduct a nationwide health facility assessment. This data was combined with publicly available information on spatial, geographical, socioeconomic, and health system factors. Using regression analysis, multilevel modeling, and spatial autocorrelation techniques, we identified facility-, district-, and provincial-level factors associated with the availability of 50 essential medicines in public health facilities.

Results
On average, 66% out of 50 surveyed medicines were available in PHCs, with district-level availability ranging from 83% in top-performing areas to just 43% in the lowest. PHCs with a pharmacist, clear guidelines, and proper storage infrastructure had significantly higher availability, compared to those without. Other key drivers included the application of inventory management principles (e.g., First-Expired, First-Out), autonomy in procurement, and district level stock levels. Spatial analysis revealed strong clustering of medicine availability within a 2 km radius (Moran's I: 0.67), with high-availability clusters present even in low-performing districts, highlighting the role of localized factors.

Conclusion
Essential medicine availability in Indonesian PHCs varies substantially and is closely linked to the functionality of local pharmaceutical systems. Strengthening human resources—particularly by ensuring the presence

of a pharmacist in every PHC—and improving physical infrastructure are critical priorities. Beyond PHC-level interventions, targeted efforts to enhance the capacity of District Health Offices in managing pharmaceutical supply chains are essential, especially in rural and remote districts of eastern Indonesia.

Keywords: Medicine availability, Indonesia, Decentralization, Pharmaceutical system, Access to medicine

What is already known on this topic

- The Indonesian government is striving to achieve universal health coverage, which includes providing free access to essential medicine in public health facilities.
- While medicine stockouts in public health facilities are a known concern, little is understood about how in the decentralised health system in Indonesia, facility and district level factors, and geographical and socioeconomic characteristics drive variations in medicine availability.

What this study adds

- This study reveals significant variation in the availability of 50 essential medicines across districts, ranging from 83% in the best-performing areas to just 43% in the lowest-performing districts.
- Using a local pharmaceutical systems (LOPHAS) approach, this study identifies multiple drivers of essential medicine availability. Key contributors include the presence of pharmacists at PHCs, adequate storage infrastructure, the application of inventory management principles, and autonomy in medicine procurement.
- District level factors, such as comprehensive district planning, diversified procurement strategies, and the availability of medicines at district storage facilities, are also critical for ensuring a consistent medicine supply to PHCs.

How this study might affect research, practice, or policy

- Identifying key local system features that significantly impact medicine availability can guide policymakers in strengthening pharmaceutical management at both PHC and district levels, particularly in rural and underserved regions.

Introduction

Around the world, many countries struggle to provide access to medicine to their population. Studies consistently reveal considerable disparities in medicine availability between different regions within countries [9, 40]. These local variations exacerbate inequalities, as medication availability is often higher in richer urban areas and lower in rural and remote areas, where residents typically have lower incomes and more limited access to health care [2, 111, 163, 164]. Limited availability of medicines, combined with high prices, poses significant risks to patients' health by increasing the likelihood of untreated conditions, suboptimal care, and inflated healthcare costs. Furthermore, the scarcity of medicines in public facilities often drives patients to seek alternatives from private, unregulated sources, which raises the risk of exposure to expensive, expired, or falsified medications [22, 23, 88, 89, 165].

Previous studies indicate that several factors influence the availability of essential medicines. These include infrastructural, geographical, socio-economic aspects, as well as the organization of the health and pharmaceutical systems [81, 141]. Poor road conditions, limited transportation options, and long travel times can significantly hinder access to medicines. Additionally, geographical and political challenges—such as rurality, distance from distribution points, poor governance, and insecurity—are well-documented barriers to maintaining a consistent supply of essential medicines [166]. In contrast, effective procurement, proper storage and dispensing practices, well-trained personnel, real-time monitoring, transparent funding mechanisms, and a strong health and pharmaceutical system significantly enhance access to medicines [28, 48].

One of the countries striving to improve access to essential medicine in public facilities is Indonesia, the world's fourth most populus nation. Indonesia faces a unique set of challenges. The geographic, social and economic diversity of this vast archipelago country is exceptional [62]. More than half of its population of 270 million people are squeezed into Java Island, just the 6 % of the land mass [146]. The other 120 million citizens are scattered across some other 7.000 islands, spread out over the area of 5.1 million square kilometres [65]. While fiscal capacity of districts in Java tends to be classified as high and very high, the others, especially rural districts in Eastern in Indonesia were mostly classified as low and very low [167].

Indonesia has managed to sign up 98% of its population for its mandatory national health insurance scheme, which promises free access to essential medicines in public facilities [27, 62]. Primary health centers (PHCs) play a key role in providing health services and ensuring access to medicines. There are over 10.000 PHCs, which are strategically located throughout the archipelago and are the most accessible health service points for the population [66, 67]. A recent study indicates that while the availability of the 17 most-needed essential medicines in PHCs is relatively high at 82%, the availability drops to 58% when considering a broader selection of 60 essential medicines [70, 146].

A major concern is the significant variation in medicine availability across the country. Medicine stockouts are most frequently reported in more remote and peripheral areas in Indonesia, especially in the rural districts in the east, where the population tends to have the lowest income and highest health need, and access to alternative medicine dispensing points, such as hospitals and drug stores, is also most limited [168].

To reduce the stark local variation and improve access to medicines across Indonesia, analysts should not only focus on national policies and regulations but also examine the local factors that shape medicine availability. Indonesia has 514 District Health Offices (DHOs), which play a key role in allocating staff, such as pharmacists, and in managing the supply of medicines to (PHCs) [169, 170]. DHOs procure, store, and distribute medicines to PHCs within their districts. Large PHCs classified as financially independent are permitted to procure their own medicines, while other PHCs may do so only in emergency situations and with DHO approval.

Several aspects of DHOs and PHCs can influence their capacity to manage pharmaceutical supplies, including the availability of trained personnel, adequate facilities, transportation capacity, sufficient funding, and effective monitoring systems. A core idea underpinning this study is that these interrelated local factors collectively form and function as a local pharmaceutical system, which is inspired by the existing conceptual framework of a pharmaceutical system [9, 40]. A local pharmaceutical system comprises the people, structures, resources, practices, and interactions at the sub-national level that contribute to ensuring access to medicines, promote their appropriate use, and support the delivery of health services that improve health outcomes. In Indonesia, these local systems encompass community-, health facility-, and district-level entities that operate within the broader national health and pharmaceutical system.

Local circumstances, including health needs, the socioeconomic situation and logistical and geographical factors are also related to the local availability of medicines. Local differences in health needs, health insurance coverage, income levels and poverty rates directly influence the demand for medicines. Logistical factors also differ for different areas, including the travel time, infrastructure quality and the need to cross the sea to travel to another island [171].

Although multiple factors influence the performance of local pharmaceutical systems, it remains unclear which are most critical for ensuring access to medicines. Generating new insights into the key drivers of medicine availability is essential for guiding interventions, targeting investments, improving access, reducing inequalities, and advancing understanding of effective strategies to achieve universal access to medicines in a large, diverse, and decentralized nation.

In this study, we assess the availability of essential medicine in PHCs in Indonesia and analyse the local pharmaceutical, health system, socio-economic and geographical indicators driving variation in medicines availability. In 2019, enumerators visited each of the 514 DHOs and 9831 PHC to conduct a health facility assessment and collect data on the availability of essential medicines. We analysed the availability of 50 essential medicines, and explored its relationship with the organization of the local pharmaceutical system, health insurance coverage, district fiscal capacity, health expenditure and demographic and geographical indicators, such as the distance to the district capital. Since the PHCs are nested within districts and provinces, we conducted a multi-level analysis. To gain insight into the geographical clustering of medicines availability, we also performed a spatial autocorrelation analysis.

Methods

This article presents the results of a nationwide health facility survey, for which enumerators visited all 514 District Health Offices and all Primary Health Centers (Pusat Kesehatan Masyarakat) across Indonesia. The 2019 cross-sectional survey, named Riset Fasilitas Kesehatan (Rifaskes) was organized by the Indonesian National Institute of Health Research and Development (Balitbangkes), with technical guidance and support from academic experts. For our analysis, we combined this with additional data regarding district characteristics related to accessibility, financial, and demographical determinants and geographical and spatial information, which were derived from four other datasets. These are 1) the fiscal capacity map of Indonesian provinces and districts, 2) local government expenditures data containing provinces and districts, 3) health insurance coverage per district and 4) village potential survey [64, 172]. A detailed description of the Local Pharmaceutical Systems approach and framework can be found in Supplemental Figure 1 and online at: https://dataverse.harvard.edu/dataverse/Local_Pharmaceutical_System.

Sample size and data collection

The data in the Rifaskes study were gathered on site from all 514 DHOs and 9909 PHCs in Indonesia. We included all registered PHCs that were listed as active at the start of 2019 and were functioning as PHCs when physically reached by the enumerators (n = 9831 PHCs).

Data collection and management:

The data collection began with a pilot phase in Cirebon District, West Java. The pilot phase was led by staff of the Ministry of Health, who later participated as field coordinators at the provincial level.

Data collectors interviewed the PHC staff with a paper-based structured questionnaire and submitted the data through the Redcap online platform. To control the quality of data collection, the field coordinators provided daily supervision and regularly checked the performance of each enumerator. Field coordinators checked the data and ensured that data in the system matched the paper questionnaire. The electronic data was stored at the data management unit at the National Institute for Health

Research and Development. Data were ready to be used in 2021 after compiling them in 2020. More details about the research method have been published in Rifaskes report[173].

The additional datasets were derived from two ministry data repositories and the Indonesian statistics agency. The data about PHCs' characteristics was derived from the Ministry of Health, and data about fiscal capacity of districts and provinces and local government expenditure were obtained from the Ministry of Finance.

Spatial data concerning the Euclidean distance (km) from each PHC to the district capital, provincial capital and nearest PHC were calculated using QGIS software based on latitude and longitude coordinates.

All data was merged before being statistically analysed using district and province codes provided by the Ministry of Home Affairs. We had 36 observations with missing values. These cases were excluded from the analyses through listwise deletion. Given the small number of missing observations, we believe that their exclusion did not have a substantial effect on our results.

Variables:

Our main outcome variable was the availability of 50 essential medicine availability at DHOs and PHCs. The selection of these 50 medicines was guided by the World Health Organization's Service Availability and Readiness Assessment (SARA) instrument and finalized in consultation with the Indonesian Ministry of Health. Medicines that are only relevant in specific regions, such as antimalarials, were excluded to ensure national applicability. Enumerators visited PHCs and DHOs and physically verified the presence of each of the 50 selected essential medicines at the facility. A medicine was considered available if a full course for at least one patient was present in the facility's pharmacy at the time of the visit. The outcome variable was then calculated as the percentage of the 50 essential medicines that were available at each facility. In alignment with Indonesia's national medicine policy, two pairs of medicines were treated as therapeutically substitutable: glibenclamide and metformin (oral antidiabetic agents), and furosemide and hydrochlorothiazide (HCT) (antihypertensive/diuretic agents). For each pair, the presence of at least one of the two medicines was considered sufficient to indicate availability within the respective therapeutic category.

To determine which variables are associated with medicine availability, we used the local pharmaceutical system approach, and adapted it to the Indonesian context. We focused on our analysis on four core system components 1) managing human and physical resources, 2) financing, 3) monitoring performance, and 4) managing pharmaceutical supply. We evaluated the functioning of these core components and their impact on the availability of medicines in PHCs. Our analysis also considered other external factors, including demographic, social and geographic characteristics [174]. Supplemental Table 1 shows all covariates and their operational definitions.

Statistical analyses:

We started the analysis by inspecting the outcome variable. The medicine availability variable was normally distributed (c.f. Figure 1). For each covariate, we calculated the mean and standard deviations of the outcome. For numerical covariates, we presented the median and interquartile ranges. We continued our statistical analysis in three steps.

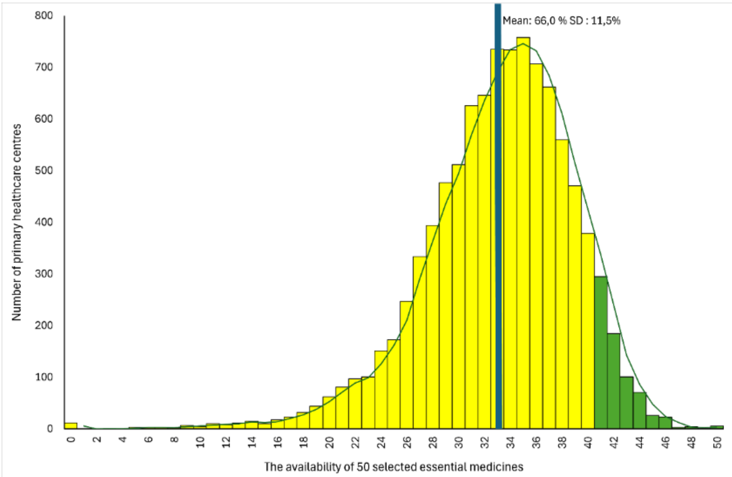


Figure 1. Distribution of the medicine availability in primary health centres in Indonesia in 2019.

The first step is selecting covariates based on the multivariable analyses within subdimensions. Covariates were tested for multicollinearity prior to model building, covariates with a significant correlation coefficient beyond 0.8 were excluded. Next, separate multivariable models were built for each subdimension. Using a backward selection process, we removed variables from the model that were not statistically significant at the 5% level. The remaining variables were included in the full models. We presented the univariable and multivariable results (crude model).

In the second step, we considered two different methods to account for the dependency of medicine availability between PHC's: 1) by fitting a multilevel model with a random intercept on province and district level, and 2) by fitting a spatial lag model using the average medicine availability of two nearest neighboring PHC's. We first investigated the strength and scale of spatial autocorrelation in medicine availability by computing the Moran's I statistic at various district bands. We then tested the residuals of the multi-level model and the spatial-lag model for spatial autocorrelation to ensure that the models accounted for the spatial dependency in medicine availability. We compared the fit of the crude model, the multi-level model and the spatial lag model based on the Aikake' Information Criterion (AIC) and R-squared (R2). The residuals and predictions of both models were visualized to ensure assumptions of linear regression analyses hold (Supplemental Figure 2).

In the final step, we assessed the contribution of each sub-dimension of the LOPHAS framework to the multilevel and spatial models. This was done by removing all variables from a single sub-dimension (e.g. financing) from the models and evaluating the change in R2 and AIC.

The descriptive and regression analyses were performed using Stata version 18. The assessment of spatial autocorrelation was performed using GeoDa version 1.12.

Ethical considerations

The Rifaskes survey obtained Ethical approval from Health Research Ethics Committee, National Institute of Health Research and Development (HREC – NIHRD). The reference number was LB.02.01/2/KE.011/2019. All respondents were provided with written information outlining the purpose of the study and signed a written informed consent form prior to participation.

Patient and Public Involvement

Patients or the public were not involved in the design, or conduct, or reporting, or dissemination plans of our research.

Results

We start with our descriptive analysis. Next, we present the analysis of spatial autocorrelation. We then present the statistical results of multilevel and spatial lag models. Our investigations of collinearity and multivariable analyses within sub-dimension result in 50 covariates that can be used for the statistical analyses.

Descriptive analyses.

On average, 66 % of the 50 essential medicines were available in the PHCs as presented in Figure 1. Table 1 illustrates the availability of medicines in PHCs, taking into account 58 covariates with nominal and ordinal scales. The numerical covariate descriptions can be found in Supplemental Table 2. They represent the characteristics of PHCs, DHOs, and district contexts. The result of the multivariable analysis can be found in Supplemental Material 2.

Table 1. The average of medicine availability based on geographical accessibility and fiscal capacity, district health office and primary health centre characteristics.

	The availability of 50 medicines			
	N	**%**	**Mean**	**Standard deviation**
PHC Level				
Output				
Medicine availability	9831	100,00	66,00	11,50
Local pharmaceutical systems				
Managing human and physical resources				
The availability of pharmacists	7630	77,61	67,17	10,58
The availability of medicine shelves	9483	96,46	66,42	11,11
Perceived of sufficient number of shelves	5886	59,87	66,92	11,01
The availability of lighting	9066	92,22	66,51	11,14
The availability of the guidelines of medicine and medical product services	8393	85,37	66,96	10,91
The availability of the guidelines for preparing and dispensing medicine concoction prescription	8702	88,52	66,91	10,89
Inpatient services	4094	41,64	68,70	11,06
Accredited	7569	76,99	67,71	10,5
The availability of ventilation or air circulation	8628	87,76	66,44	11,19

The availability of a separated room for pharmaceutical products	9548	97,12	66,38	11,15
The availability of the guidelines for preparing and dispensing dry syrup	7848	79,83	66,99	10,99
Financing				
Receiving district government funds	6289	63,97	66,73	11,08
Receiving retribution from patients	6569	66,82	67,75	10,6
Receiving non-capitation funds from the National Health Insurance Agency (BPJS Kesehatan)	6570	66,83	67,87	10,5
Receiving central government fund	7562	76,92	66,11	11,57
Receiving capitation fund from the BPJS Kesehatan	9441	96,03	66,26	11,44
Having independent financial autonomy	3239	32,95	68,24	10,62
Monitoring performance				
Having PHC management information system (SIMPUS)	6087	61,92	66,82	11,22
Having an electronic PHC management information system (SIMPUS)	4257	43,30	67,78	10,66
Having an online SIMPUS	3430	34,89	67,98	10,47
Managing pharmaceutical product supply				
Developing an independent medicine quantification	8119	82,59	66,81	10,81
The availability of Medicine use and ordering monthly report (LPLPO)	9722	98,89	66,17	11,44
The completeness of LPLPO	9351	95,12	66,41	11,22
Implementing DRP planning for an 18-month period	7285	74,10	66,76	11,22
Sources of medicine - combining DHO & PHC	3984	40,52	67,92	10,5

Achieving the volume target	6383	64,93	66,72	11,1
Procuring using capitation fund via e-purchasing scheme	3612	36,74	67,92	10,61
Procuring using capitation fund through direct purchasing	5229	53,19	67,21	10,88
Note for medicine in and out in 2018	9343	95,04	66,56	11,02
Use the FIFO and FEFO methods.	9036	91,91	66,86	10,77
Reporting Rational Use of Medicines	8430	85,75	67,10	10,72
Sources of medicine - Only DHO procurements	5665	57,62	64,85	12,09
Able to use capitation fund	8437	85,82	66,45	11,38
Independently procurement medicines using capitation fund	3625	36,87	66,74	11,22
Conduct independent medicine quantification (RKO)	9237	93,96	66,46	11,17
All medicines were from the PHC procurement	150	1,53	64,23	11,89
Accessibility, financial and demographical determinants				
PHC type				
Remote/very remote[reference]	2192	22,30	62,57	13,75
Rural	4663	47,43	67,15	11,08
Urban	2976	30,27	67,02	9,86
District level				
Local pharmaceutical systems				
Managing human and physical resources				
Having a pharmacist as the PIC at district warehouses	8082	82,21	66,29	11,53

Availability of Pharmacist staff	8864	90,16	66,08	11,52
Having a staff with a pharmacy background as the PIC at the district warehouses	8568	87,15	66,22	11,58
Financing				
Financial Resources for the medicine procurements - National Fund	9162	93,19	66,22	11,6
Financial Resources for the medicine procurements - Provincial Fund	1090	11,09	69,2	11,47
Financial Resources for the medicine procurements - Local Fund	4149	42,2	67,31	11,11
Financial Resources for the medicine procurements - Capitation	2515	25,58	66,4	12,29
Managing pharmaceutical product supply				
Conduct Medicine quantification	9550	97,14	66,09	11,63
Procurement schemes – National e-catalogue platform	9241	94,00	66,29	11,43
Procurement schemes - local auction	4337	44,12	66,75	11,77
Procurement schemes - local direct purchasing	4635	47,15	67,38	11,28
Implement procurement medicine policy: over 2 years of date expiration	9316	94,76	66,15	11,51
All medicines procured with policy: over 2 years of date expiration	6416	65,26	65,83	11,74
Waiting time for medicine procurement is less than one month	2356	23,97	67,12	10,95
Accessibility, financial and demographical determinants				
District Type				
Rural	8131	82,71	66,08	11,93
Urban	1700	17,29	66,14	9,54
Percentile of the total district total expenditure				

Quartile 1	1292	13,14	62,85	12,14
Quartile 2	1324	13,47	64,15	12,19
Quartile 3	1688	17,17	64,44	12,22
Quartile 4	2144	21,81	68,23	11,36
Quartile 5	3383	34,41	67,55	10,25
Percentile of district population				
Quartile 1	1127	11,46	60,73	14,31
Quartile 2	1241	12,62	64,62	12,03
Quartile 3	1731	17,61	65,30	11,73
Quartile 4	2136	21,73	67,06	10,97
Quartile 5	3596	36,58	68,08	9,92
District fiscal capacity				
Low and very low	3535	35,96	63,66	12,48
Medium	2315	23,55	67,79	11,52
High and Very High	3981	40,49	67,26	10,28
Located on a separate island from its provincial capital	1267	12,89	63,41	13,37
Provincial level				
Accessibility, financial and demographical determinants				
Region				
Eastern Indonesia	1215	12,36	60,12	14,59

Sumatera	2547	25,91	65,06	11,48
Borneo, West Nusa Tenggara, Sulawesi	2373	24,14	65,89	11,04
Java and Bali	3696	37,60	68,89	9,77
Provincial fiscal capacity				
Low and very low	2661	27,07	64,57	12,2
Medium	2299	23,39	66,53	10,53
High and Very High	4871	49,55	66,71	11,57

Spatial Autocorrelation

The medicine availability of a PHC tends to be similar to its neighbours. Supplemental Figure 3 presents Moran's I statistic across various distance bands and shows Moran's I value of 0.34 and p-value of <0.05, indicating that the availability of medicines is spatially clustered. Spatial autocorrelation was highest for PHCs within 2 km of one another (Moran’s I: 0.67), indicating that PHC’s in close vicinity of one another have similar levels of medicine availability as presented in Figure 2 and Supplemental Figure 4.

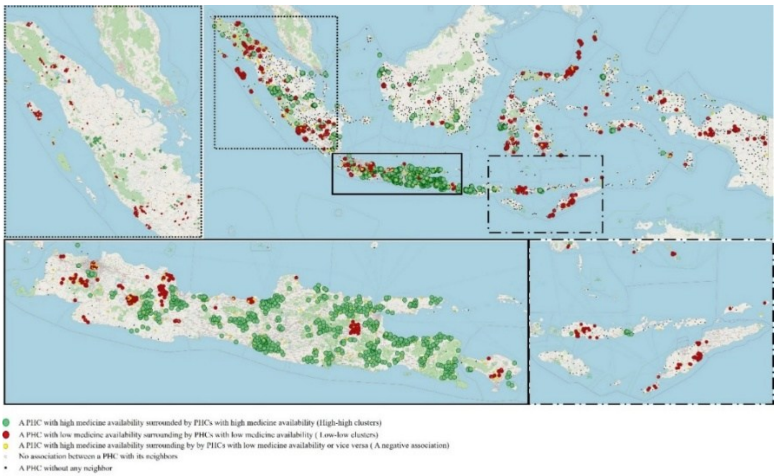


Figure 2. The map of a hotspot analysis to identify clusters of medicine availability at the PHC level in Indonesia.

Regression models

The multilevel and spatial lag models are presented in Table 2. These models provide a better fit compared to the crude model based on the AIC and R2. They also account for all spatial auto correlation.

At the PHC level, both models provide similar results. There are 16 variables which matter to the availability of medicines at the PHC level in three subdimensions of the local pharmaceutical system. For example, increased capacity for managing human and physical resources (e.g. with pharmacists, lighting, guidelines, inpatient service and being accredited) was associated with a higher availability of essential medicines (coefficients range from 0.42 to 1.47). In addition, better managing the medicine supply chain (e.g. with the availability of the monthly medicine reports, ability to use capitation fund, and medicine management techniques) was also positively associated with medicine availability. Furthermore, in the multilevel model, urban PHCs were associated with a slightly higher medicine availability as compared to remote PHCs, but this association was not significant in the spatial lag model.

At the district level, various covariates describing the management of the supply chain are associated with medicine availability in PHCs, such as procuring medicines via a local auction, which had a positive coefficient. In addition, a higher availability of medicines at the DHO level is also associated with a higher medicine availability at the PHC level.

The main difference between the two models is that covariates describing the type of districts, percentage of subsidized JKN participants, and fiscal capacity are associated with medicine availability in the spatial lag model, but not in the multilevel model.

At the provincial level, only the region variable was associated with medicine availability at the PHC level. There was an 8.8% disparity in medicine availability between PHCs in Eastern Indonesia and those on the Java- Bali region in the descriptive table. The spatial autocorrelation analysis affirms this difference with B: 0.67, CI [0.08 - 1.26].

Table 2. Univariable, Multilevel and Spatial autocorrelation analyses of the association between the availability of 50 essential medicines and its determinants at the PHC, District and provincial levels.

	Univariable		**Multilevel**		**Spatial Autocorrelation**	
	B	CI	B	CI	B	CI
PHC Level						
Local pharmaceutical systems						
Managing human and physical resources						
The availability of pharmacists	2.43***	[2.16 - 2.70]	**0.92*****	**[0.67 - 1.16]**	**1.06*****	**[0.82 - 1.31]**
The availability of medicine shelves	1.03***	[0.80 - 1.26]	0.31	[-0.44 - 1.06]	-0.10	[-0.90 - 0.70]
Perceived as a sufficient number of shelves	4.75***	[4.14 - 5.36]	-0.16	[-0.36 - 0.04]	-0.15	[-0.36 - 0.06]
The availability of lighting	2.74***	[2.32 - 3.16]	**0.46***	**[0.05 - 0.87]**	0.41	[-0.02 - 0.85]
The availability of the guidelines of medicine and medical product services	2.99***	[2.67 - 3.31]	**0.50****	**[0.14 - 0.85]**	**0.42***	**[0.04 - 0.80]**
The availability of the guidelines for preparing and dispensing medicine concoction prescription	3.59***	[3.24 - 3.95]	**0.45***	**[0.04 - 0.85]**	**0.47***	**[0.04 - 0.90]**
Inpatient services	2.24***	[2.01 - 2.46]	**1.28*****	**[1.07 - 1.49]**	**1.47*****	**[1.25 - 1.68]**

Accredited	3.52***	[3.26 - 3.78]	**0.74*** **	**[0.47 - 1.01]**	**0.78*** **	**[0.51 - 1.06]**
Financing						
Receiving district government funds	1.61***	[1.37 - 1.85]	-0.01	[-0.27 - 0.25]	-0.08	[-0.29 - 0.14]
Receiving retribution from patients	0.89***	[0.65 - 1.13]	**0.38** **	**[0.10 - 0.67]**	**0.34** **	**[0.10 - 0.59]**
Receiving non-capitation funds from the National Health Insurance (BPJS Kesehatan)	2.50***	[2.26 - 2.74]	**0.33* **	**[0.07 - 0.59]**	**0.27* **	**[0.02 - 0.52]**
Having Independent financial autonomy	2.68***	[2.45 - 2.92]	0.02	[-0.33 - 0.36]	0.20	[-0.03 - 0.44]
Monitoring performance						
Having an online Simpus	1.46***	[1.22 - 1.69]	0.20	[-0.02 - 0.43]	0.10	[-0.13 - 0.32]
Managing pharmaceutical product supply						
Implementing PRB program	2.08***	[1.78 - 2.38]	**0.54*** **	**[0.28 - 0.80]**	**0.45*** **	**[0.18 - 0.71]**
The availability of Medicine use and ordering a monthly report (LPLPO)	3.88***	[2.79 - 4.96]	**1.76*** **	**[0.78 - 2.74]**	**1.54** **	**[0.50 - 2.58]**
The completeness of LPLPO	3.28***	[2.75 - 3.80]	0.26	[-0.24 - 0.76]	0.36	[-0.16 - 0.88]
Implementing DRP planning for an 18-month period	1.29***	[1.03 - 1.55]	**0.39*** **	**[0.16 - 0.62]**	0.20	[-0.04 - 0.43]

Sources of medicine - Combining DHO & PHC procurements	1.54***	[1.31 - 1.77]	**0.51*****	**[0.28 - 0.74]**	**0.28***	**[0.06 - 0.51]**
Achieving the volume target	0.90***	[0.66 - 1.14]	0.05	[-0.16 - 0.25]	**0.26***	**[0.05 - 0.46]**
Procuring using capitation fund via e-purchasing scheme	1.45***	[1.21 - 1.68]	**0.31***	**[0.06 - 0.55]**	**0.31****	**[0.08 - 0.53]**
Procuring using capitation fund through direct purchasing	1.20***	[0.97 - 1.42]	**0.58*****	**[0.36 - 0.80]**	**0.49*****	**[0.27 - 0.70]**
Note for medicine in and out in 2018	4.73***	[4.21 - 5.24]	0.23	[-0.39 - 0.84]	0.47	[-0.18 - 1.12]
Use FIFO and FEFO methods	4.74***	[4.33 - 5.15]	**1.14*****	**[0.71 - 1.58]**	**1.68*****	**[1.22 - 2.14]**
Reporting rational use of medicines	3.56***	[3.24 - 3.88]	**0.92*****	**[0.60 - 1.23]**	**0.94*****	**[0.63 - 1.25]**
Accessibility, financial and demographical determinants						
PHC type						
Remote/very remote						
Rural	2.29***	[2.00 - 2.58]	0.27	[-0.04 - 0.58]	0.07	[-0.24 - 0.37]
Urban	2.23***	[1.91 - 2.54]	**0.53****	**[0.16 - 0.91]**	0.26	[-0.12 - 0.63]
Distance between PHC and its district capital point	-0.01***	[-0.01 - -0.00]	0.00	[-0.00 - 0.00]	0.00	[-0.00 - 0.00]

Distance between PHC and the nearest PHC	-0.00	[-0.00 - 0.00]	-0.00	[-0.00 - 0.00]	-0.00	[-0.00 - 0.00]
District Level						
Local pharmaceutical systems						
Managing human and physical resources						
Having a pharmacist as the PIC at the district warehouses	0.58***	[0.28 - 0.88]	0.12	[-0.47 - 0.70]	-0.12	[-0.39 - 0.14]
Financing						
Financial resources for the medicine procurements - national fund	0.96***	[0.50 - 1.41]	0.23	[-1.00 - 1.45]	0.14	[-0.42 - 0.69]
Financial resources for the medicine procurements - provincial fund	1.75***	[1.39 - 2.11]	**0.78***	**[0.00 - 1.56]**	**0.72*****	**[0.40 - 1.05]**
Financial resources for the medicine procurements - local fund	1.06***	[0.83 - 1.29]	-0.34	[-0.86 - 0.18]	-0.15	[-0.37 - 0.08]
Managing pharmaceutical product supply						
Conduct medicine quantification	0.03	[-0.65 - 0.72]	**-4.06****	**[-6.61 - -1.51]**	**-2.56*****	**[-3.44 - -1.68]**

Procurement schemes - e-catalogue	1.68***	[1.20 - 2.16]	-1.05	[-2.41 - 0.31]	**-1.93*** **	**[-2.56 - -1.30]**
Procurement schemes - local auction	0.59***	[0.36 - 0.82]	**0.65***	**[0.13 - 1.16]**	**0.27***	**[0.04 - 0.49]**
Procurement schemes - local direct purchasing	1.23***	[1.00 - 1.45]	0.48	[-0.03 - 0.98]	**0.33** **	**[0.11 - 0.55]**
Implement procurement medicine policy: over 2 years of date expiration	0.63*	[0.12 - 1.14]	0.73	[-0.36 - 1.81]	0.36	[-0.13 - 0.84]
All medicines procured with policy: over 2 years of date expiration	-0.37**	[-0.61 - -0.13]	-0.16	[-0.68 - 0.37]	-0.04	[-0.26 - 0.19]
Waiting time for medicines is less than one month	0.68***	[0.41 - 0.94]	0.03	[-0.57 - 0.62]	0.23	[-0.03 - 0.49]
Medicine availability at the DHO level						
The availability of 50 medicines	0.15***	[0.13 - 0.16]	**0.20*** **	**[0.17 - 0.24]**	**0.14*** **	**[0.12 - 0.16]**
Accessibility, financial and demographical determinants						
District Type						
Rural						
Urban	0.03	[-0.27 - 0.33]	-0.65	[-1.45 - 0.15]	**-0.52***	**[-0.92 - -0.12]**

Percentile of the total district expenditure						
Quartile 1						
Quartile 2	0.65**	[0.21 - 1.08]	0.63	[-0.17 - 1.42]	0.27	[-0.14 - 0.68]
Quartile 3	0.79***	[0.38 - 1.21]	0.23	[-0.61 - 1.08]	0.05	[-0.36 - 0.46]
Quartile 4	2.69***	[2.30 - 3.08]	0.47	[-0.46 - 1.40]	0.33	[-0.11 - 0.77]
Quartile 5	2.35***	[1.99 - 2.72]	-0.93	[-2.09 - 0.23]	**-0.76****	**[-1.27 - -0.26]**
Percentage of Subsidised JKN participants	-0.03***	[-0.03 - -0.02]	-0.01	[-0.03 - 0.01]	**-0.01***	**[-0.02 - -0.00]**
District fiscal capacity						
Low and very low						
Medium	2.06***	[1.76 - 2.36]	0.42	[-0.25 - 1.10]	**0.45****	**[0.14 - 0.76]**
High and very high	1.80***	[1.54 - 2.06]	0.69	[-0.19 - 1.57]	**0.68*****	**[0.30 - 1.06]**
Separated from the provincial capital	-1.54***	[-1.88 - -1.20]	0.01	[-0.00 - 0.03]	-0.00	[-0.01 - 0.01]
Accessibility score to other dispensing points	0.06***	[0.05 - 0.06]	0.20	[-0.60 - 1.00]	-0.29	[-0.64 - 0.07]
Provincial level						
Accessibility, financial and demographical determinants						
Region						

Eastern Indonesia						
Sumatera	2.47***	[2.09 - 2.85]	0.90	[-0.52 - 2.31]	0.28	[-0.20 - 0.77]
Borneo, West Nusa Tenggara, Sulawesi	2.88***	[2.50 - 3.27]	0.79	[-0.60 - 2.19]	0.05	[-0.41 - 0.50]
Java and Bali	4.39***	[4.02 - 4.75]	1.47	[-0.19 - 3.13]	**0.67***	**[0.08 - 1.26]**
Percentage of health expenditure from total expenditure	0.19***	[0.16 - 0.22]	-0.01	[-0.13 - 0.11]	0.00	[-0.03 - 0.03]
Provincial fiscal capacity						
Low and very low						
Medium	0.98***	[0.66 - 1.30]	-0.07	[-1.05 - 0.91]	-0.23	[-0.53 - 0.07]
High and very high	1.07***	[0.80 - 1.34]	0.19	[-0.86 - 1.23]	-0.12	[-0.43 - 0.20]
Spatial lag					0.00***	[0.00 - 0.00]

** = p value <0.05*

*** = p-value <0.01*

**** = p-value<0.001*

The contribution of the subdimensions

Table 3 shows the contribution of each subdimension and in each system tier to the multilevel and spatial lag models. Variation in medicine availability is explained most by variation in PHC level covariates, followed by district and then provincial level.

Determinants of the local pharmaceutical system (with the AIC 58016 and R-square 29,1 %) explain more variations in medicine availability than the accessibility, financial and demographic determinant (with the AIC 58919 and R-square 20,1 %). Within the local pharmaceutical system, managing human and physical resources at the PHC level and medicine availability at the DHO level explain more variations compared to the other subdimensions.

Table 3. The investigation of the individual dimension's contribution in the multilevel and spatial autocorrelation models by inspecting their estimator of prediction error (AIC) and coefficient of determination (R2).

	AIC change in multilevel				R2 change in spatial autocorrelation			
	Dimension only		Excl. Dimension		Dimension only		Excl. Dimension	
	Actual Value	The changes	Actual Value	The changes	Actual Value	The changes	Actual Value	The changes
Level of data								
Full model: All dimensions	*57922*				*29,5%*			
Primary health centres level	58024	+102(+0,18%)	58847	+925(+1,6%)	26,3%	-3(-10,85%)	22,7%	-7(-23,05%)
District Level	58843	+921(+1,59%)	58031	+109(+0,19%)	22,3%	-7(-24,41%)	26,4%	-3(-10,51%)
Provincial Level	58964	+1042(+1,8%)	57914	+-8(-0,01%)	19,0%	-11(-35,59%)	24,5%	-5(-16,95%)
Local pharmaceutical system	*58016*	*+94(+0,16%)*	*58919*	*+997(+1,72%)*	*29,1%*	*0(-1,36%)*	*20,1%*	*-9(-31,86%)*
Primary health centres	58025	+103(+0,18%)	58814	+892(+1,54%)	26,3%	-3(-10,85%)	22,8%	-7(-22,71%)
Managing physical and human Resources	58422	+500(+0,86%)	58229	+307(+0,53%)	24,2%	-5(-17,97%)	26,8%	-3(-9,15%)
Financing	58877	+955(+1,65%)	57942	+20(+0,03%)	20,0%	-10(-32,2%)	29,4%	0,1(-0,34%)

Monitoring and evaluation	58963	+1041(+1,8%)	57923	+1(+0%)	17,7%	-12(-40%)	29,5%	0(0,00%)
Managing supply chain	58401	+479(+0,83%)	58270	+348(+0,6%)	22,5%	-7(-23,73%)	28,1%	-1(-4,75%)
District Health Offices	58869	+947(+1,63%)	58036	+114(+0,2%)	20,0%	-9(-32,2%)	26,9%	-3(-8,81%)
Managing Physical and Human Resources	58967	+1045(+1,8%)	57920	-2(+0,00%)	17,3%	-12(-41,36%)	28,8%	-1(-2,37%)
Financing	58966	+1044(+1,8%)	57922	+0(+0,00%)	17,8%	-12(-39,66%)	29,4%	0(-0,34%)
Managing supply chain	58958	+1036(+1,79%)	57937	+15(+0,03%)	17,9%	-12(-39,32%)	28,8%	-1(-2,37%)
Medicine availability - DHO	58854	+932(+1,61%)	58024	+102(+0,18%)	18,8%	-11(-36,27%)	27,5%	-2(-6,78%)
Accessibility, financial and demographical determinants	58919	+997(+1,72%)	58016	+94(+0,16%)	20,1%	-9(-31,86%)	29,1%	-0,4(-1,36%)
Primary health centres level	58929	+1007(+1,74%)	57922	+0(+0,00%)	18,2%	-11(-38,31%)	29,5%	0(0,00%)
District Level	58946	+1024(+1,77%)	57921	-1(0,00%)	19,6%	-10(-33,56%)	29,1%	-0,4(-1,36%)

Discussion

This study investigates the factors driving variation in essential medicine availability across primary health facilities in Indonesia, with a focus on the performance of local pharmaceutical systems and the impact of socioeconomic and geographical factors. Our findings reveal substantial disparities in medicine availability between districts. On average, only 66% of the 50 essential medicines surveyed were available in PHCs, with district-level availability ranging from 83% in the best-performing areas to just 43% in the lowest-performing ones. A strong correlation emerged between the availability of medicines at District Health Offices (DHOs) and the stock levels in PHCs within their jurisdiction. PHCs that demonstrated stronger management of human and physical resources consistently reported higher medicine availability. Furthermore, effective supply chain management at the PHC level —marked by regular medicine reporting, strategic use of capitation funds, and the application of inventory management techniques—was significantly associated with improved medicine availability. These results highlight the critical role of local pharmaceutical systems in ensuring equitable access to essential medicines.

The substantial variation in medicine availability across districts in Indonesia is consistent with findings from other countries. Similar disparities have been observed in India, where availability ranged from 43% in Bihar to 88% in Tamil Nadu [2]; in China, with higher availability in the Eastern region compared to the central and western regions [3]; and in Brazil, where the Southeast region had up to 14% higher availability than the North and Northeast [4]. These local differences highlight significant regional inequalities, emphasizing the need to look beyond national indicators for medicine availability and conduct local assessments of medicine access. Beyond identifying local differences, our study contributes to the understanding of factors influencing these variations by examining both the organization of the pharmaceutical system and the local circumstances.

The system component that is most strongly related to medicine availability is the management of human and physical resources, and especially the presence of a pharmacist. PHCs with a pharmacist had a significantly higher medicine availability compared to those without. In Indonesia, approximately 20% of PHCs operate without a pharmacist, a shortage that is particularly problematic in rural and remote areas. In the absence of a pharmacist, other staff—such as assistant pharmacists or nurses—step in to manage medicines, sometimes with support from a pharmacist at another PHC. These other professionals are not trained to make decisions on dispensing medicines, which may impact the quality of pharmaceutical services.

Our findings suggest that having a pharmacist in every PHC not only improves medication dispensing practices but also enhances medicine availability. However, increasing the number of pharmacists in remote PHCs remains a significant challenge [175]. Studies from Indonesia and other regions indicate that pharmacists are often reluctant to work in these areas due to geographical isolation, inadequate infrastructure, and lower living standards [176]. In contrast, urban settings provide better opportunities for professional growth and additional income [177]. Addressing these challenges requires a comprehensive approach, including improving working conditions and collaborating with health and non-health sector authorities to make rural placements more appealing [176].

The availability of essential medicines was positively associated with procurement and storage practices. PHCs with the flexibility to use their own capitation funding for medicine procurement maintained higher stock levels than those relying solely on District Health Office supplies. This highlights the potential benefits of granting PHCs greater autonomy in procurement. In 2023, the Indonesian government reformed its procurement policy, allowing public healthcare facilities more flexibility to source medicines directly from suppliers. Monitoring the impact of this policy on medicine availability will be crucial, as fragmented procurement may lead to higher cost. Particular attention should be given to remote areas, where fragmented demand, high distribution costs, and low order volumes could drive up prices and exacerbate shortages [27, 169].

We also found that medicine availability is positively associated with the use of inventory management principles, such as First-Expired, First-out (FEFO) and First-In, First-out (FIFO). In Indonesia's pharmaceutical supply chain, FEFO is the preferred method for managing medicine stocks, as it helps to ensure that expired products do not reach patients. Its implementation is seen as critical for minimizing waste, ensuring patient safety, and maintaining regulatory compliance. Our finding, that the use of these methods is also associated with higher medicine availability, is consistent with a recent study in Ethiopia, which also showed a link between availability and these inventory management principles [178]. In Indonesia, the use of FEFO principles should be combined with the use of a digital inventory management system, named LPLPO (Laporan Pemakaian dan Lembar Permintaan Obat), which is also associated with higher medicine availability. Together, FEFO principles and LPLPO inventory management can help prevent shortages and waste. To truly benefit from these systems, the health sector needs to address challenges such as manual reporting, logistics issues, and limited digital integration.

A key component of effective pharmaceutical services is promoting the rational use of medicines. While our study did not assess actual dispensing practices, our analysis shows that reporting on rational medicine use is associated with higher medicine availability. This finding may reflect the clustering of various aspects of good pharmaceutical practice at the local level. These patterns need to be explored further in qualitative studies, and could perhaps be a starting point for developing interventions aimed at improving pharmaceutical practices [179].

Our study found that essential medicine availability in primary health centers (PHCs) was closely tied to the availability at district health offices (DHOs). Districts with more proactive DHOs that employed a variety of purchasing channels generally had better medicine availability. In contrast, DHOs relying on a single procurement strategy often faced shortages, leaving health facilities and communities without essential medicines. Additionally, districts experiencing frequent payment delays tended to have lower medicine availability, likely due to reduced supplier willingness to deliver medicines. These findings highlight the need to strengthen the capacity of DHOs in managing pharmaceutical supply chains. Special attention should be given to improving supply chains in remote districts and PHCs, which are particularly prone to shortages [169]. Pooling procurement for these areas could be an effective strategy, as increasing order volumes may make distribution more attractive to suppliers [133, 138].

Our analysis reveals that medicine availability is shaped not only by the district health office but also by local clustering patterns among PHCs. This local clustering of medicine availability was significant. We found clusters of PHCs in Java Island with low medicine availability, and clusters in relatively poor parts of East Nusa Tenggara, Sumatra, and Maluku provinces with high medicine availability. This clustering, observed within a few kilometers, appears to be driven by two key factors. First, nearby PHCs may collaborate by sharing stock during shortages or referring patients to other facilities for specific health programs [169]. Second, medicine distribution may be influenced by established supply routes, contributing to the observed clustering. These findings highlight the significance of local dynamics in determining medicine availability, suggesting that interventions aimed at improving access should consider localized strategies. Further research is needed to evaluate the extent of stock-sharing practices and identify ways to optimize them for enhanced medicine availability.

Our findings highlight the need to consider local systems and contextual factors when aiming to improve access to medicines. This observation is in line with a recent study in Afghanistan, which used the same framework and similar methodology, revealing that variations in medicine availability were less affected by the security situation and more by the type of organization managing healthcare, with non-governmental organizations (NGOs) generally performing better than local government entities [111].

Policy implications

Given Indonesia's vast size and regional diversity, it is worth questioning whether a single national essential medicines list is suitable for all districts across the archipelago. Currently, Indonesians enrolled in the National Health Insurance Scheme are entitled to free access to nearly 300 medicines through their PHCs. Our results show that even among the 50 most commonly used medicines, a significant number are frequently unavailable. This inconsistency generates uncertainty for both patients and healthcare providers, undermines trust in the public healthcare system, and often compels patients to seek medicines from alternative sources, increasing their risk of exposure to costly, expired, substandard, or even falsified medicines [180, 181].

One potential strategy to improve access to medicines is to streamline the list of promised medicines, focusing on a smaller, more manageable selection that can be consistently supplied. By narrowing the scope, health systems can allocate resources more effectively, ensuring reliable availability of essential medicines rather than overpromising and underdelivering. In parallel, increasing the number of PHCs staffed with qualified pharmacists can directly enhance medicine availability, as pharmacists play a critical role in inventory management, procurement, and rational dispensing. Additionally, providing up-to-date, transparent information on medicine availability at each PHC could enhance patient trust and enable healthcare providers to make more informed prescribing decisions. Together, these strategies not only help manage patient expectations and reduce unnecessary stockouts but also strengthen the credibility, efficiency, and overall performance of the healthcare system.

Additionally, a more localized approach to essential medicines lists—tailored at the provincial or district level—could better reflect regional healthcare needs and practical conditions [182]. A similar model, the Municipal Essential Medicine Lists (MEMLs) has been implemented in Brazil and is used effectively to assess local PHCs and reduce stock-outs [16]. Adopting a comparable system in Indonesia may help align procurement with local needs, provide greater clarity to patients regarding medicine availability, and enable healthcare providers to better meet expectations while enhancing accountability within the system.

Strengths and Limitations

This is the first study to use nationwide data from all districts, DHOs, and PHCs in Indonesia, incorporating a wide range of health system and contextual indicators. By combining these datasets, we were able to conduct comprehensive multi-level and spatial analyses of medicine availability in one of the world's largest and most diverse nations. A key limitation is that our data reflect availability only in public facilities and do not capture the extent to which local communities can access these medicines. Additionally, measurements were taken at a single point in time, so temporal fluctuations in availability are not captured, although the large sample size reduces the likelihood of major deviations.

Importantly, this study examines associations between variables and medicine availability, which does not establish causality. As a result, observed patterns should be interpreted as indicative of potential relationships rather than definitive causal effects. Future research using longitudinal or quasi-experimental designs could provide stronger evidence of causal links and guide targeted interventions to improve medicine availability.

Conclusion

Overall, this study demonstrates that the availability of essential medicines in Indonesian PHCs varies widely across districts and is closely linked to the functionality of local pharmaceutical systems. Ensuring consistent medicine availability requires a multifaceted approach that addresses both facility-level and district-level factors. Our findings underscore the importance of investing in the physical and human resources of PHCs, particularly by ensuring the presence of trained pharmacists. Furthermore, the application of sound inventory management practices and strong coordination between PHCs and district health offices is critical for optimizing medicine distribution. While locally specific initiatives to strengthen PHCs are important, targeted interventions that build the capacity of DHOs to manage pharmaceutical supply chains are equally vital. Strengthening these local pharmaceutical systems will be essential to achieving a reliable, equitable supply of essential medicines across Indonesia's diverse regions.

Chapter 5:
Managing medicines in decentralization: discrepancies between national policies and local practices in primary healthcare settings in Indonesia

This chapter was published as:
Fanda, R.B., Probandari, A., Kok, M.O. and Bal, R.A., 2025. Managing medicines in decentralization: discrepancies between national policies and local practices in primary healthcare settings in Indonesia. Health Policy and Planning, p.czae114.

Abstract

In Indonesia, primary health centres (PHCs) are mandated to provide essential medicines to ensure equal access to medication for all Indonesians, as stated in the national medicine policy. However, limited information is available regarding the actual practices of health workers within the context of decentralised governance. This paper investigates the discrepancies between national policies and local practices in two Indonesian districts, shedding light on coping mechanisms employed in each phase of medicine management within PHCs. The mixed-method study began by identifying pertinent policies addressing medicine management in PHCs. Subsequently, panel data on patient visits to tuberculosis, maternal and neonatal health (MNH) and non-communicable disease (NCD) services were collected from 2019 to 2022. After analysing the panel data, interviews were conducted with 56 health workers, including physicians, nurses, pharmacists, midwives, and public health programme managers, regarding their views on fluctuations in medicine stocks and the patient visits data. These participants included pharmacists and programme managers specialising in tuberculosis, MNH, and NCD care and were affiliated with PHCs and district health offices (DHO). Our findings highlight the occasional unavailability of essential medicines in PHCs, with stockouts being attributed to supplier shortages at provincial and national levels and to variations in the capacity of the local health system. Low-skilled pharmaceutical staff are a contributing factor in each phase of medicine management. Additionally, health workers employ coping mechanisms, such as deviating from policy on the use of capitation funds to purchase medicines, to manage temporary stockouts. To tackle systemic stockouts, central government should prioritise capacity-building among health workers, by establishing a continuous and easily accessible local learning system.

Key messages

- The main challenge in providing essential medicines in Indonesia arises from national regulations in the context of decentralised governance. Local government systems, each with their distinct characteristics, contribute to the complexity involved in adopting the national policy.
- Insufficient training of pharmaceutical staff contributes to stockouts, a problem observed in every phase of medicine management, including quantification, procurement, distribution, and dispensing.
- To address temporary stockouts, health workers resort to coping mechanisms, an approach that does not resolve or identify the root problem.
- To address the policy discrepancies that contribute to systemic stockouts, central government should prioritise capacity-building, by establishing a continuous and easily accessible learning system.

Introduction

Nearly two billion people worldwide lack access to medicines. Limited access to medicines, coupled with high prices, poses serious risks to patients' health by increasing the likelihood of non-treatment, inadequate treatment, and excessive healthcare costs [2, 145, 163, 164]. Moreover, restricted availability in public facilities and licensed pharmacies drives patients to seek medications from unregulated outlets, heightening the risk of encountering costly, expired and falsified medications [88, 154]. Failing to ensure equitable medicine distribution indicates incomplete success of universal health coverage (UHC), which aims to prevent financial catastrophe and ensure optimal health services for every citizen.

Indonesia, the world's largest archipelagic country, is committed to ensuring equal access to medicines for all its citizens. As the largest pharmaceutical market in Southeast Asia, with a population of more than 270 million, Indonesia has prioritised medicine accessibility and affordability since 2006 [160]. The government has reduced the prices of 80% of essential medicines in the public sector by up to 70% in 2017, compared to the prices in 2013 [76]. This significant reduction was driven by the national agenda implementing UHC [27, 62]. The Indonesian UHC system, *Jaminan Kesehatan Nasional* (JKN), has enrolled more than 95% of the country's citizens (National Social Insurance Board [DJSN] 2022). Indonesians are entitled to free medication when they use public sector health facilities, including primary health centres (PHCs).

A prior study reported that most essential medicines are generally available in Indonesian PHCs [146]. PHCs are more accessible than private clinics, hospital and community pharmacies [65, 66]. This represents a positive step towards UHC, since most JKN participants select a PHC as their first-level health facility.

While Indonesia has achieved significant milestones, inequality in access to medicine remains in various regions and districts. Limited income individuals in urban areas in Java Island, have better access to PHCs than those in rural areas [183]. Medicine stockouts at PHCs are a systemic problem in certain districts outside Java and Bali. An earlier study identified two main reasons for medicines being unavailable: (1) the district health office (DHO) failed to supply the essential medicines, or (2) the essential medicines fell outside the PHC's health programmes. Undersupply was found in rural districts in Sumatra, Borneo, Sulawesi, and in the east, including East Nusa Tenggara, the Malukus, and Papuas. This is even more problematic because districts in Eastern Indonesia have low population densities, with most people having limited economic capacity and restricted access to alternative healthcare [65, 168]. In contrast, PHCs in Java and Bali had the highest availability of medicines.

Supplying medicines for Indonesia's public sector entails complex interactions within a multi-layer governance structure. Since decentralisation began in 2001, the central government transferred the power and responsibility to DHOs, including public health programme development. As a consequence, 514 DHOs play a vital role in managing medicines for more than 10,000 PHCs. The DHOs establish medicine purchasing plans, procure medicines and oversee logistics and utilisation [63, 184].

Improving access to essential medicines requires strong governance at local level. Bigdeli et al. mention that many studies tend to focus more on the health services and stewardship role of higher government levels, whereas interactions with decentralised actors and other stakeholders are understudied [185]. In the case of access to medicines, little is known about how local government entities, including DHOs and PHCs, manage medicines (Kok and Fanda et al. 2024, Soucy Brown et al. May 2021). Gaining insight into these levels and their interactions is essential since many health policies and programme management activities are established at the regional and/or local level or require local adjustments during policy implementation [186, 187]. In a large country with a decentralised system, it is paramount to establish a national policy to standardise equal access to medicines and serve as a crucial guide for local systems. It is, however, also imperative to strike the right balance by not only acknowledging but also accommodating the inherent variations within these local systems.

This paper explores the dynamics among health workers (including physicians, nurses, pharmacists, midwives, and public health priority programme managers) within a local pharmaceutical system and the consistencies and discrepancies between the policies and practices governing access to medicines in primary healthcare settings in Indonesia. We also investigate how health workers cope with these discrepancies.

We began our research by examining national policies governing how PHCs and their DHOs manage medicines. We purposely selected two districts, one in Java Island and the other in Eastern Indonesia, to explore the practices of health workers. In both, we tracked monthly data on patient visits and medicine availability for three national priority programmes, non-communicable diseases (NCD), maternal and neonatal health (MNH), and tuberculosis, from 2019 to 2022, using descriptive analyses in our interviews to explore causes and health worker efforts to control stocks. After analysing the panel data, we used our findings in our in-depth interviews and small group discussions to explore the dynamics within local pharmaceutical systems.

Material and Methods

Research design

There were three stages of data collection in our mixed method research. We first collected data regarding medicine stocks and consumption over a four-year period. We then conducted interviews and focus group discussion with pharmacists regarding these data to understand how they managed medicine stocks and stockouts. The final stage involved triangulating our findings by interviewing health programme managers in the DHOs and PHCs. We followed the COREQ (COnsolidated criteria for

REporting Qualitative research) method and have attached the details as a supplementary document 1 [188].

Setting

Our study concerns rural districts, since these are the most problematic, with major constraints on access to essential medicines. Bantul, in the Special Region of Yogyakarta, and Kupang District, in East Nusa Tenggara, were selected to represent districts inside and outside Java Island. Details about the two districts are presented in Table 1.

Table 1. Study location contexts.

	Bantul District	**Kupang District**
Province	Special Region of Yogyakarta, in Java	East Nusa Tenggara, in Eastern Indonesia
Fiscal Capacity Category*	Middle	Middle
Population in November 2023**	902,102	364,473
Percentage of JKN participants**	87.6	86.4
Percentage of subsidised JKN participants (PBI)**	56.9	72.5
Total land area (KM^2)	506.8	53,958.2
Number of PHCs	27	29
Number of PHCs with inpatient services	16	8
Types of PHCs	5 PHCs urban 22 PHCs rural	8 PHCs remote 19 PHCs very remote
Number of Hospitals**	10	1
Number of Private Clinics**	39	3
Number of Physicians ***	466	46
Number of Pharmacists***	279	13
Numbers of Technical Pharmaceutical Staff***	444	49
Number of Midwives and Nurses***	2602	1223
Prior findings on medicine availability **[146]**	High	Low

Sources: *Ministry of Finance, **DJSN, *** Ministry of Health

Data collection and participant selection

The research team hired two field assistants for data collection. An offline kick-off meeting with the selected participants was held to introduce the study and validate the panel data questionnaires. Pharmacists from eleven PHCs and two DHOs, as well as six programme managers attended the meeting. Most of the panel data were derived from self-reporting techniques, meaning that health workers completed the questionnaires.

The field assistants distributed the questionaries and collected panel data ten selected essential medicines used at Hypertension, Diabetes Meletus, tuberculosis, and MNCH services from 2019 to 2022. They reported the data to the first author for analysis of medicine availability trends. The medications included tablets (amlodipine 5mg, captopril 12.5mg, hydrochlorothiazide 25mg, metformin 500mg, glibenclamide 5mg, ferrous sulphate, and tuberculosis fixed-dose combination) and injections (methylergometrine maleate, oxytocin, and vitamin K (phytomenadione)). Medicine data were collected based on monthly medicine control cards, called *Lembar Pemakaian and Permintaan Obat (LPPO).*

We also added the source of the data for the number of patient cases in the PHCs' monthly patient visits reports (*Laporan bulanan* or *LB1*) as an extra control to explore contexts and reasons for fluctuations in medicine stocks. The number of cases for hypertension and Diabetes Meletus were identified based on their ICD 10 codes. At the same time, data on tuberculosis cases were derived from records of the total number of Presumptive tuberculosis cases and Positive tuberculosis cases. In the case of the MNH data, the PHCs reported numbers of pregnant women and childbirth. During our interviews, we showed and discussed two graphics, in which one figure displayed the patient visits rate per month, and another displayed medicine consumption and stocks per month.

In Bantul, five of the six PHCs reported the data independently; one was unable to do so because it was working on its accreditation, so our field coordinator collected their data directly from their documents. PHCs in Kupang district were only able to report medicine stockouts because records of patient visits were located elsewhere; the Kupang DHO provided these data. After data analysis, the assistants scheduled interviews and small group discussions.

At the beginning of the interviews, we asked participants to prepare their data again for crosschecking. Before conducting each of our interviews, we thoroughly discussed the data with our respondents, showing them our initial analyses for the 48 months period. We began with NCD medicines (amlodipine, Hydrochlorothiazide, captopril, glibenclamide, and metformin), continued with tuberculosis FDC medicines, and ended up with MNH medicines (methylergometrine maleate, oxytocin, vitamin K, and ferrous sulphate). Once we saw a pattern of a sharp increase/decrease or zero values in medicine stock, we inspected the stock data from the previous six months. We only began our proper interviews once we had verified all the data. All panel data were subsequently verified to ensure accuracy.

As our aim was to understand notions regarding medicine management. Our interview guideline was constructed accordingly. We covered four topics: perspectives on providing essential medicines; current situation and problems related to managing medicines at national, regional and local level; actions undertaken to address such issues; and recommendations for improving system performance. The topic list is attached as supplementary document 2. All questions were communicated in PowerPoint presentations during data collection.

The first author conducted 18 in-depth interviews and six small group discussions from June to October 2023. The interviews included staff in charge of pharmaceutical logistics at PHCs and DHO staff. NCD, MNH, and tuberculosis programme managers at PHCs participated in the small group discussions. No prior relationship existed with these individuals and the interviewer ensured that the data collection only served the research purposes. Data collection sessions were conducted online and lasted 60 to 120 minutes. Transcripts were not returned to participants.

We selected research participants based on their roles in the local pharmaceutical system. To obtain a richer context, we included all types of PHCs, categorised according to the Indonesian Ministry of Health's classification system (geographical location) and inpatient service capacity. Table 2 summarises participant characteristics in the two districts.

Table 2. Participant characteristics

	Participant characteristics	Bantul district	Kupang district	Total
	Profession			
1	Pharmacist	6	3	9
2	Pharmaceutical staff	2	4	6
3	Physician	2	0	2
4	Medical laboratory technician	2	3	5
5	Nurse	8	5	13
6	Midwife	7	7	14
7	Public Health program manager	2	5	7
	Programme or section			
8	Pharmaceutical Logistics and Services	8	7	15
9	Non-Communicable Diseases	6	7	13
10	Maternal and Neonatal Health	6	7	13
11	Tuberculosis	7	6	13
12	Public Health Data	0	1	1
	Government entity			
13	DHOs	4	5	9
14	PHCs	23	23	46
	PHC classification			
15	PHCs urban	14	0	14
16	PHCs rural	9	0	9
17	PHCs remote	0	11	11
18	PHCs very remote	0	12	12
	Inpatient service			
19	PHCs with inpatient services	9	12	21
20	PHCs without inpatient services	14	11	25
	Total participants	27	29	56

Data analysis

Panel data on medicine stocks and number of cases were analysed and visualised in graphs using Microsoft Excel to show the four-year trends. We assessed the availability of the ten essential medicines by first examining stock levels in January 2019. Subsequently, we calculated stock fluctuations for the following month based on reports detailing the number of medicines received and issued from a PHC pharmacy room, as documented in the medicine stock control card. In Indonesia, the term 'issued' refers to the number of medicines dispensed from the shelves for health service purposes or waste management. For example, if the stock of amlodipine 5 mg was 60 tablets at the beginning of January 2019, and no new tablets were received during that month while 20 tablets were issued, the remaining stock at the end of January 2019 would be calculated as 40 tablets. This figure would then serve as the beginning stock for February 2019. Furthermore, the availability of 10 selected medicines was counted based on a dichotomous scale which was available or not available. We calculated how many months the medicine was (not) available. Additionally, we directly analysed numbers of patient visits using a line graph to comprehend the fluctuations observed in the obtained data.

The interviews and small group discussions were transcribed verbatim in Indonesian. The first author coded various health system themes, covering such concepts as management of essential medicines, medicine planning and procurement, governance of local systems, human resources, finance, and medicine availability statuses. These statuses covered well-controlled stock, overstock, and out-of-stock scenarios. The coding tree was derived from the data and structured in English. The first author coded all data and the second author checked the codes and nodes, including coding descriptions. We used Atlas.ti for data analysis. Our qualitative analyses elaborate the dynamics of the essential medicine stocks over four years.

Results

We begin this section by identifying the availability of ten essential medicines in the PHC setting. Providing essential medicines is a responsibility shared between the Ministry of Health (MoH) and local governments, which include Provincial Health Offices (PHOs), DHOs and PHCs [189]. We then delve into the four key phases of essential medicine management: quantification, procurement, distribution (including storage and distribution of medicine based on PHC requirements), and dispensing to the community, as depicted in Figure 1. The level of consistency between policy and practice, discrepancies in practices, and coping mechanisms employed by health workers, are illustrated in Figure 2.

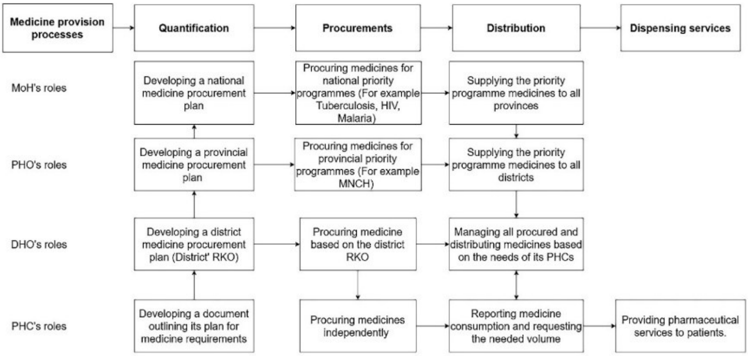


Figure 1. Local system perspectives on medicine management logistics for PHCs within the decentralized system in Indonesia.

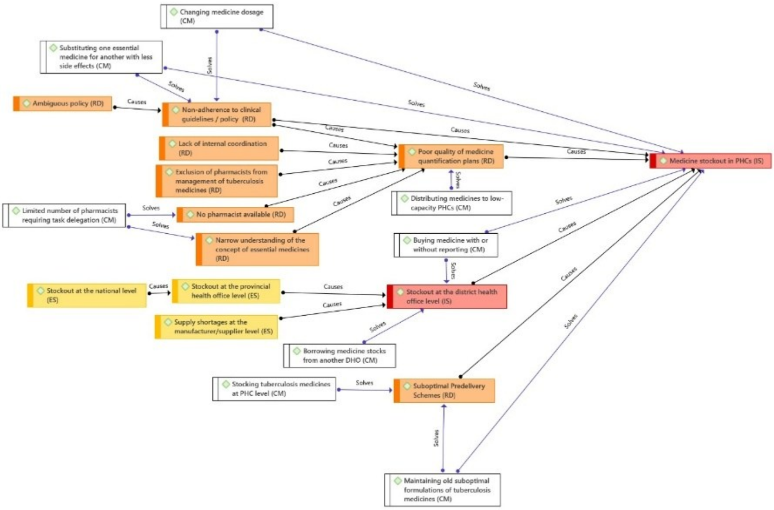
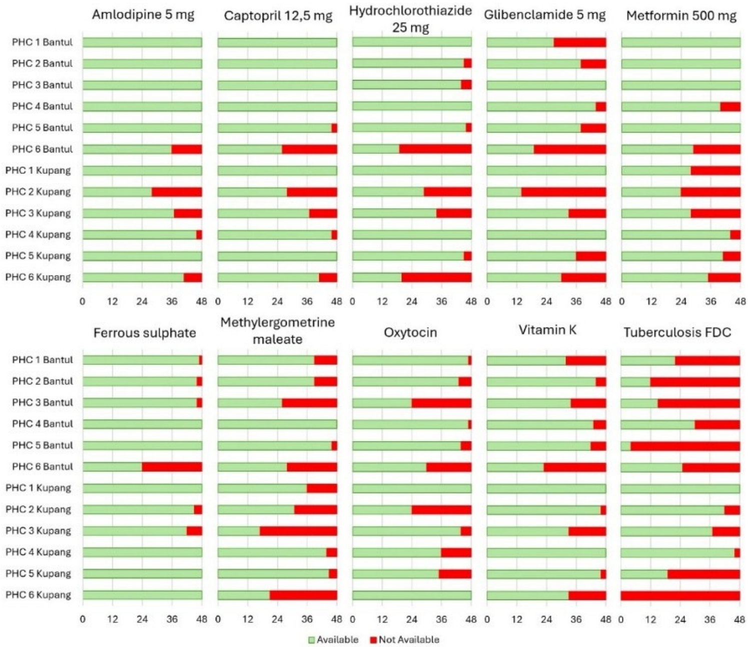


Figure 2. Thematic analyses of stockouts based on reasons for policy discrepancies and coping mechanisms meant to resolve them.

Notes: ES refers to a stockout in the external local system, IS attributes to a stockout in the internal system, RD indicates the reason for a discrepancy, and CD assigns the coping mechanism.

Medicine availability

The concept of essential medicines entails the selection of most-needed medicines that should be consistently available in health facilities, depending on their level of service. Indonesia's national medicines policy states that community access to essential medicines is a human right [190]. However, our quantitative results show that priority medicines were sometimes unavailable. At least one of the four medications for the MNH programme was reported 'unavailable' in twelve PHCs in a certain month. While some PHCs were able to supply a complete set of the three hypertension medicines, they lacked one of the two medicines for diabetes mellitus during a specific period. Figure 3 illustrates the availability of the ten most-needed medicines from 2019 to 2022 (see Methods section).



Notes: The bars represent the availability of medicines on the shelves of PHC facilities over a 48-month span. The fuller the line graph, the longer the drug will be available in the medicine basket, or vice versa.

Figure 3. Availability of 10 most-needed medicines over a 4-year period at 12 PHCs.

Medicine quantification

Medicine quantification forecasts the quantity of medicine required by the relevant PHCs in a single period. This phase encompasses medicine planning, selection, and calculation. It begins in the PHC's pharmacy room and involves creating a medicine requirement plan (*Rencana Kebutuhan Obat* or RKO Puskesmas in Bahasa Indonesia) for a single year. The planning process is bottom-up, with information flowing to the DHO's warehouse. This warehouse compiles all PHC RKO documents into the DHO's RKOs. The DHO's RKO is then used to communicate the DHO medicine requirements to the PHO and the MoH [191].

The national Essential Medicine List (NEML), and Indonesia's National Formulary were introduced to help achieve equal access to medicines. The latest version of the NEML was issued in 2021 and the National Formulary was updated in 2022 and implemented in November 2023 [192–194]. PHCs are required to select medicines based on the two, which together list more than 300 items and 26 therapeutic classes. The two lists have become bibles for pharmacists, as illustrated by the following: *'Essential medicines are those that should be provided since they are used to support all existing government programmes. There are more than 100 medicines based on health indications that can be treated by a PHC, derived from the National Formulary.' Pharmacist at PHC 1 in Kupang District.*

Some pharmacists argue that the list of essential medicines should be more closely related to the prevalence of diseases in specific areas:

> *'The NEML should be adapted to disease prevalence in the health centre's working area. For instance, our health centre sees a higher number of skin disease cases due to difficulties in accessing clean water. In contrast, in urban subdistricts, hypertension is the dominant health concern, leading to frequent medication usage. Different places have different health needs, and a one-size-fits-all approach is not suitable.' Pharmacist at PHC 5 in Kupang District.*

The NEML is meant to be based on the most-needed health services, including disease diagnostics, prophylaxis, therapeutics, and rehabilitative services. Currently, however, it is set at the national level without regard for variations in disease prevalence among districts.

Health workers also had narrower concepts of essential medicines in general and the prioritised essential medicines in particular. To monitor the performance of each PHC, the MoH and Ministry of National Development Planning drew up an aggregated list of forty most-needed medicines, used to evaluate the performance of the health system at national, provincial, and local levels. A minimum of 80% of these most-needed medicines must be available each month. Monitoring by means of this list has led to a narrower concept of essential medicines among pharmaceutical staff and Nine of the eleven pharmacists interviewed had this narrower concept.

> *'Interviewer: How many medicines are essential medicines?*
> *Participants: There are forty essential medicines that must be available at a PHC. We report their availability using the Selena software every month, starting this year (2023).' Pharmacist at PHC 4 in Kupang District.*

Pharmaceutical staff shortages can undermine the quality of the medicine quantification plan. Our interview data revealed unforeseen staff rotations without proper handover. One DHO pharmacist was deeply concerned about new staff lacking any standardised knowledge of medicine management. *'Our friends [pharmacists at PHCs] in charge often get transferred. New officers sometimes draw up the medicine requirement plan without considering the actual quantity of medicine used or expired.' Pharmaceutical staff at Kupang DHO.*

The medicine quantification process should involve other health workers, including general practitioners, dentists, midwives, nurses, and health programme managers providing curative services. Any proposed medicines and quantities must be based on PHC data concerning medicine consumption and patient visits. Such collaboration was, however, rare at the PHC level, and its absence meant that quantification was carried out solely by pharmaceutical staff. The quote below indicates that health worker groups stuck to their silos. '*We seldom have joint meetings that include GPs, midwives, and nurses…it's crucial to discuss the job description of those who write prescriptions, and plan for* *pharmacists or pharmaceutical staff, [so we can] coordinate efforts…' Pharmacist at PHC 2 in Kupang District.*

Medicine procurement

Procurement involves acquiring targeted medicines in the right quantities through various acquisition schemes, including e-purchasing, tenders, and direct procurement. This entails interactions across regulations, financial allocations, and human resources. DHOs may use funding schemes under the Local Revenue and Budget (APBD) in their district, as well as Non-Physical Special Allocation Funds (DAK-Non Fisik) under the National Budget (APBN) provided by the Ministry of Health. A DHO, as a local government agency, is therefore the brains behind the entire local pharmaceutical system, especially in medicine procurement. [195]

The availability of medication at PHCs thus relies heavily on the supply of medication at its DHO. This underscores the pivotal role and responsibility of the DHO in designing and implementing effective strategies to maintain the medicine supply chain, also because most of the budget flows into DHO accounts under Indonesia's performance-based budgeting system. *'If the allocated budgets [for procuring medicines] are available, we [the DHO] are safe [having enough stocks of medication]. If we are safe, our PHCs are safe, too. So, all communities have access [to medicines].' Pharmacist at Bantul DHO.*

Medicine stockouts in the supply chain are a major problem. Our interview with a pharmacist at a PHC without inpatient services revealed why the PHC was unable to provide medicines: a lack of supplies from the DHO.

> *'The supply of methylergometrine maleate was empty, it seems because it was out of stock at its manufacturer's. We've tried to place an order [via independent procurement], but it took a long time, and the product was still unavailable. We've also repeatedly requested it from the [DHO] warehouse, but stocks were still empty. We wanted to buy it at the pharmacy, but it's also out of stock.' Pharmacist at PHC 2 in Kupang District.*

We continued by interviewing the pharmaceutical staff at Kupang DHO regarding the shortages. Their response is below.

> *'The medication [methylergometrine maleate] is supposed to be provided by the province [provincial health office] since it was a [provincial] programme medication. If our DHO wanted to procure it, we had to justify the need. It was the responsibility of the province to supply it. We requested the medication from the province, but it was unavailable there. It was not our responsibility.' Pharmaceutical staff at Kupang DHO.*

PHCs may procure medicines independently when they cannot be provided by the DHO and are available for purchase in the supply chain. The two main requirements are that the PHC has a pharmacist and adequate financial capacity [196]. PHCs may use their capitation fund from the National Health Insurance (BPJS Kesehatan) and healthcare service fees from non-JKN participants. PHCs therefore receive some funding and three of the eleven reported procuring medicines independently using their capitation fund. '*When an essential medicine hasn't been supplied yet because it hasn't been received from the wholesaler [at our DHO], we purchase it in limited quantities.' Pharmacist at PHC 4 in Bantul District.*

In some cases, the pharmacist and the head of the PHC decided to purchase medicines without reporting this. The requirements for using the capitation fund to procure medicine were perceived as difficult for certain PHCs. Only those that managed their finances independently could use their own income to procure medicines, and some were required to deposit their income with the local government. PHCs wishing to procure medicine using their capitation fund could face lengthy consultations with their DHO. A vignette detailing a PHC's decision to procure medicine informally is presented in table 3, Box 1.

Table 3. Box 1. Informal action to cope with geographical challenges in medicine procurement by a PHC.

An isolated PHC is located on a separate island from its DHO. There is no alternative medicine dispensary, such as a hospital, private pharmacy, or other health worker practice. The patients served are mostly individuals with limited financial means. The PHC's role in providing medicine is crucial for the island because otherwise the people would need to spend an hour travelling to the main island by boat. For the PHC health workers this was an entire day because they faced another four hours of travel to reach their DHO after arriving on the main island. The demographics and geographical context meant that the PHC's ability to provide medicines was crucial. If a medicine was not supplied by the DHO, the pharmacist chose to procure it directly through a round trip. Health workers did not favour the formal procurement process, which often required more time and was costly, since it involved multiple validation processes with their district warehouse. The head of the PHC decided to take informal action to make medicine procurement faster and more convenient. Health workers at the PHC agreed to pool the leftover budgets from their health programmes to purchase medicines and reported perfect budget absorption for their programmes. When we raised concerns about the unavailability of vitamin K injections, the pharmacist replied, "We procured it, but we did not include it in our recorded stock. We used our pooled cash system to procure the medicine."

If a PHC does not have a pharmacist, a DHO pharmacist can utilise their licence for procurement. Kupang DHO had no pharmacist in their DHO warehouse, however, only a staff member with a vocational pharmaceuticals qualification. At the lower level, their PHCs had three registered pharmacists to help them manage their medicines. *'The DHO issued a decision letter entrusting me with the medicine management at*

PHC A, PHC B, and PHC X, all PHCs without a registered pharmacist. If the PHCs wish to procure medicine independently, they can do so with this letter.' Pharmacist at PHC 2 in Kupang District.

A coping mechanism may be used within a local pharmaceutical system or between systems to ensure that it can achieve its main objective. One mechanism we identified was to address patient needs by borrowing medicine stock from other DHOs. *'While awaiting the arrival of our order in October, we asked to borrow 200,000 metformin tablets from the Sleman Health Office, as this medication is essential.' Pharmacist at Bantul DHO.*

Medicine distribution

Medicine distribution process entails submitting monthly requests for required medicines from a PHC, storing these pharmaceuticals in its pharmacy room, and internally distributing them to the smallest units within the PHC. The distribution of medicine to PHCs proceeds along two services: routine and predelivery. A DHO warehouse supplies medicines on schedule based on the documentation in a PHC's RKO. The predelivery service addresses unforeseen medicine stockouts at PHCs. Since the demand for a medicine may be unpredictable, both DHOs offered a predelivery services allowing PHCs to request a medicine before regularly schedule delivery.

Once the PHCs understood that policy, the health workers believe that their medicine stocks were effectively controlled. '*We have never experienced constraints that resulted in a stockout of amlodipine. Our DHO supplies our medicines twelve times a year. If amlodipine were to run low, we could request pre-delivery.' Pharmacist at PHC 4 in Bantul District.*

This quote indicates that participants were generally optimistic about the availability of medicines, whereas the quantitative results, depicted in Figure 3, reveal instances where they fell short in providing the medication on their shelves.

Participants reported that medicine stockouts at PHCs were caused mainly by the medicine being unavailable at the DHO, due to problems in either distribution or supplier stockouts as we presented in the prior section about stockout of methylergometrine maleate.

In another case of stockout, predelivery was left unused because the pharmacist failed to notice that the supply of amlodipine at the PHC had run out. The DHO responded as follows.

> *'Amlodipine is listed as one of the indicator drugs, and it (the PHC) is required to provide it… They can order a predelivery at any time, so if supplies ran out, it's their [the PHC's] responsibility, as they should have controlled their medicine stock.' Pharmaceutical staff at Kupang DHO.*

The policy assigns a pivotal role to pharmacists in medicine distribution. In practical terms, medicine for the MNH programme is organised by a pharmacist who coordinates *all* pharmaceutical services at PHC level.

> *'We are implementing a one-stop-service for medicine, so all in and out logistics are supervised by our pharmacist. If we don't have medicines for MNH services, we coordinate with the pharmacist, check what's available at the DHO, and put in a request.' Midwife, MNH programme manager in Kupang District.*

In the tuberculosis programme, a PHC tuberculosis programme manager neglected to involve a PHC pharmacist in requesting the medicine from a DHO.

> *'We were never informed when the tuberculosis programme manager [at the PHC] requested the* tuberculosis *medicines. They had a Goods Exit Order, and [later] the medicines appeared in our [pharmacy] room. Unfortunately, we were not included in the process of requesting these medicines.' Pharmacist at PHC 2 in Kupang District.*

While most medicines were stored in PHC pharmacy room, tuberculosis medicines were stored at a DHO warehouse. FDC tablets are considered "very essential medicines" and mandated under a "one gate policy" for tuberculosis medicines and other logistics [197]. The Kupang DHO made an exception by allowing some PHCs to keep tuberculosis FDC medicines on their shelves, as presented in Figure 3, mainly because these PHCs were situated a long distance from the DHO. They could ask to stock FDC to reduce the time and cost of travel for only a single patient.

Medicines were still distributed to a PHC even in the event of a poor-quality quantification. The pharmaceutical staff in Kupang decided to not stick to the PHC medicine requirement plan because they thought the required quantities it reported were inaccurate.

> *'The main barrier in the medicine planning process is [universal] coordination. We can organise our RKO properly, but we are only one of 27 PHCs. Or maybe there are five active [closely collaborating] PHCs and the rest are uninformed. When the medicine for those active PHCs arrives, the rest then also request them [without stating the requirements in their plan]. Then we get a smaller portion [required quantity].' Pharmacist at PHC 2 in Kupang District.*

Medicine dispensing service

At the end of the medicine management process, a pharmacist dispenses medicines to patients and supplies them to both internal and external units. The act of dispensing medicines is the responsibility of the pharmacists and must take place in a pharmacy room, as instructed in the MoH regulation [198].

We found that all twelve PHCs are equipped with pharmaceutical facilities to assess medications based on prescriptions and patient conditions. Pharmacists are also expected to consider the availability of drugs from the DHO as an integral part of their responsibilities and can suggest alternatives if a specific drug is not available. Looking for alternatives is another coping mechanism in dealing with out-of-stock medicines. The quote below emphasises the crucial role of pharmacists in ensuring effective medicine services.

> *"Of course, every time I dispense medication, I ensure it aligns with the doctor's prescription. If supplies of the prescribed medication are limited or out of stock, I always inform the GP and propose a substitution, such as replacing glibenclamide with glimepiride. I always confirm with the doctor that this substitution meets the patient's needs." Pharmacist at PHC 4 in Bantul District.*

When essential medicines were not available, some pharmacists were comfortable finding a substitute. While the national medicine policy conceives community access to essential medicines as a human right, the NEML policy states that essential medicines are those selected as the most-needed medicines and that they should be available in a health facility, depending on its level of service. A PHC without inpatient services is not obliged to provide methylergometrine, oxytocin or vitamin K injections because it does not deliver maternity services. '*Methylergometrine maleate injections were not available because the prior stock had expired. We never use it, so we don't require [new stocks].' Pharmacist at PHC 3 in Kupang District.*

In the case of NCD medicines, amlodipine, captopril, and metformin come in two dosages. As long as one of them was available, the health worker was comfortable switching to another dosage. The following quote reveals how health workers change the dosages.

> ‘*As far as I know, we are fine if we have captopril 12.5mg when the 25mg version is unavailable. In such cases, we give patients double the amount. Conversely, if we only have the 25mg version, we give them half the amount and tell the patient [who needs only 12.5mg] to take half.’ Pharmacist at PHC 4 in Bantul District.*

When the supply of tuberculosis FDC medication was unavailable, pharmacists purchased rifampicin and isoniazid separately to meet the needs of tuberculosis patients temporarily.

> *‘In the past, the DHO redirected from the combined fixed-dose combination (FDC) to individual compound drugs…due to limited availability…’ Pharmacist at PHC 4 in Bantul District.*

As shown in this section, PHCs also dealt with shortages by substituting or providing other dosages.

Discussion

To our knowledge, this is the first study to unveil policy discrepancies in essential medicine management within the Indonesian PHC system from the perspective of the local pharmaceutical system. Policy consistencies and discrepancies are perceived as opposite sides of the same coin and can be considered critical for tackling medicine stockouts. The main reason for the discrepancies is variation in district capacity, including medicine stockout in the supply chain, pharmacist availability, and pharmacist competency in medicine management, including actions to cope with discrepancies. These coping mechanisms show that local pharmacy systems exhibit self-organising features which enable them to fix their weaknesses autonomously. These coping mechanisms may only alleviate stockouts, however, and do nothing to address the root causes. They thus often mask systemic deficiencies that then go unnoticed and remain unresolved.

This study used an evaluative method to discuss medicine availability data covering stockouts, shortages, and efficient stock control over a four-year period as the strength of our research. Unlike recent studies focusing on individual medicine scenarios, we examined three medicine groups (tuberculosis, MNH, and NCD) to understand health workers' roles and their actions in light of national policies [199–201]. Our findings are based on two of 514 local pharmacy systems in Indonesia, so we must limit our generalisations. Although we did not pilot our interview guidelines, participants found them comprehensible. However, we acknowledge one of our study limitations is that our quantitative findings rely on self-reporting without inspection of actual documents, and data may not include individual PHC procurements. Further research with extended observations at DHOs and PHCs is needed to explore how the local pharmaceutical system is viewed from such external entities as PHOs, the

MOH, and medicine suppliers, leading to more comprehensive insights and technical policy recommendations for system performance.

Variation in pharmaceutical staff competency, especially among PHC pharmacists, highlights the need for accessible and continuous capacity-building. Competence gaps were identified in various aspects of medicine management (subpar quantification, underutilisation of capitation funds, suboptimal use of predelivery, inconsistent dosage or substitution practices). For instance, although national policies and regulations are clear about capitation fund use, health workers often find the administrative process cumbersome [202]. Implementing a continuous learning system for both current and new pharmaceutical staff is crucial for improving local health worker capacity [170]. This aligns with global and Indonesian health agendas aimed at monitoring health indicators at the district level [203]. A medicine availability indicator could be paired with a national indicator quantifying health workers' training in local learning systems for medicine management.

Effective coordination within individual institutions and across the multilevel system of governance in this decentralised country is crucial for ensuring that local pharmaceutical systems provide equal access to essential medicines. Such local systems are integrated into larger frameworks, including the local health system and national pharmaceutical system [40, 46, 174]. Specific sub-systems within the local pharmaceutical system handle medications for priority programmes.

Implementing the interactions outlined in the regulations, such as those between pharmacists and health workers in PHCs, has proved challenging. High patient numbers and the professional pride of general practitioners limit communication time, emphasising the need to address coordination skills, particularly in PHCs, through future training programmes [204]. Indonesia should prioritise creating equality in interprofessional relationships within its healthcare system, as this is crucial for ensuring optimal system performance. Coordination skills, particularly among health workers in PHCs, merit attention in any future training programmes.

National policies require adjustments at the local level, resulting in consistencies but also discrepancies. National policy is occasionally politically driven, making implementation challenging [205]. One critical concern is the dilemma of supplying non-mandatory essential medicines based on PHC capacity, as identified for oxytocin and methylergometrine maleate injections. Despite not being mandated by the Indonesian NEML and the National Formulary, PHCs without inpatient services still have access to these medicines when their DHO can supply them. This practice, motivated by the desire to enhance PHC performance reports, has led to medicines expiring on PHC shelves. Interviews with health workers reveal varying perspectives, with some acknowledging mistakes and others considering unavailability acceptable. On the other hand, if the DHO does not provide, PHCs might opt not to purchase the medicine. This approach overlooks district-specific challenges, such as the difficulty local people may have reaching PHCs with inpatient services and other health facilities. In rural areas, low-income pregnant women may choose unskilled birth attendants if access to MNCH services at their PHC is uncertain [206].

Flexibility in system capacity improvement based on local resources is crucial during policy implementation, which should allow for specific needs, capacities, and geographical factors [138]. The performance of the local pharmaceutical system is influenced by regional and district contexts, creating difficulties in national policy implementation. It processes these inputs with its capacity and generates an output in terms of medicine availability [45, 207]. Our finding shows that DHOs still take action to continue to provide limited stock of tuberculosis medicines to those PHCs located far from the DHO warehouse. Their action contradicts the national policy which centralises all tuberculosis medicine stocks in a DHO warehouse. When local systems encounter current or perceived pressure due to the unintended demand for medications, they resort to coping mechanisms. We also found other coping mechanisms such as delegating tasks, distributing medicines to PHCs that have not adequately planned for their medication needs, and ensuring the consistent supply of medications such as metformin by borrowing from another DHO. These temporary solutions may conceal deeper systemic issues, such as unclear policy and guidance for health workers to providing the right medicines for the right health problems, inadequately prepared staff to serve the population, and a lack of defined roles within the local system. A space for flexibility is needed in the national policy in Indonesia given local variation across the country. Such flexibility can be facilitated and supported by national stakeholders at higher levels of the healthcare system to ensure ethical compliance and service standards in policy implementation guidelines and could be monitored at the DHO level.

We have shown how the pharmaceutical system is both layered and dynamic. The perspective of a top-down functioning of the system does not hold as at each level — national, regional and local — specific problems occur and are managed in such ways that overall the system can function. The level of the DHO plays a crucial role — next to that of the PHC — as it forms the mediator between the local and the national levels [45, 208]. In that sense, current plans to bypass the DHO by strengthening primary care — while this strengthening in itself is good — might be counterproductive. On the basis of our findings, we would rather plead for strengthening the function of the DHO, including capacity building and information infrastructures.

Conclusions

Discrepancies between national policy and health worker practices in the four phases of managing medicines at PHCs are influenced by variations across local system contexts and capacities. These discrepancies result in medicine stockouts, with coping mechanisms often obscuring systemic deficiencies in local systems, rendering them unnoticed and unresolved. Ensuring continuous and easy access to capacity-building platforms for health workers is essential to guarantee equal access to quality health services with an adequate supply of essential medicines. A further recommendation is to not only adjust national policy to local systems for practical implementation but also to develop indicators and accountability mechanisms for monitoring improvements in how local systems manage medication.

Chapter 6:
General discussion – Making sense of insights gained from the LoPhaS approach and empirical studies

Recap of research niche and research question

One of the Sustainable Development Goals (SDG) is to achieve universal health coverage by improving access to affordable essential medicines. Many larger countries struggle to live up to this goal and to ensure equal access to medicines in their health facilities due to internal variation. Differences with respect to geographical factors, population density and income, distribution of health workers (such as pharmacists), and size of the medicines market all affect medicine availability [2, 111, 163, 164]. Previous studies have tended to neglect this variation and focused instead on the performance of the *national* pharmaceutical system. I argue, however, that a local approach provides a better understanding of fundamental pharmaceutical system dynamics and challenges across a country, as it functions as a "system in between". In Indonesia, decentralisation was implemented by delegating responsibility to local governments—including primary health centres (PHCs) and their associated District Health Offices (DHOs)—to manage the provision of medicines in public sector facilities. This thesis therefore focuses on understanding variations in the availability of essential medicines at PHCs in Indonesia.

I have divided the work into three specific sub-questions:

- How can we conceptualise and assess local pharmaceutical systems from a complexity perspective?

- How does the local pharmaceutical system in Indonesia perform and how can we explain variations in medicine availability?
- How do actors in the local pharmaceutical system deal with predictable and unpredictable system dynamics in the Primary Health Centres' medication management?

Previous *chapters* have focused on the sub-questions, providing the structure for my thesis. To conceptualise a model for the local pharmaceutical system (LoPhaS), I began by reviewing existing reports and research publications that conceptualised and sought to improve the pharmaceutical system at the national level (Chapter 2). I continued by investigating the extent to which variations in essential medicines availability exist and why specific medicines were not (always) available at PHCs (Chapter 3). Advanced statistical analyses were performed to assess which components and features of the local pharmaceutical system were associated with the variation in medicine availability (Chapter 4). Finally, I investigated the medication management practices of health workers to understand how local actors deal with the availability or non-availability of medicines (Chapter 5).

In this concluding chapter, I first answer the sub-questions and overall question. I begin with the knowledge derived from our conceptualisation of the LoPhaS and how to measure the system's performance. I then provide key insights from my empirical studies in Indonesia regarding variations in medicine availability and the interaction between sub-elements within the local system. I subsequently turn to discussing the implications of my findings with regard to complexity theory and the practicality of efforts to improve pharmaceutical systems. Next, I reflect on the methodological approach chosen for this thesis, followed by a section on research implications. This section also discusses what is needed to improve the resilience of the pharmaceutical systems at the national and local levels. The thesis ends with a brief conclusion.

Building the critical local pharmaceutical system (LoPhaS) approach

Variation in essential medicine availability can be measured using the local pharmaceutical system approach, as we argue that it is a "system in between". In Chapter 2, we defined the local pharmaceutical system (LoPhaS) as:

> "All people, structures, resources, policies and interactions that ensure access to and appropriate use of medicine and related services at the local level to promote better health outcomes."

This definition places the four core elements—people, structures, resources, and policies—and their interactions within a local system at the centre of this system's operation. A LoPhaS serves to ensure that local communities can access medicines whenever they need them at their nearest public health facility. One structural characteristic of a LoPhaS is that it functions as an independent sub-system, nested in and co-evolving with the multilevel structure of other larger systems, such as the national health, economic and pharmaceutical systems. Multiple factors, including people and their interactions, result in variations in local contexts and system performance. Along with other system outputs such as the affordability, geographical accessibility and acceptability of essential medicines, variations in their availability impact the full measure of social justice within a country with regard to access to medicines.

After describing the local pharmaceutical system, we identified the six core functions of the LoPhaS: 1) Local governance and stewardship; 2) Managing pharmaceutical product supply; 3) Financing, i.e. securing and allocating funds; 4) Developing and sustaining human and physical resources; 5) Ensuring quality and promoting appropriate use; and 6) Monitoring performance. These functions have their operational elements or indicators, for example a strategic vision for local governance of the pharmaceutical system, the accuracy of a medication forecasting plan used in managing pharmaceutical product supply, and medicine availability data used to inform the policymaking process encompassed in system performance monitoring.

The conceptual framework also takes into account external factors such as local community health needs and socioeconomic, cultural, logistical, geographical, and security factors. Each LoPhaS functions in relation to the community's needs for medications, which are shaped by its population's health status and preferences. Communities with better financial capacity have more options when it comes to medicines and health facilities. At the same time, those with a low socioeconomic status tend to rely on the public sector or what their insurance recommends. Cultural practices in some rural areas, e.g. traditional healing methods such as herbal remedies, acupuncture, and folk healers, may also influence medicine use. In some countries, the eldest family member or husband determines when, where, and which medicines the other family members may take. The combination of geographical and logistical factors influences access to medicines, since more difficult access (i.e. road conditions, very remote areas, islands) affects the cost of transport. A similar consideration applies to conflict areas, where safety or instability issues can disrupt supply chains and thus limit access.

Assessing local pharmaceutical systems in Indonesia

The LoPhaS analytical approach can assist in delivering quantitative or qualitative evidence or, preferably, a combination of the two. I have stated that studies aiming to assess LoPhaS performance need to follow four steps, presented in Figure 1: 1) Describe the formal organisation of the system; 2) Identify connections between elements in local pharmaceutical systems; 3) Explore system dynamics; and 4) Integrate insights. In this thesis, I have described my attempt to use the LoPhaS approach in **Chapters 3**, **4** and **5**. The following sections integrate and reflect on the insights I gained and discuss the implications.

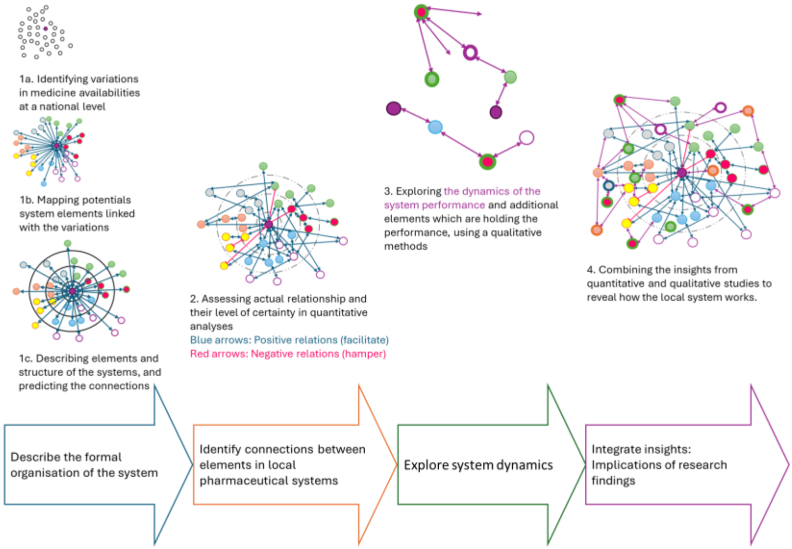


Figure 1. Assessing local pharmaceutical system performance

Step 1: Describe the formal organisation of the system

I began this work by identifying variations in essential medicine availability at PHCs in Indonesia to ensure the appropriateness of LoPhaS utilization. The median availability of most priority medicines in the PHC baskets was 82%, indicating that the Indonesian government has succeeded in ensuring access to these medicines at the national level, as shown in **Chapter 3**. However, a broader selection of essential medicines at PHCs showed great variations in availability across the country. These variations were observed across the relevant essential medicines, groupings of medicines based on treatment categories, regions, and districts.

My analysis showed the complexity involved in defining essential medicines in a country as large as Indonesia. Let me first summarise the main findings from my review and empirical studies. The primary indicator used to assess local system performance was the availability (in %) of a basket of essential medicines (Chapter 2), but it was a challenge to select and interpret this indicator. Indonesia's central government maintains a National Essential Medicine List (NEML), consisting of more than 300 medicines categorised as essential for the country's PHCs. Based on the NEML, we narrowed the list down to sixty essential medicines and found that their availability rating dropped from 82% to 58%. In **Chapter 4**, we deliberately excluded ten items from the list of sixty medicines because certain drugs, such as those treating malaria and HIV, are essential only in districts with high disease prevalence or require specialised services and training for distribution. We found that the average availability for the remaining fifty essential medicines was 66%. We also observed variations in the availability of ten essential medicines over four years in **Chapter 5**. One essential medicine, glibenclamide, was unavailable for more than two months in certain districts or PHCs.

In this large country, there is significant variation in medicine availability not only across PHCs but also across districts. The best-performing district achieves an average medicine availability of up to 83% across its PHCs, while others report rates as low as 43%. This variation aligns with our assumption, reinforcing the need to analyse and compare local pharmaceutical system performance.

I then described the formal organisation of Indonesia's local pharmaceutical system. The more than 10,000 PHCs and their medicine supply are organised by their associate DHO. The DHO procures most of the medicines and distributes them based on each PHC's demand. The central government supplies medicines for TB, HIV and malaria, with the DHO being prohibited from procuring these. If the DHO fails to deliver the medicines needed, the PHC may use its own limited financial resources to procure medicines, with the DHO's approval. The total of 514 DHOs play a key role in promoting the national agenda to improve access to medicine for all Indonesians. Most of the information is already presented in the introductory chapter.

Having a clear vision of the local pharmaceutical system's function helped guide and shape our analyses. In our framework, we proposed two main performance indicators: community access to medicines and appropriate use of medicines. To manage the complexity of the local pharmaceutical system, I focused in my empirical research on medicine availability at PHCs. I then contextualised and identified four key system functions that support the main function: 1) managing pharmaceutical product supply; 2) financing; 3) developing and sustaining human and physical resources; and 4) monitoring performance. These functions were later used in our analyses. This process also helped me to map the associated stakeholders within local pharmaceutical systems, including pharmacists, general practitioners, midwives, and health programme managers at both PHCs and DHOs.

Step 2: Identify connections between elements in local pharmaceutical systems

In **Chapter 4**, we found that multiple internal operational components within the LoPhaS contributed to variation in essential medicines availability at PHCs. Regarding the internal factors of the LoPhaS, we found a total of fifty variables embedded at the level of PHCs and DHOs. The availability of pharmacists, financing allocations, medicine guidelines, reports, and monitoring systems were reported descriptively. LoPhaS dynamics and interaction characteristics (i.e. using PHC funds to procure medicine, reporting rational use, and attempting to procure medicines with an expiration period of more than two years) were studied.

Along with our analyses, we further addressed a number of external factors that affected the availability of medicines, including accessibility and financial and demographic determinants. Geographical factors, such as the remoteness of a region, are also associated with availability, as shown in **Chapter 3**. The performance of the local pharmaceutical system in ensuring the supply of medicine may be hampered by its remoteness and rural setting, distances between PHCs, percentage of the community on limited incomes, and the local government's health expenditure and fiscal capacity. We examined these external determinants at the level of the PHC, district and province, as a LoPhaS is organised within a multilayered governance system.

Our analysis showed that medicine availability at PHCs is clustered spatially within a range of two kilometres. In other words, the availability of medicines at a PHC is most likely to be predicted by availability at their nearest neighbour, other PHCs within its district, and other PHCs outside its district but within the same province. This intriguing finding indicates that an informal network of PHCs has emerged that helps its members fulfil their medication demands. It also means that even if the majority of the network members cannot provide a specific medicine to their patients, a PHC is perceived to be okay not having this medicine in their basket because it can be obtained from some other health facilities if necessary.

Our quantitative analyses show that the main factor affecting the availability of essential medicines is the performance of the local pharmaceutical system. Availability tends to be lower at PHCs in geographically disadvantaged areas or in socioeconomically underprivileged communities. Nevertheless, PHCs in areas with better LoPhaS capacity have a higher medicine availability rate compared to those in other areas. Focusing on improving local pharmaceutical performance might therefore reduce the gap caused by variations in local geographical and community circumstances. Three main features of the system played significant roles in improving the availability of medications: managing physical and human resources, managing the medicine supply chain, and financing. It is important to note that better financing arrangements, better medication data and better human resources—i.e. availability of monthly medicine reports, use of capitation funds, and medicine management techniques—are associated with better medicine availability for communities.

The foregoing interactions were inspected at PHCs. On another level, both positive and negative associations were found between DHOs and the availability of medicines at PHCs. Variation in the supply of medicines in PHCs' baskets tends to be similar to that of their DHO, indicating that PHCs depend heavily on their DHO. Another surprising finding is the negative association between DHOs that quantified their medicine demand and procured their medicines through the e-catalogue and lower essential medicine availability at their PHCs. These findings indicate that further research is needed into how DHOs quantify and procure their medicines based on their plan.

Step 3: Explore system dynamics

Indonesia presented its vision of equal access to medicines in its national medicine policies in 2006. Recent new health legislation (Law No. 17 of 2023 on Health) reiterates that ensuring access to medicines is the joint responsibility of central and local government. The national government provides the overall design of essential medicine policy, while the local government, including health workers, are charged with implementing this policy to achieve a minimum standard in health services.

In **Chapter 5**, we shared the findings of our in-depth qualitative analysis, which examined health worker practices in managing their essential medicines. These practices may be consistent or inconsistent with national policy. The three main reasons for medicines not being available in PHC baskets are the confusing nature of national policy instructions, undersupply by the medicine markets, and pharmacist availability and competence. Some pharmacists coped with unavailability by buying medicines with their own money, writing prescriptions for patients to purchase out-of-pocket, or switching them to substitute medicines at a higher dosage. Since they utilised these coping mechanisms routinely, they never reported the actual problem, i.e. the unavailability of essential medicines, which then went unnoticed and remained unresolved.

The local pharmaceutical system's role in providing medicines has become increasingly complex due to various interactions within the system. Our findings indicate that the supply of medicine involves a vertical hierarchy, from the Directorate-General of Pharmaceuticals down to pharmacists or other healthcare providers responsible for dispensing medicines at PHCs. At the same time, pharmacists must collaborate with their peers, including general practitioners, public health managers, and PHC treasurers, to plan medicine procurement.

Given that health workers often juggle multiple responsibilities, however, pharmacists face challenges in effectively communicating medicine procurement plans with other health professionals. While they may rely on the NEML to estimate population demand, they often find that some medicines do not align with their community's actual requirements. Despite this, they must still provide these medicines, as their performance is measured by the percentage of monitored essential medicines they have available. As a result, some pharmacists at PHCs continue following existing medicine supply patterns, aligning their supply with the NEML rather than actively adapting that supply to local needs. Furthermore, PHCs that are better at medicine planning are obliged to share their allocated stock with PHCs that fail to plan effectively, creating a challenge within the local pharmaceutical system. These workarounds affect medicine quantification at the DHO level, as the DHO procures medicines for all PHCs.

Step 4: Integrate insights: Implications of research findings

Our research provides valuable insights into how the theory of complexity can be applied in local pharmaceutical systems and policymaking, the practicality of healthcare routines in Indonesia, and a future research agenda in pharmaceutical policy and practice. I discuss the implications in that order below.

Theoretical implications for complexity in access to medicines

In seeking to understand access to medicines in Indonesia, I applied complexity theory to the local pharmaceutical system by developing my approach, exploring the component elements of a local system and how these elements are interconnected and impact system performance, and making sense of progress and achievements. The multiple elements in local pharmaceutical systems enter into unique relationships in managing medicine provision because they interact with other elements within and outside the system. In addition, understanding the actual system dynamics in multilayered governance—which emerge from complex interactions and relationships between different levels of the health system—requires a complete description of the related stakeholders and how they function in providing essential medicines [25, 44]. After contextualising this knowledge to the Indonesian setting, we explored and measured the functions of local pharmaceutical systems and furnished associated performance indicators for PHCs, districts and provinces. In the following paragraphs, I explain how our research on medicines management at PHCs in Indonesia has contributed to complexity theory.

The main contribution of this thesis to improving access to medicines is our critical approach to developing a model for local pharmaceutical systems, which fills a gap in the academic literature and in pharmaceutical policy and practice. As mentioned in the introduction, the existing literature predominantly analyses pharmaceutical systems from a national perspective, following a top-down positivist approach that is often superficial and overlooks the deeper meaning of variations [8–11]. In contrast, another framework advocates a complex adaptive systems approach, starting from the community level [209], but it is challenging to compare local pharmaceutical systems using this approach. Our work fills the gap in the literature on complexity theory in pharmaceutical policy and practice by integrating the prior two frameworks into a new approach that highlights the system "in between" national and primary healthcare:

the local system. Our local pharmaceutical system (LoPhaS) approach enables both comparative analyses of local system performance and in-depth examinations of system dynamics. I have used this approach to examine the key features of local pharmaceutical systems, measure the system outcomes, and investigate dynamics within two local pharmaceutical systems. The previous section summarised my empirical findings.

In addition to the main contribution described above, our empirical studies also made a number of other contributions. The first is the finding that a local pharmaceutical system is a self-organising entity that functions as an individual system embracing its own local context. The health system in a district is already shaped by its geographical, demographic, financial, and community status, and the pharmaceutical system must understand this existing shape. Taking the example of how pharmacists at the DHO manage their human resources, financing, and external network (other DHOs), we see that the system deals with threats by utilising its existing resources. As we found in Chapters 3 and 4, variations in the supply of essential medicines have emerged across Indonesia and are associated with multiple factors. Nevertheless, the main factor influencing performance is the availability of physical and human resources. We can only predict 30% of these existing outcome variations in our quantitative models, indicating more arbitrary patterns than assumed when using a total samples technique. I believe all 514 local pharmaceutical systems in Indonesia organise their resources independently to cope with system threats, such as national policy requiring them to meet their community's demand for medications.

Our second additional contribution is the finding that repair work or coping mechanisms are important in ensuring the local system's ability to meet its goal. Self-organisation and coping mechanisms are two related characteristics showing a system's independence and sustainability. As we showed in our qualitative study, some pharmacists at PHCs do not request certain essential medicines from their DHOs because they find these medicines irrelevant for their population. In other cases, some coping mechanisms, such as borrowing medications from other DHOs and/or PHCs, manipulating financial reports, and altering medicine dosages, lead to dialectical questioning: "Is this practice purely wrong?" or "Should we prioritise the community's medication needs, even though it's unethical to manipulate the budget?". Repair work can be described as a double-edged sword because it prevents chaotic situations on the one hand but hides systemic problems on the other. Space for flexibility is needed to prevent system malfunctions and ensure that health workers can use their own resources to achieve the system goal – that is, a space where workarounds are hidden but can be reflected upon to improve the overall system's functioning [138]. The local pharmaceutical system is thus a self-organising system, working towards its goals while focusing on its sustainability, and this self-organisation can be used for system learning. This finding fills a gap in the literature, which has so far paid scant attention to the work that local actors do to repair system malfunctions.

Such coping mechanisms are a natural property of a self-organising system and always emerge in response to system pressures, specifically mediating between community needs and national policies.

The third and fourth additional contributions of our research also pertain to the combination of self-organisation and coping mechanisms. The third contribution is the finding that a local system can adjust its role to ensure proper performance, but only under specific conditions. One condition is that the pharmacist must play a critical role in managing medicines. As we found in our quantitative model, the availability of a pharmacist at a PHC is the covariate most closely associated with medicine availability; more than 20% of PHCs serve their community without the presence of a pharmacist. Our qualitative analysis showed that local pharmacists repaired weaknesses by means of cross-appointments with other PHCs. In Kupang district, for example, a PHC pharmacist manages the medication needs of three other PHCs that do not have a pharmacist. This finding reflects the managerial work of pharmacists, which can be leveraged to the DHO level to cope with staff shortages and thus ensure that all PHCs achieve an adequate supply of essential medicines. This theoretical angle is important to the prior debate about which coping mechanisms should be encouraged.

The fourth additional contribution that our research makes—one that is also related to the previous point—is the finding that local pharmaceutical systems are able to put one of their core functions on hold in order to achieve their mission of ensuring access to medicines. For example, a local system can decide on a trade-off whereby it maximises its budget allocation and compromises on performance monitoring. Pharmacists may take on more than one responsibility; we found, for instance, that one of them had also stepped in to manage a PHC’s financial budget in order to procure medicines; she did so by exercising her authority to collect “leftover budget” from other staff, but she then reported it as fully absorbed. Some people perceived this as illegal because she was in fact obliged to report the surplus budget and pay it back to the national government. She also did not report that certain medicines were available because she and the head of the PHC would get caught for inappropriate budgetary practices. This finding showed that the trade-off (a strategic decision to compromise one aspect of the system's performance in order to improve its main function) is actually meant to cover the community's medication demand. The health worker used this practice as a coping mechanism to ensure access to medicines when such access was threatened by discrepancies in implementing the national policy.

The final additional contribution of our research is that it demonstrates that individual PHCs within a local pharmaceutical system perform similarly. The relationship between medicine availability and PHC performance is shaped by the latter’s position in the multiple systems to which they belong. That position can have both negative and positive effects on medicine availability. In Chapter 4, we found that PHCs within a range of two kilometres of one another have similar stocks of medicine available, indicating that if a PHC and its DHO have run out of a medicine, the pharmacist will seek help from its nearest neighbours, and that the neighbour is likely to oblige. In Chapter 5, we related how a pharmacist at a PHC borrowed some TB FDC tablets from its neighbour. A solidarity principle emerged in the local system to ensure access to medicines. The idea of solidarity and mutual support was unintended and activated when the local system was in difficulty. Health workers in a local system share responsibilities and burdens equally. In Indonesian culture, there is an old adage: *Berat sama dipikul, ringan sama dijinjing* (similar to the idiom "Many hands make light work"). I believe this spirit of solidarity among health workers facilitates the local system's performance in Indonesia.

Practical and policy implications for improving access to medicines across the country

Our study on variations in medicine availability in Indonesia offers useful insights for actual practice. Below, I describe the implications of our findings for the policymaking process, health workers' practices, and efforts to increase access to medicines, broken down into the following recommendations.

Take context into account when determining essential medicine lists.

In Indonesia, the national government has become more ambitious in framing its policy on essential medicines. The WHO recommended taking their EML as a minimum to support a country's health system, consisting of a core list of mandatory medicines and a supplementary list for specific conditions or settings. The Indonesian government, however, describes its National Essential Medicines List (NEML) as “a list of medicines that should be available at *each level of health facility*". In 2023, the list of essential medicines that must be available at a PHC exceeds one hundred items, raising doubts about its feasibility in practice. This ambition has made implementation more challenging, and I provide more details about these challenges in the following paragraphs.

The first challenge is monitoring actual performance based on the essential medicine availability performance indicator. It is nearly impossible to ensure that all PHCs report on every medicine listed in the NEML. While the policy instructions around essential medicines have not changed, the Ministry of Health and the Ministry of National Development Planning have decided to focus on a priority grouping of forty medicines for the national reporting system.

The existence of these two national lists gives rise to the second challenge, which is confusion among health workers in the field. The priority medicines, i.e. the shorter list of essential medicines, are those most in demand at all PHCs across all districts. While the terminology is the same, only the NEML is the product of a legitimate policy. Even so, health workers tend to focus more on the medicines most in demand, while overlooking other medicines listed in the NEML.

On top of this, the list of priority medicines does not align with the varying needs of PHCs and districts, giving rise to the third challenge. In Chapter 5, we saw that some pharmacists felt bad if the priority medicines were unavailable, while others reported that some of the medicines on the NEML are never used at their PHCs. Some essential medicines, such as methylergometrine, are critical because they can be administered to pregnant women with pre-eclampsia. In other cases, such as glibenclamide and metformin, the status as a priority medicine is questionable because alternative medicines such as glimepiride can serve as substitutes. Some pharmacists have in fact decided to limit their basket to glimepiride alone. It is clear that local variation does exist and impacts practices at PHCs, and that local systems know best what their population needs.

I therefore recommend that national policymakers simplify the NEML while also allowing for variations in local medication demand. National stakeholders need to engage local stakeholders in selecting the medicines for their performance indicator, which may also help to enhance local ownership, facilitate improvement efforts, and promote accountability among national and local health authorities[124]. The central government could, for example, identify twenty medicines on the NEML and provide a supplementary list of medicines from which local government can assemble its own essential medicines list. It would then be able to propose a list of, for example, thirty *additional* essential medicines. A combination of these two lists can be used to monitor the actual performance of the local pharmaceutical system. Variations between lists should align with the local epidemiological factors, such as disease prevalence and health problems.

Consolidate decentralisation by improving DHO leadership.

Indonesia's national Health System Transformation Agenda has focused in recent years on improving primary healthcare, but it neglects the DHO's role in managing their PHCs. Our quantitative analyses showed only a slight variation between PHCs and DHOs in average medicine availability, revealing that most medicines in PHC baskets were procured from a DHO. Our qualitative study further showed how the work of managing medicines at PHCs is interconnected with DHOs. Multiple ongoing initiatives at national level, however—for example, requiring PHCs to report public medication data directly to the central government, encouraging PHCs' independent financial management systems, and training PHC staff to procure medicines themselves from the e-catalogue—bypass the DHO. I understand the desire to make the healthcare system more efficient, but these efforts oversimplify the health system network and may potentially lead to chaos.

This top-down approach fails to consider that the national health system and PHCs cannot interact without the DHO function [45, 208]. The DHO plays a critical role as a mediator between national expectations and local capacities. Under the decentralisation system, medicine management is coordinated mainly by the DHO. While PHCs serve as the front lines in providing medicines to the community, DHOs function as the brains of the local pharmaceutical system. In our interviews, health workers at PHCs mentioned that they had no difficulty meeting the demand for medicine as long as their DHOs stocked the necessary drugs. Together, these two entities shape the local pharmaceutical system, which operates as a public-sector system that engages with private-sector medicine suppliers. In addition, the local system has its own political dynamics, often resulting in unpredictable staff rotations. The Ministry of Health cannot handle these dynamics and supervise 10,000 PHCs directly on its own.

I recommend that the national plan should incorporate efforts to strengthen the DHO's role in directing, managing, monitoring, and empowering the elements that make up the local health system. Our observations show that DHOs employ various coping mechanisms to maintain local system performance, such as cross-appointments, leveraging DHO networks to handle temporary stockouts, and arranging pre-delivery services. These practices demonstrate how crucial the DHO's role is in ensuring that the local system functions effectively [27]. Strengthening the DHO's leadership in managing district demand is crucial to ensuring a local strategy for providing access to medicines, coaching PHC performance, engaging with medicine suppliers, monitoring, and taking action when medicine management is hampered. Such tasks should be designed as DHO responsibilities [170].

Improve pharmacist performance in managing medicines.

In my research, I saw that a shortage of pharmacists and limited competence in medicine management led to multiple problems. The first problem is that PHCs without pharmacists had a more limited supply of medicines, as we found in our quantitative analyses. That is why the Kupang DHO asked three of its pharmacists to manage the medicines at PHCs that did not have pharmacists on staff. The second problem concerns the competence of pharmacists in medicine quantification. Poor skills in calculating the medication demand led to the submission of poor medicine quantification plans, which in turn resulted in incorrect stockpiling of medicines. The third problem is poor communication within PHCs. Although the national rules for pharmaceutical services specifically instructs PHC pharmacists to cooperate with other health programme managers on evaluating their medicine plans and patient visit data, joint meetings are hard to schedule. Another issue related to communication concerns the use of the capitation fund to procure medicines as needed.

To my knowledge, there are few educational programmes that have been set up to address these gaps in the competences and technical skills needed to manage pharmaceutical supplies. The personal roles that pharmacists play in medicine management are the backbone of efforts to ensure adequate access to medicines. Not only must they be able to perform clinical pharmaceutical tasks, such as assessing patients and drafting medication plans, but they should also be able to manage proper medicine logistics. Indonesia’s national policy sets the standard for pharmaceutical practices and services and offers guidance for pharmacists who work for the PHCs. However, this policy only gives examples of clinical pharmaceutical service reports, and it is too conceptual. A training course in the technical skills pharmacists need to ensure the availability of medicines at PHCs is still under development.

Multiple training programmes should be made available in each district, accessible for all health workers, especially pharmacists. Although the MoH has established a national training platform, *Plataran Sehat*, which could be used to develop a national training programme, I recommend setting up local training programmes. I propose developing a programme of continuing training to ensure pharmacists remain competent at managing medicines using a local pharmaceutical system approach. For effectiveness and efficiency, training should be scheduled at regular intervals at a provincial health training centre, and the course curriculum should be supervised by the MoH. The training materials should reflect local issues, such as managing medicines using local resources, communication in pharmaceutical services and management, and leadership based on the institutional level. The MoH would need to monitor and control programme implementation to ensure quality.

I would further encourage educational institutions and the pharmacists' professional association to play an active role in developing more practical course materials for this local programme. The current practice of quantifying the demand for medicines relies on a consumption-based method, which oversimplifies the circumstances. According to this method, pharmacists simply calculate the average volume of medicines stocked over the past year and add 10% to estimate the inventory needed for the next two years. Problems have emerged because this calculation fails to account for disruptions in the medicine supply chain and unmet demand based on epidemiological data. To improve local pharmaceutical system performance, I recommend that universities and the pharmacists' association promote and build capacity for using the morbidity-based method in medicine quantification [210].

Monitor and evaluate local pharmaceutical system performance at the local level.

There is as yet no well-established method in Indonesia for monitoring local pharmaceutical system performance. Monitoring and evaluation are crucial to ensuring that the local pharmaceutical system is working towards its goal, with data and other evidence being used to inform both national and local policies. Public medical data on stocks, budget allocation and spending on procurement, and patient visits need to be accessible and verifiable to improve PHC performance in providing medicines [63, 211]. Managing the supply of medicines effectively requires data beyond evaluations of medication stock and usage data, as such additional data could feed a more comprehensive analysis of the progress made and the challenges involved in ensuring access to medicine. All the reporting and monitoring systems are separate, divided into relevant health programmes and funding sources, so that monitoring is fragmented in a local system. To conclude, the main problem is that the actors in the local pharmaceutical system are not learning from the system's memory, which is crucial to optimising its performance.

As a result, inaccuracy in medication forecasting remains a major systemic problem. In our interviews, health workers reported using incomplete data and calculating only the medicines received from the DHO over the course of one year. Health workers at PHCs rely on medication stock and usage data to forecast their medication demand and submit quantification reports to their DHO. As we found, health workers also procure additional medicines using capitation funds, and they do not include these purchases in their medication usage reports to their DHO. Health workers separated out these reports based on where they had sourced medicines, leading to partial reports and incomplete data on medication management. Later, this in turn resulted in a miscalculation of actual usage in specific periods and of the forecast demand for medicines in the following year. Such routine tracking data are not being utilised to improve the performance of local systems.

Another concern related to monitoring is the absence of a designated controller. The central government has tasked the DHO with managing and monitoring all PHC performance and expects it to fulfil this function. Nevertheless, the current initiative to obtain data on medicine availability directly from PHCs bypasses the DHO. In practice, the DHO focuses on responding to the needs of its PHCs and neglects its active role in monitoring the medicine supply within a district.

My recommendation is that central government should reorganise the current reporting system by integrating it into a district health system and allow DHOs to access PHC data. This recommendation aims to empower DHOs and boost their capacity and performance in managing and curating data on public health, including medication. This can be achieved by helping PHCs provide full data, by interpreting medicine and other public health data over a certain period at the district level, and by monitoring collaboration among health programme divisions [212–214]. I propose that the central government should develop a roadmap to ensure that all DHOs and PHCs have the capacity to use their routinely collected data in their local policymaking process. A periodic evaluation, for example, once a month or every three months, should be conducted to ensure the system is self-learning and understands to what extent it can allow repair work. Such efforts have the potential to foster data-driven policies at the district level, using insights gained from routine monitoring systems [215].

Build strong local pharmaceutical systems to improve health system resilience.

We have observed many disruptions in Indonesia's local pharmaceutical systems. Some are addressed through coping mechanisms, others remain unresolved. Our study shows that essential medicines are not always available because they are not supplied or are not considered necessary for a particular health programme. Medicine manufacturers and distributors are private parties that prioritise profitability and the survival of their business, and their decisions sometimes create unpredictable dynamics in the medicine supply chain. For example, the companies that won the national tender for the e-catalogue refused to supply medicines to areas where shipping proved expensive or were unable to fill all orders placed for medicines due to the rising cost of raw materials. In some cases, companies participated in national auctions with unrealistically low bids merely to win the contract. These fragilities have domino effects on medicine procurement at DHOs and PHCs; examples include TB patients not receiving medication due to national shortages, higher net prices outside the e-catalogue platform resulting in fewer purchases of cardiovascular medicines, and dispensing practices not aligning with clinical guidelines. These findings illustrate how medicine management, adequate supplies, local system performance, coping mechanisms, and health system resilience are interconnected.

As the National Health System Transformation Agenda aims to improve health system resilience by ensuring adequate medicine production capacity, I recommend boosting local pharmaceutical system resilience to better manage unpredictable market dynamics. This recommendation aligns with earlier suggestions to enhance the role of DHOs, upgrade pharmacists' competencies and skills, and improve monitoring. Building awareness of which disruptions occur when and how they impact medicine supply, including patients' access to essential medicines, is crucial for improving system resilience. Additionally, given Indonesia's geographical location within the Ring of Fire and its vulnerability to multiple natural disasters, such as floods, landslides, and volcanic eruptions, it is essential for local pharmaceutical systems to develop pathways for responding to crises. Improving local resilience will help ensure continuous access to medicines, even during emergencies.

Design pooled procurement mechanisms in disadvantaged regions.

Medicine availability in PHCs varies from region to region in Indonesia, with availability being especially low in the east of the country. Priority medicines were not supplied to PHCs in rural districts in this region. Local contexts, such as low population density and a predominantly low-income population, contribute to making this region unattractive to the medicine markets, as the cost of supplying a medicine may be higher than its actual price.

One suggestion is to implement a national pooled procurement mechanism to ensure adequate medicine supply to remote regions that lie outside Java and Bali. Although Indonesia is adopting a new regulation for admitting multiple medicine suppliers to the national e-catalogue platform [161], this one policy may not be enough to lower rejection rates for medication orders. An alternative policy, such as pooled procurement in the east, may be more effective at motivating suppliers because it would generate higher volumes with better prices and lower the cost of distribution [134]. This policy would involve a trade-off between administrative efficiency and effectiveness. One of the provincial health offices in Eastern Indonesia could act as the regional pooling agency. The policy does require thorough assessment; hence, implementation research is needed to evaluate its feasibility and acceptability.

Reflections on our methodological approach

Potential insights gained from studying the complexity of providing medicines in Indonesia are documented in the foregoing empirical chapters. Here, I provide additional reflections on our systematic approach to modelling the local pharmaceutical system and applying this model in the Indonesian setting as a whole process. The following paragraphs offer a reflection on our methodological approach with a view to another study going forward. Some reflections focus on our methods, while others are my personal perspectives.

Familiarisation with the project theme is important and takes time and effort, but it has been a crucial investment for me in mapping out our sub-studies. In my work as a researcher in Indonesia, I have been involved in multiple projects addressing the functioning of the country's health system. In this work, I have observed variations in that system, especially in primary care capacity. At the start of my PhD, I was responsible for organising a study on incentives in the Indonesian medicine supply chain. During this project, I noticed that medicines were not available in some regions in Indonesia, especially in peripheral areas. Multiple factors shaped the decisions of medicine market actors and public health workers as to which medicines could be procured, and these factors included late payment of invoices submitted by actors in the medicine markets, and market favouritism in selecting medicine procurement channels. After spending a year familiarising myself with the research theme and attending a course on pharmaceutical policy in health systems, I had enough knowledge to develop an integrative review of local pharmaceutical systems.

In my PhD project, I adopt a multidisciplinary approach that integrates insights from various fields to examine the role of local pharmaceutical systems in Indonesia. As a public health researcher focusing on pharmaceutical policies, I recognise the need to go beyond superficial knowledge. This requires engaging with many different fields: economics, business, and management to understand the incentives driving medicine distribution; public administration to examine governance structures, decentralisation, and multilayered governance systems; anthropology to explore health workers' perspectives and social contexts; and pharmacy to understand pharmaceutical practices and service delivery. This comprehensive approach is essential to fully capture the complexity of local pharmaceutical systems in Indonesia.

I designed a mixed-method study to develop the concept of a local pharmaceutical system by exploring its component elements, interconnections, and dynamics and by integrating my findings into existing knowledge and practice. The data collection and analysis were carefully planned, starting with literature reviews, then quantitative analyses and exploratory case studies using a mixed-method approach. This process allowed my team and I to quantify the scale of medicine availability issues at the national level while also capturing the complexities of management, including the discrepancies between national policies and local practices. Taken as a whole, the evidence delivers comprehensive insights that deepen our understanding of this field.

Studying the existing approaches—i.e. the national pharmaceutical system framework and the Pharmaceutical System Strengthening framework—reveals the strengths and limitations of our research. The main strength of our methodological approach in developing our critical thinking is the use of previous academic journals and reports from reputable agencies working in many countries. We analysed these together with empirical studies using the existing frameworks, aiming to contextualise the pharmaceutical system to a more local setting. Although the documents we selected offered an overview and described the national pharmaceutical system, there was limited direct discussion of the role of the *local* health system. The process took longer than we had expected because our interpretations required the involvement of experts in medicines access and pharmaceutical systems.

Acquiring national datasets in Indonesia is tricky and sometimes required us to take an informal approach. After gaining an idea of the local pharmaceutical system's structure and scope, I developed a protocol to assess all local pharmaceutical systems in Indonesia. After contextualising the research plan to a quantitative approach, I submitted the protocol to the MoH, and one month later, our application was rejected on the grounds of data intensity; the MoH reviewers believed that the data we requested could be used for multiple research questions. It was suggested that we reduce the number of outcome variables, i.e. the selection of medicines we wished to study. I then remembered who the key person was in the National Health Facility Survey that delivered the data we wanted, and discussed it with them. In 2018, before my PhD programme period, I received an invitation from Indonesia's National Institute of Health Research and Development (Litbangkes) to participate in developing and piloting an updated version of this survey. It took more than formal communication and meetings to reengage with them and plan how best to combine formal and informal approaches to acquire the datasets. Another informal approach was direct monitoring of the dataset application process by the aforementioned key person. In the end, our application was granted twice, since we thought that more variables were needed in our quantitative study than had been recorded in the first trial.

Having our application to receive all data on essential medicines rejected was a red flag. When we developed the list of essential medicines that we wished to study, I incorporated the 300+ medicines on the NEML directly into our proposal. Now, I realise that the reviewers rejected my application because they suspected that the medicines designated as essential in the national policy were not all reflected in the actual performance of health workers. I took lorazepam as an example and showed that the availability of this essential medicine was very low because a PHC needed to have a psychologist on staff to obtain it. Mental health is an emerging issue in Indonesia, but the current health system, especially the PHC system, is not ready to address it. Very few PHCs employ psychologists. A similar situation became clear when we investigated HIV treatments, which consist of a combination of tenofovir, emtricitabine and efavirenz tablets, or a combination of tenofovir, lamivudine, and efavirenz tablets. PHCs that do not provide HIV services are not entitled to have these medicines in their baskets. In addition, we found that health workers also selected essential medicines themselves. As we demonstrated, this selection process is complex in Indonesia and interpreting findings correctly requires an intricate knowledge of the workings of the system.

Scheduling interviews with participants in different counties requires the interviewer to adjust their working time. This final reflection on our methodological approach is derived from my qualitative research. After the COVID-19 pandemic ended, people, including my research participants, were used to having online meetings on Zoom, and we had no technical difficulties during the interviews. All interviews were perfectly recorded in my Zoom clouds. The actual challenge was the time difference, which is six hours between Rotterdam and Kupang and five hours between Rotterdam and Bantul. After conducting initial meetings in the two districts in Indonesia and analysing their medical data, I asked my research assistants in the local area to manage the time schedule. Although I specifically asked them to schedule the meeting in the morning on Rotterdam time, the participants were reluctant to attend because they were busy with their work. Most of them preferred to meet during their morning, which was 3:00 AM in Rotterdam, and I had to follow their timetable. Caffeine was needed to improve my concentration, but it carried me through until my morning. Once we started the interview, the participants took the time to speak honestly about what they actually did to ensure adequate medicine provision in their PHCs and DHOs. On average, our interviews lasted more than an hour and delivered rich insights. They allowed us to include participants in very remote areas in Indonesia, where accessibility is limited and very challenging.

Call for future research

Our findings reveal that variations in access to medicines in Indonesia are the result of complex interactions between elements within a local pharmaceutical system. Although I have considered the implications and offered reflections, I would also call for more research to be carried out to monitor progress in access to medicine in Indonesia and to understand the behaviour of local pharmaceutical systems in certain circumstances in more global settings.

I encourage the central government to continue allocating funding and conducting another National Health Facility Survey (Rifaskes) in order to monitor progress in the entire PHC population, including local pharmaceutical performance. One of our strengths is our large-scale national datasets, based primarily on the National Health Facility Survey of 2019. Since the National Institute of Health Research and Development (Litbangkes) no longer exists, there is some doubt as to whether another survey will take place. Multiple national policies and academic publications have used this survey data since 2011. The operational cost of conducting the most recent survey was around IDR 150,000,000,000 (around EUR 8,600,000), which was very expensive. This cost can only be financed by the central government using the Indonesian national budget. This national survey must be continued to ensure that the performance of each local health system, including the local pharmaceutical system, can be properly monitored in the longer term.

Progress in the local pharmaceutical system can be studied by comparing data from the National Health Facility Surveys of 2011 and 2019. Analyses of these data can help us understand health development trends in the regions, provinces and districts and reveal which PHCs and areas improved significantly or made no progress in the intervening eight years. The results can be used to inform both national and local governments regarding which areas should be prioritised in the National Health System Transformation Agenda.

A further investigation into how PHCs in very isolated areas in Indonesia manage medicine availability would potentially deliver new insights regarding unintended mechanisms in ensuring community access. In our qualitative study, we collected data from Kupang district, a rural district in which all PHCs are classified as remote or very remote. We found that PHCs and DHOs here make trade-offs between local health system functions to ensure medicine availability, for example those in districts such as Aru and Southwest Maluku, which are very isolated from their provincial capital and where accessibility is more challenging. Flights to these districts are expensive and it takes days to reach them by ferry; as a result, medicine distribution is extremely expensive. The rainy season, with frequent heavy precipitation, rough seas and strong winds, hampers transport and increases isolation. An ethnographic study could capture how health workers there prepare the local system to cope with this difficulty during the rainy season.

Another possible ethnographic study would postulate the impact of health worker's subjectivity on how they manage medications for the entire year and on community access. In our qualitative study, I observed pharmacists deciding to prescribe partial dosages of necessary medicines or substituting one medicine for another. Most felt bad letting patients leave the PHC without a medicine. Elsewhere, a pharmacist wrote a prescription so that patients could buy medicines themselves or instructed the patient to return in a few days when they thought the medicines would be delivered. It is not clear what conditions in managing the medicine supply led to variations in the pharmacists' decisions. Research involving close observation of health workers' daily practices could provide a comprehensive picture of what shapes their beliefs and motivations.

My research has indicated the importance of the DHO in mediating between national and local policies in relation to medicine availability and I have made some recommendations for strengthening its role. Future studies could examine how to further improve the intermediary role of the DHO, or similar structures in other countries.

I would encourage researchers studying global health and pharmaceutical systems and policy to use the LoPhaS approach to examine variations in local system mechanisms ensuring access to medicines. In larger countries such as Brazil, China, India, and the USA, the role of local health systems is crucial to organising the supply of medication from the national level to local public health facilities [216]. In our study, we found that variations in the availability of essential medicines emerged between districts and local systems as they struggled to ensure community access to medication. A similar study in Afghanistan used this approach and reported variations at the provincial level, which were associated with the types of health service contracts managed by provincial health departments, as well as geographical challenges such as mountainous terrain and the risk of natural hazards, including avalanches, earthquakes, and flooding [111]. I believe that similarly unanticipated insights will emerge in other low-income countries concerning the extent to which the local pharmaceutical system can and cannot ensure access to medicines. Additionally, high-income countries can use this approach to understand specific medication contexts, such as medications for treating dementia or Alzheimer's, cardiovascular disorders and cancer.

Intervention studies should be driven by the health workers' need and capacity to manage medications locally. A baseline study is crucial to understanding the existing local system circumstances and should cover current health worker practices in ensuring their performance. Nevertheless, existing reports tend to describe the system outputs, such as medicine availability in specific time frames and system resource availability and fail to systematically address the changing behaviours of the health workers. This top-down approach delivers the data before the implementation or intervention phase, using it later to predict the system outcomes. In order to improve overall local system performance, however, researchers need to investigate health worker behaviours, which are shaped by their subjectivity, including their beliefs, current situation, and motivations. Our studies show that a local pharmaceutical system used pharmacists working at selected PHCs to manage medicine for another PHC that did not have a pharmacist on staff. The simple solution is to bring a pharmacist on board, but this may be unaffordable for the district budget and may also be unsustainable if the assistance provided by the central government or other entities is only temporary. A research proposal developing an intervention should take into account alternative policies for improving the system functions and discuss each policy's benefits, cost, and uncertainty. Potential barriers and changes in health worker practices should also be elaborated. Health workers in local systems should decide what interventions they can undertake, given their local situation.

Conclusion

Variations in access to medicines across Indonesia are shaped by the local system, including the local pharmaceutical system. This system is self-organising as it attempts to ensure its capacity to deal with external pressures, such as the national policy on essential medicines and a lack of internal resources. Our conceptual framework addresses the six core functions of the local system: 1) Local governance and stewardship; 2) Managing pharmaceutical product supply; 3) Financing; 4) Developing and sustaining human and physical resources; 5) Ensuring quality and promoting appropriate use; and 6) Monitoring performance. The availability of 17 prioritised essential medicines in PHCs across Indonesia was relatively high (82%). A further investigation of the availability of sixty selected medicines revealed lower availability (58%), and the rate varied across the regions but tended to be similar within a district and province. While challenges in geographical location, fiscal capacity, and community income hamper the provision of medicines, PHCs and districts that belong to better local pharmaceutical systems can still make an adequate supply of medicines available. Health workers in the field had one overriding goal in managing their medication supplies: ensuring a sufficient stock of medicines for their community. Pharmacists handled stockouts or limited stocks in various ways, and some of these efforts masked systemic problems, such as the absence of a pharmacist or a low level of competence, frequent medicine stockouts in the supply chain, and unclear instructions under the national policy. What is necessary is to improve the position of District Health Offices and the availability and performance of pharmacists. The LoPhaS model developed in this thesis can be used in other policies and research focusing on the availability of essential medicines.

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Thesis Summary: Systems in Between

Availability of essential medicines is one of the Sustainable Development Goals that underpins the World Health Organisation's efforts to assist countries in providing better access to medicines and achieving universal health coverage. Medicine availability is usually measured at the national level, but is often unequally distributed, especially within larger countries, such as India, China, Brazil, and Indonesia. Variations in regional capacities pose challenges to the national government's efforts to develop and bolster policies that balance the conflicting interests of all actors in ensuring access to medicines. For example, the value for money achieved in medicine procurement differs from one sub-national region to another, depending on their budgets and health programme priorities. The variation in public expenditure is one of the socioeconomic and geographical factors influencing access to medicines, which are often interconnected. Such variation may challenge a national policy with a single design from working well for all districts, because each district has different needs and capacities.

Existing frameworks to ensure access to medicines rarely focus on the organisation of medicine supply at more local levels within a country. Some of them propose a strong top-down approach, which might not be suitable for those larger countries. Others suggest a complex adaptive systems approach to improving access to medicines in LMICs, using a bottom-up approach, but fail to take into account variations in the health system, including health facilities and local governance. There is thus a need for an approach that allows for the layered nature of medicine supply, local and regional variations in resources, and geographical conditions, as well as reactions from the local healthcare system.

In this thesis, I aim to understand how local systems operating within a national system work to ensure equal access to medicines for all the citizens of the country. I argue that a local approach provides a better understanding of fundamental pharmaceutical system dynamics and challenges across a country, as it functions as a “system in between”. In Indonesia, decentralisation was implemented by delegating responsibility to local governments—including primary health centres (PHCs) and their associated District Health Offices (DHOs)—to manage the provision of medicines in public sector facilities. This thesis, therefore, focuses on understanding variations in the availability of essential medicines in PHCs in Indonesia and answers the main research question: “How do insights into the functioning of the local pharmaceutical system in Indonesia lead to a better understanding of efforts to improve access to medicines?”

We started our study by defining the local pharmaceutical system (LoPhas), as “All people, structures, resources, policies and interactions that ensure access to and appropriate use of medicine and related services at the local level to promote better health outcomes.” The six core functions of this system are: 1) Local governance and stewardship; 2) Managing pharmaceutical product supply; 3) Financing, i.e. securing and allocating funds; 4) Developing and sustaining human and physical resources; 5) Ensuring quality and promoting appropriate use; and 6) Monitoring performance. These functions have their operational elements or indicators, for example, a strategic vision for local governance of the pharmaceutical system and the accuracy of a medication forecasting plan used in managing pharmaceutical product supply. The conceptual framework also takes into account external factors such as local community health needs and socioeconomic, cultural, logistical, geographical, and security factors.

In my empirical research, I focused on medicine availability at the PHC level as an outcome of local pharmaceutical systems. In Indonesia, variation in essential medicine availability at PHCs was observed across the relevant essential medicines, groupings of medicines based on treatment categories, regions, and districts. In general, the median availability of most priority 17 medicines in the PHC baskets was 82%, indicating that the Indonesian government has largely succeeded in ensuring access to these medicines at the national level. However, the availability rating of a broader selection of 60 essential medicines at the national level dropped to 58%. Furthermore, there is significant variation in medicine availability, not only across PHCs but also across districts. The best-performing district achieves an average medicine availability of up to 83% across its PHCs, while others report rates as low as 43%. This variation aligns with our assumption, reinforcing the need to analyse and compare local pharmaceutical system performance.

In this thesis, four steps are followed that can guide the analysist to assess local pharmaceutical systems: (1) describing the formal organisation of the pharmaceutical system, (2) identifying connections between the elements in local pharmaceutical systems, (3) exploring dynamics within local pharmaceutical systems, and (4) integrating all insights.

The first step is to describe the formal organisation of the pharmaceutical system in terms of the actors involved, the relations between multiple actors, and their functions in managing medicines within multilayers of governance in Indonesia. The more than 10,000 PHCs and their medicine supply are organised by their associated DHO. The DHO procures most of the medicines and distributes them, based on each PHCs demand. The central government supplies medicines for TB, HIV, and malaria, with the DHO being prohibited from procuring these. If the DHO fails to deliver the medicines needed, the PHC may use its own limited financial resources to procure medicines, with the DHO's approval. The total of 514 DHOs play a key role in promoting the national agenda to improve access to medicine for all Indonesians.

The second step is to identify connections between the elements in local pharmaceutical systems. We found that availability tends to be lower at PHCs in geographically disadvantaged areas or in socioeconomically underprivileged communities. Nevertheless, PHCs in areas with better LoPhaS capacity have a higher medicine availability rate compared to those in other areas. Focusing on improving local pharmaceutical performance might therefore reduce the gap caused by variations in local geographical and community circumstances. Three main features of the system played significant roles in improving the availability of medications: managing physical and human resources, managing the medicine supply chain, and financing. On another level, both positive and negative associations were found between DHOs and the availability of medicines at PHCs. Variation in the supply of medicines in PHCs' baskets tends to be similar to that of their DHO, indicating that PHCs depend heavily on their DHO. A surprising finding is the negative association between DHOs that quantified their medicine demand and procured their medicines through the e-catalogue and lower essential medicine availability at their PHCs. These findings indicate that further research is needed into how DHOs quantify and procure their medicines based on their plan. In addition, the availability of medicines at a PHC could be predicted by medicine availability at their nearest neighbour, other PHCs within its district, and other PHCs outside its district but within the same province.

The third step is to explore dynamics within local pharmaceutical systems. The findings of our in-depth qualitative analysis showed health worker practices in managing the availability of essential medicines. These practices may be consistent or inconsistent with national policy. The three main reasons for medicines not being available in PHC baskets are the confusing nature of national policy instructions, undersupply by the medicine markets, and pharmacist availability and competence. Some pharmacists coped with unavailability by buying medicines with their own money, writing prescriptions for patients to purchase out-of-pocket, or switching them to substitute medicines at a higher dosage. Since they utilised these coping mechanisms routinely, they never reported the actual problem, i.e., the unavailability of essential medicines, which then went unnoticed and remained unresolved.

The last step is to integrate all insights to understand the implications of the research findings. Our research provides valuable insights into how the theory of complexity can be applied in local pharmaceutical systems and policymaking, the practicality of healthcare routines in Indonesia, and a future research agenda in pharmaceutical policy and practice.

In seeking to understand access to medicines in Indonesia, I applied complexity theory to the local pharmaceutical system by developing my approach, exploring the component elements of a local system, how these elements are interconnected and impact system performance, and making sense of progress and achievements. The multiple elements in local pharmaceutical systems enter into unique relationships in managing medicine provision because they interact with other elements within and outside the system.

The main contribution of this thesis to improving access to medicines is our critical approach to developing a model for local pharmaceutical systems, which fills a gap in the academic literature and in pharmaceutical policy and practice. In addition, our empirical studies made a number of other contributions. The first is the finding that a local pharmaceutical system is a self-organising entity that functions as an individual system embracing its own local context. The health system in a district is already shaped by its geographical, demographic, financial, and community status, and the pharmaceutical system must understand this existing context in order to perform well. Our second contribution is the finding that repair work and coping mechanisms are important in ensuring the local system's ability to meet its goal. Self-organisation and coping mechanisms are two related characteristics showing a system's independence and sustainability. The third contribution is the finding that a local system can adjust its role to ensure proper performance, but only under specific conditions. One condition is that the pharmacist must play a critical role in managing medicines. The fourth contribution is the finding that local pharmaceutical systems are able to put one of their core functions on hold in order to achieve their mission of ensuring access to medicines. For example, a local system can decide on a trade-off whereby it maximises its budget allocation and compromises on performance monitoring. The final contribution of our research is that it demonstrates that individual PHCs within a local pharmaceutical system perform similarly.

Our study on variations in medicine availability in Indonesia offers useful insights for actual practice that are presented as study recommendations. Firstly, national policymakers should simplify the National Essential Medicines List (NEML) while also allowing for variations in local medication demand. Secondly, Indonesia’s national Health System Transformation Agenda should incorporate efforts to strengthen the DHO's role in directing, managing, monitoring, and empowering the elements that make up the local health system. Thirdly, educational institutions and the pharmacists' professional association need to play an active role in developing more practical course materials for the local programme. Fourthly, the central government should reorganise the current reporting system by integrating it into a district health system and allowing DHOs to access PHC data. Fifthly, the national agenda needs to boost local pharmaceutical system resilience to better manage unpredictable market dynamics by building awareness of which disruptions occur when, and how they impact medicine supply and by responding to crises caused by natural disasters. Lastly, a national pooled procurement mechanism to ensure adequate medicine supply to remote regions that lie outside Java and Bali might be a policy alternative to make those regions more attractive to the medicine markets.

Thesis Summary: Systems in Between In Dutch

De beschikbaarheid van essentiële geneesmiddelen is een van de Duurzame Ontwikkelingsdoelen die ten grondslag liggen aan de inspanningen van de Wereldgezondheidsorganisatie om landen te ondersteunen bij het verbeteren van de toegang tot geneesmiddelen en het realiseren van universele gezondheidsdekking. De beschikbaarheid van geneesmiddelen wordt doorgaans op nationaal niveau gemeten, maar is vaak ongelijk verdeeld, vooral in grotere landen zoals India, China, Brazilië en Indonesië. Verschillen in regionale capaciteit vormen een uitdaging voor nationale overheden bij het ontwikkelen en versterken van beleid dat de uiteenlopende belangen van alle betrokken actoren in het waarborgen van toegang tot geneesmiddelen in evenwicht moet brengt. Zo varieert de kosteneffectiviteit van geneesmiddeleninkoop tussen subnationale regio's, afhankelijk van beschikbare budgetten en prioriteiten binnen gezondheidsprogramma's. Variaties in overheidsuitgaven behoren tot de sociaaleconomische en geografische factoren die de toegang tot geneesmiddelen beïnvloeden en die vaak onderling samenhangen. Dergelijke verschillen kunnen ertoe leiden dat nationaal beleid met een uniforme opzet niet in alle districten effectief functioneert, aangezien elk district beschikt over eigen behoeften en capaciteiten.

Bestaande beleidskaders voor het waarborgen van toegang tot geneesmiddelen richten zich zelden op de organisatie van de geneesmiddelenvoorziening op meer lokale niveaus binnen een land. Sommige kaders hanteren een sterke top-downbenadering, die mogelijk minder geschikt is voor grotere landen. Andere benaderingen stellen een kader van complex adaptieve systemen voor om de toegang tot geneesmiddelen in lage- en middeninkomenslanden te verbeteren via een bottom-up benadering, maar houden onvoldoende rekening met variaties binnen het gezondheidszorgsysteem, waaronder verschillen tussen zorginstellingen en lokale bestuursvormen. Er bestaat daarom behoefte aan een benadering die recht doet aan het gelaagde karakter van de geneesmiddelenvoorziening, aan lokale en regionale verschillen in middelen en geografische omstandigheden, en aan de reacties van het lokale zorgsysteem.

In dit proefschrift beoog ik inzicht te krijgen in de wijze waarop lokale systemen die binnen een nationaal systeem opereren functioneren om gelijke toegang tot geneesmiddelen voor alle burgers te waarborgen. Ik betoog dat een lokale benadering beter inzicht biedt in de fundamentele dynamiek en uitdagingen van het farmaceutische systeem in een land, omdat zij fungeert als een “systeem daartussenin”. In Indonesië is decentralisatie doorgevoerd door verantwoordelijkheden te delegeren aan lokale overheden—waaronder eerstelijnsgezondheidscentra (Primary Health Centres, PHC’s) en de daarbij behorende District Health Offices (DHO’s)—voor het beheer van de geneesmiddelenvoorziening in openbare zorginstellingen. Dit proefschrift richt zich daarom op het begrijpen van variaties in de beschikbaarheid van essentiële geneesmiddelen in PHC’s in Indonesië en beantwoordt de centrale onderzoeksvraag: “Hoe dragen inzichten in het functioneren van het lokale farmaceutische systeem in Indonesië bij aan een beter begrip van inspanningen om de toegang tot geneesmiddelen te verbeteren?”

Wij zijn onze studie gestart met het definiëren van het lokale farmaceutische systeem (Local Pharmaceutical System, LoPhas) als: “alle personen, structuren, middelen, beleidsmaatregelen en interacties die op lokaal niveau zorgen voor toegang tot en gepast gebruik van geneesmiddelen en aanverwante diensten, met als doel betere gezondheidsuitkomsten te bevorderen.” De zes kernfuncties van dit systeem zijn: 1) lokaal bestuur en sturing en toezicht (stewardship); 2) beheer van de levering van farmaceutische producten; 3) financiering, namelijk het veiligstellen en toewijzen van middelen; 4) ontwikkeling en instandhouding van menselijke en fysieke hulpbronnen; 5) kwaliteitsborging en bevordering van gepast gebruik; en 6) monitoring van functioneren. Deze functies beschikken over operationele elementen of indicatoren, zoals een strategische visie op het lokale bestuur van het farmaceutische systeem en de nauwkeurigheid van een medicatieprognoseplan dat wordt gebruikt bij het beheer van de levering van farmaceutische producten. Het conceptuele kader houdt daarnaast rekening met externe factoren, waaronder lokale gezondheidsbehoeften en sociaaleconomische, culturele, logistieke, geografische en veiligheid gerelateerde omstandigheden.

In het empirisch onderzoek is de beschikbaarheid van geneesmiddelen op het niveau van de PHC’s onderzocht als uitkomst van lokale farmaceutische systemen. In Indonesië werd variatie waargenomen in de beschikbaarheid van essentiële geneesmiddelen in PHC's, zowel tussen verschillende essentiële geneesmiddelen, tussen groepen geneesmiddelen op basis van behandelingscategorieën, als tussen regio's en districten. Over het algemeen bedroeg de mediane beschikbaarheid van de meeste van de zeventien prioritaire geneesmiddelen in de PHC-pakketten 82%, wat erop wijst dat de Indonesische overheid er op nationaal niveau grotendeels in is geslaagd de toegang tot deze geneesmiddelen te waarborgen. De beschikbaarheids van een bredere selectie van zestig essentiële geneesmiddelen op nationaal niveau daalde echter tot 58%. Daarnaast bestaat er substantiële variatie geneesmiddelenbeschikbaarheid, niet alleen tussen PHC's, maar ook tussen districten. Het best presterende district bereikt een gemiddelde beschikbaarheid van maximaal 83% over zijn PHC's, terwijl andere districten percentages van slechts 43% rapporteren. Deze bevindingen benadrukken de noodzaak om de prestaties van lokale farmaceutische systemen systematisch te analyseren en onderling te vergelijken.

In dit proefschrift worden vier stappen onderscheiden die richting geven aan de beoordeling van lokale farmaceutische systemen: (1) het beschrijven van de formele organisatie van het farmaceutische systeem; (2) het identificeren van verbanden tussen de elementen binnen lokale farmaceutische systemen; (3) het verkennen van de dynamiek binnen deze systemen; en (4) het integreren van alle verkregen inzichten.

De eerste stap bestaat uit het beschrijven van de formele organisatie van het farmaceutische systeem, met betrekking tot de betrokken actoren, de onderlinge relaties en hun functies bij het beheer van geneesmiddelen binnen de verschillende bestuurslagen in Indonesië. De meer dan 10.000 PHC's en hun geneesmiddelenvoorziening worden georganiseerd door de bijbehorende DHO's. Deze DHO's kopen het merendeel van de geneesmiddelen in en distribueren deze op basis van de vraag van elke PHC. De centrale overheid levert geneesmiddelen voor tuberculose, hiv en malaria;het is DHO's niet toegestaan deze geneesmiddelen zelf in te kopen. Indien een DHO er niet in slaagt de benodigde geneesmiddelen te leveren, kan een PHC, met goedkeuring van de DHO, gebruikmaken van haar eigen beperkte financiële middelen om geneesmiddelen aan te schaffen. In totaal spelen de 514 DHO's een sleutelrol bij het bevorderen van de nationale agenda om de toegang tot geneesmiddelen voor alle Indonesiërs te verbeteren.

De tweede stap betreft het identificeren van verbanden tussen de elementen binnen lokale farmaceutische systemen. De beschikbaarheid van geneesmiddelen blijkt doorgaans lager te zijn in PHC's die zich bevinden in geografisch achtergestelde gebieden of sociaaleconomisch kwetsbare gemeenschappen. Daarentegen vertonen PHC's in gebieden met een sterkere LoPhas-capaciteit een hogere geneesmiddelenbeschikbaarheid. Een gerichte verbetering van de prestaties van lokale farmaceutische systeem kan derhalve bijdragen aan het verkleinen van de kloof die voortvloeituit verschillen in lokale geografische en maatschappelijke omstandigheden. Drie kernkenmerken van het systeem bleken hierbij van doorslaggevend belang: het beheer van fysieke en menselijke hulpbronnen, het beheer van de geneesmiddelenvoorzieningsketen en de financiering. Op een ander niveau werden zowel positieve als negatieve verbanden vastgesteld tussen DHO's en de beschikbaarheid van geneesmiddelen in PHC's. De variatie in geneesmiddelenbeschikbaarheid in de PHC-pakketten vertoont doorgaans sterke overeenkomsten met die van hun DHO, wat wijst op een hoge mate van afhankelijkheid tussen PHC's en hun DHO. Een opvallende bevinding is de negatieve samenhang tussen DHO's die hun geneesmiddelenbehoefte kwantificeerden en hun geneesmiddelen via het e-catalogussysteem inkochten, en een lagere beschikbaarheid van essentiële geneesmiddelen in hun PHC's. Deze bevindingen wijzen op de noodzaak van verder onderzoek naar de wijze waarop DHO's hun geneesmiddelenbehoefte plannen, kwantificeren en inkopen. Daarnaast kon de beschikbaarheid van geneesmiddelen in een PHC worden voorspeld op basis van de beschikbaarheid bij de dichtstbijzijnde PHC, bij andere PHC's binnen hetzelfde district en bij PHC's buiten het district maar binnen dezelfde provincie.

De derde stap richt zich op het verkennen van de dynamiek binnen lokale farmaceutische systemen. De resultaten van onze diepgaande kwalitatieve analyse laten zien hoe zorgverleners in de praktijk omgaan met het beheer van de beschikbaarheid van essentiële geneesmiddelen. Deze praktijken kunnen in overeenstemming zijn met het nationale beleid, maar er ook van afwijken. De drie belangrijkste oorzaken van het ontbreken van geneesmiddelen in PHC-pakketten zijn de verwarrende aard van nationale beleidsinstructies, onderaanbod vanuit de geneesmiddelenmarkt en de beschikbaarheid en deskundigheid van apothekers. Sommige apothekers gingen met deze onbeschikbaarheid om door geneesmiddelen met eigen middelen aan te kopen, recepten uit te schrijven zodat patiënten deze zelf konden aanschaffen, of patiënten over te zetten op substitutiegeneesmiddelen met een hogere dosering. Doordat dergelijke copingmechanismen routinematig werden toepasten, werd het daadwerkelijke probleem—namelijk de onbeschikbaarheid van essentiële geneesmiddelen—niet gerapporteerd, waardoor het onopgemerkt en onopgelost bleef.

De laatste stap bestaat uit het integreren van alle inzichten om de implicaties van de onderzoeksbevindingen te duiden. Ons onderzoek biedt waardevolle inzichten in de toepassing van complexiteitstheorie lokale farmaceutische systemen en beleidsvorming, in de praktische realiteit van zorgroutines in Indonesië, en in een toekomstige onderzoeksagenda voor farmaceutisch beleid en praktijk.

In het streven naar een beter begrip van de toegang tot geneesmiddelen in Indonesië heb ik de complexiteitstheorie toegepast op het lokale farmaceutische systeem door een analytische benadering te ontwikkelen, de samenstellende elementen van een lokaal systeem te onderzoeken, te analyseren hoe deze elementen met elkaar samenhangen en de systeemprestaties beïnvloeden, en betekenis te geven aan de geboekte vooruitgang en resultaten. De verschillende elementen binnen lokale farmaceutische systemen gaan unieke relaties aan bij het beheer van de geneesmiddelenvoorziening, doordat zij interageren met andere elementen binnen en buiten het systeem.

De belangrijkste bijdrage van dit proefschrift aan het verbeteren van de toegang tot geneesmiddelen is onze kritische benadering bij de ontwikkeling van een model voor lokale farmaceutische systemen, waarmee een lacune wordt opgevuld in zowel de academische literatuur als in het farmaceutisch beleid en de praktijk. Daarnaast hebben onze empirische studies meerdere aanvullende bijdragen geleverd. Ten eerste tonen zij aan dat een lokaal farmaceutisch systeem een zelforganiserende entiteit is die functioneert als een afzonderlijk systeem, ingebed in zijn eigen lokale context. Het gezondheidssysteem binnen een district wordt reeds gevormd door geografische, demografische, financiële en maatschappelijke kenmerken; het farmaceutische systeem moet deze bestaande context begrijpen om effectief te kunnen functioneren. Ten tweede blijkt dat herstelwerk en copingmechanismen van groot belang zijn voor het vermogen van het lokale systeem om zijn doel te bereiken. Zelforganisatie en copingmechanismen zijn samenhangende kenmerken die de onafhankelijkheid en duurzaamheid van een systeem weerspiegelen. Ten derde laat ons onderzoek zien dat een lokaal systeem zijn rol kan aanpassen om goede prestaties te waarborgen, maar uitsluitend onder specifieke voorwaarden, waaronder een centrale rol voor de apotheker in het beheer van geneesmiddelen. Ten vierde blijkt dat lokale farmaceutische systemen in staat zijn één van hun kernfuncties tijdelijk op te schorten om hun missie—het waarborgen van toegang tot geneesmiddelen—te realiseren. Zo kan een lokaal systeem bijvoorbeeld kiezen voor een beleidsafruil waarbij het de budgetallocatie maximaliseert ten koste van prestatiemonitoring. Tot slot toont ons onderzoek dat individuele PHC's binnen een lokaal farmaceutisch systeem vergelijkbare prestaties leveren.

Onze studie naar variaties in de beschikbaarheid van geneesmiddelen in Indonesië biedt waardevolle inzichten voor de praktijk, geformuleerd als onderzoek aanbevelingen. Ten eerste zouden nationale beleidsmakers de Nationale Lijst van Essentiële Geneesmiddelen (National Essential Medicines List, NEML) moeten vereenvoudigen, met behoud van ruimte voor variatie in lokale geneesmiddelenvraag. Ten tweede zou de nationale agenda voor de transformatie van het Indonesische gezondheidssysteem inspanningen moeten omvatten om de rol van de DHO's te versterken bij het aansturen, beheren, monitoren en ondersteunen van de elementen waaruit het lokale gezondheidssysteem bestaat. Ten derde dienen onderwijsinstellingen en de beroepsvereniging van apothekers een actieve rol te spelen bij de ontwikkeling van meer praktijkgerichte onderwijsmaterialen voor lokale opleidingsprogramma's. Ten vierde zou de centrale overheid het huidige rapportagesysteem moeten herstructureren door dit te integreren in het districtsgezondheidssysteem en DHO's toegang te geven tot gegevens van PHC's. Ten vijfde dient de nationale agenda de veerkracht van lokale farmaceutische systemen te versterken om beter om te gaan met onvoorspelbare marktdynamiek, door inzicht te vergroten in het optreden en de impact van verstoringen in de geneesmiddelenvoorziening en door adequaat te reageren op crises als gevolg van natuurrampen. Tot slot kan een nationaal mechanisme voor gezamenlijke inkoop worden overwogen om een adequate geneesmiddelenvoorziening te waarborgen voor afgelegen regio's buiten Java en Bali, als beleidsalternatief om deze regio's aantrekkelijker te maken voor de geneesmiddelenmarkt.

Ucapan Terimakasih – Dankbetuiging – Acknowledgements

Saya berterima kasih kepada Lembaga Pengelola Dana Pendidikan atas kesempatan yang diberikan kepada saya melalui beasiswa Afirmasi Daerah untuk melanjutkan pendidikan saya di Belanda selama empat tahun.

I would like to thank my supervisors for their commitment and guidance as part of my supervisory team: Roland Bal, Ari Probandari, and Maarten Kok, who patiently trained and guided me in finalising my trajectory and writing this book.

Roland is a truly inspirational figure, a professor who understands my struggles and strengths in writing and in enduring the Dutch weather (tell me about it). He challenges the typical image of a healthcare professor, who is often seen as being served like a king. He asked me, “What guidance do you need from us?” Even though I responded with a smile, I was at a loss for words because I wasn't prepared for that million-euro question. As someone accustomed to working as a junior researcher at a research centre affiliated with a faculty of medicine in Indonesia, it is a must to follow what senior researchers, especially those designated as professors, say. It took me many weeks to clearly define my expectations for this PhD journey: to become an independent thinker who prioritizes the public as beneficiaries in the healthcare system over simply praising theories, global health agendas and national policies. After working more with Roland, I have found that he continues to emphasize the importance of understanding health workers' experiences and motivations to truly grasp their practices. As he positioned the community as the centre of

knowledge, Roland took a similar approach by making me the focus of this PhD capacity-building program, and to be fair, this approach is needed in a global health setting. This PhD journey is not easy, but I am grateful to have Roland as my promotor. I will keep asking him, “When will you visit us in Indonesia?” until he does it.

Maarten, I want to thank you for being my daily supervisor and tracking my progress since we first met. You took the risk of accepting me as a PhD student— that was a gamble. You consistently push me to go beyond my limits in research and thinking to help me grow, and you lift me up when I'm down. For example, you once mocked my beautiful graph by calling it “Embus' b****,” but you've also allowed me to travel to Indonesia once a year for nearly six months multiple times. You've done a great job. During this coaching period, you gave me the flexibility to challenge your ideas, and you constantly challenged mine, which has made me more confident about what I know, what I still need to learn, and when to end a conversation and my curiosity with "I don't want to know." This flexibility has a side effect, so please don't be surprised if you hear that I've started to show some rebelliousness lately, especially when nonsense is involved—haha. In addition, since “simple is gold” is your motto, ensuring that my work is understandable to 11-year-olds has never been easy. In other words, it means that we should not be lazy about ensuring our audience understands what we are trying to say. Still, we await further collaborations in Indonesia.

Prof Ari, Bu Ari, saya berterimakasih atas dukungan Bu Ari selama proses pendidikan doktoral ini. Terimakasih sudah menjadi penengah dan penenang saat ketiga pria ini berdiskusi yang kadang agak panas dan pemberi saran praktis untuk penyelesaian studi ini. Maafkan jika dalam satu minggu Ibu harus bertemu dengan saya dan Ucha dalam acara penelitian yang berbeda. Bagi saya, Bu Ari selalu punya jalan anti ribet untuk menyelesaikan suatu masalah, dan terbukti, saat masih bimbang dengan paper kualitatif saya, saya pergi ke UNS dan pulang bawa manuscript yang siap disubmit. Tolong jangan bosan-bosan yah Bu, untuk selalu mentoring saya (dan juga istri saya), karena sepertinya akan banyak kerjaan kolaborasi kita bersama. Roland, Maarten dan Saya selalu berterimakasih kepada Bu Ari, yang rela ikut rapat pada jam 9.00 malam, ataupun saat berkendara pulang ke rumah. Saya sangat bangga mengatakan kepada orang Indonesia yang bertanya kepada saya, siapa mentor kamu dari Indonesia, dengan jawaban Prof Ari Probandari dari UNS.

I also thank you for the opportunity to present my PhD research findings to renowned professors and scholars specialising in access to medicine and universal health coverage. To Prof Aukje, Prof Ghufron, and Dr. Harwin de Vries, thank you for taking the time, and I hope we can collaborate to strengthen the global pharmaceutical management system to better ensure access to medicines for those in need the most. Professor Raffaella has been incredibly helpful, especially with the paper on the conceptual local pharmaceutical system. Unfortunately, we had to delay my postdoctoral fellowship because I have not received my degree yet. The pharmaceutical policies course in health systems was very valuable in shaping my core understanding of pharmaceutical systems. I hope that the collaboration we are building will secure funding as expected.

Prof Matthias, thank you for visiting me at UGM. I hope there will be another chance to meet. I remember I was confused after being chosen as a student representative to assess your professorship, and later, you evaluated my eligibility for a PhD degree. I hope I did well on my assessment and defence. You give me the impression of being a fun professor, and I do believe you can help ESHPM further contribute to the Global Health theme.

I'd like to take a moment to mention Susan, who has been incredibly busy assisting me during my time here at EUR. Her dedication in preparing the scholarship letter, finding Roland's available time when he was still head of the department, arranging my meetings, and so much more truly means a lot. I noted and am still giggling at some funny moments—like the time we watched a movie together, and I confused the day for the first movie time, or when I arrived on time, but still ended up 20 minutes late to the gate the second time (I asked someone willing to help, but they were very slow and didn't know what to do). Please trust me, I was trying to fix my first mistake, but I ended up making another in the second trial. When I first arrived in Rotterdam, I felt so welcomed, especially one Friday when you told Omar and me, "have a nice weekend and behave," which made me pause for a moment. I wondered, “Do I act inappropriately?” or “Do my clothes not meet academic standards here?” I asked Amalia and Kyra about it. Kyra explained that older Dutch people often tell young relatives to behave at the end of the week because they tend to go wild. That kindness meant a lot to me. And please don’t worry if you misspell my name with just one “S”; honestly, Indonesians often do worse—they butcher add, erase, or change a letter without hesitation, based on their preference.

Hester, thank you very much for continuously fostering the warm spirit of HCG, just like the vibes you always bring to the group, so I don’t feel lonely there. Meanwhile, the group itself is very system-oriented towards the Dutch healthcare system, yet you still appeared in our global health meeting about Indonesia and welcomed Prof Ari. When I was asked to represent students in evaluating Professor Matthias and had no guidance, you were willing to discuss it. The most touching event for me was when you tried to support me in a particular opportunity to stay at ESHPM, even though in the end it wasn’t for me; that effort has represented a very positive sign in my heart. I hope we can work together, both within and outside the EUR system. At the same time, I would like to thank our senior colleagues, Iris, Diana, Ian, Anne Margriet, Lieke, Jan Willem, Rik, Marcello, Martijn, Bert, Kor, Marjolijn, Jitse, Josje and Violet, who have been incredibly active in building a very constructive discussion during Monday's meeting. I have learned a lot.

I will continue this expression of gratitude to my PhD colleagues in healthcare governance. Amalia, Kyra, Jolien, Runnah, Roman and Jonathan – stories with you will be shared elsewhere. When I first arrived at HCG, besides being greeted by Roland and Maarten, I was welcomed by Koray, who was willing to be bothered by me with many appointments on WhatsApp. Several consultations I had with you to understand how to handle difficult situations were very helpful to me. Believe me, long before you told the group that you and Tessa were dating, I already knew, as I always sat next to the toilet, your meeting point. Tessa is the coolest PhD at HCG working at the Ministry of Health.

Next, I would like to thank Celine for helping to review my abstract for the International Health Economics Conference. The abstract was accepted, and the paper is currently being submitted to a journal. Wish us luck. Celine is also a very energetic person and is always there for the HCG friends. Wies, a study buddy from the GIZ course, who after finishing the course reviewed the material and tried the exercises together, was very helpful. Nando and Lot arrived at the same time. For Nando and Lot who arrived at the same time, we remember that Nando was very patient with his jujitsu training, while Lot gave the reason why we had to go to Groningen, which was to see and hug cows. The conversation arose when we were talking about Groningen, and I expressed that I wanted to go there, but didn't have a strong enough reason yet. Fenna, who attended the public speaking course with me, although for me it was a random decision, I am happy with the knowledge and skills I gained. Having you there was helpful and it made the course more fun. Laura D B and Estella also arrived at the same time with personalities that are very cheerful and fancy at the same time. Iris and Renne, who are always warm and yet can give a chill, were always observing the dynamics during our lunch and would stop friends when the conversation has gone too far in Dutch. This gesture meant a lot to me, at least having the feeling of being included, and most importantly, both of you are very fun friends. Sabrina, I thank you for being our Indonesian ally in the department. I hope you are still considering moving to Bali as a villa owner and maybe a scholar too if you find a suitable job there. Sydney, our American friend, knows a lot about conducting qualitative studies. Ghis was the first PhD student whom I saw in my first week of arriving in the Netherlands, and we talked about Indonesia and Brussels for a while. Oemar, the young pastor in ESHPM, thank you for constantly reminding me to have a grateful attitude towards the Creator. Gigi and Milan who came to evaluate the vegan kapsalon rendang, I do thank you. Syb consistently brings positive vibes with a lot of smiles and laughter to random discussions, including flying to Australia with a baby. Nada always works very hard but still has time to chat about life. Thank you for introducing the Moroccan dishes; they were incredibly delicious. Hugo, thank you for taking us to the station from Jonathan's housewarming party. Yaël, thank you for the card. It’s extra work, but it’s very meaningful and moving. Richard, another Christian who is very friendly to me as we talked a lot of random stuff. Jana, congratulations on Baby Siem. Although your journey will be more challenging, it will be worth it. Karin exemplifies this; she navigates her journey smoothly and rarely appears stressed. Discussing our child(ren) is a helpful way to cope and endure this experience. Thank you, Karin, for being a role model and sharing that balancing motherhood and a PhD is challenging, which helps me appreciate and better prepare for my wife's PhD journey.

Chiara, you're a vibrant magnet with an extraordinary fashion style. Your bright yellow hair caught my eye when I first meet you. "During our meeting, people said that because there is Embus, we need to speak in English, do you experience that?" I asked, and you replied, "yeah, shouldn't they do it without putting us on the spot?" At that moment, I knew we were on the same page. Margot, you are one of the most patient colleagues and are always there for those who need you, especially during lunchtime. With a great sense of humour yet very professional, you navigated your way through street-level bureaucracy. Although I am not surprised, as you deserve, I'm happy to know that you already landed a position at Leiden University, as you often say, "Mother is calling." You will be a fantastic professor. Lizette is a lovable girl who is very knowledgeable, fun, and always genuine about yourself. I remember you said to Edoardo, "We call Italy garlic country," and it cracked me up, honestly. Hahaha. You constantly showed your care for us as your friends, and we talked a lot, especially during Chiara's defence party. It was so fun. For Robert, thank you for talking and for searching for GH opportunities for me, and for bravely asking for the missing opportunity. You are very kind.

To my friends in global health at Erasmus, thank you Igna for the opportunity to present “One Decade of Implementation of Universal Health Coverage in Indonesia” at the International Health Economics Association. I am very pleased to have contributed to this major event and still look forward to our other gatherings. To Maria Mendoza-Jimenez and Karen Trujillo Jara, who bring bright colours to global health, I am happy to have made friends with you. Also, to Amal, even though you decided not to continue, I am very glad to have met you, especially given your strong conviction about what you want to achieve. I know you will have something better in the future.

To my external PhD friends, Wenxing Wang, Lujia Sun, and Wenran Xia, we are colleagues within the system, where we are neither students nor employees with payslips. Sharing with you strengthened me in many aspects, especially regarding the identity crisis we experience as PhD students. People know, they talk, but they do not feel the gratitude for the opportunity to pursue a PhD degree in the Netherlands and hear about some internal privileges of PhD students that we could not access, for example the NS business card. We had limited living allowances and still needed to pay for them. However, I notice that you never complained about that. I believe all of you will have a bright future.

Thank you to another amazing person from another university. I thank you, Trynke, who is always humble and there while waiting for Maarten, and for visiting UGM several times in Indonesia. Unfortunately, during your last visit, we did not meet because I was in Sumba. Next time, for sure, we will meet, and we need to implement our idea to conduct research on people with disabilities. Personal note, you once said to Maarten, “sometimes I don’t know whether you are serious or joking,”. Maarten is just being Maarten. To Rik Lubber, Nikki, and Wouter, I am happy to know that you had a good time during the internship with Maarten and me. Our papers have been published. I am glad to have had the opportunity to explore many angles in our analyses. And overall, good luck with your current jobs. To Margo from KIT, thank you for your help in shaping my quantitative papers. I hope that during your sabbatical leave, you had fun and found the things you like. Good luck with your PhD, too.

Tak lupa saya ucapkan terimakasih untuk Pak Andre selaku Direktur PKMK dan Kaka Shita Dewi yang memberikan ruang untuk saya belajar menjadi peneliti. Semua kesempatan baik dan Kerjasama yang pernah dilakukan tentunya membentuk pola pikir dan cara kerja saya. Terlebih untuk Mba Shita yang sangat peduli terhadap anak-anak ini. Untuk Kaka Likke yang merekrut saya, terimakasih atas kesempatan ini,

Terimakasih juga saya ucapkan kepada Prof Laksono yang telah memberikan dukungan dalam penulisan paper dan projek-projek terkait Jaminan Kesehatan Nasional yang membentuk pola pikir saya terkait ekuitas dalam sistem kesehatan dan memahami begitu besar perannya pemerintah daerah. Untuk Pak (Prof) Mub, terimakasih sekali terus percaya dan mendorong saya untuk terus maju termasuk mencari sekolah. Oleh karena surat rekomendasi dari Pak Prof saya berhasil mendapatkan LPDP meskipun Bapak tidak berharap saya menyelesaikan studi saya ke Belanda. Hormat selalu saya berikan kepada Bapak yang dengan ketulusan hati memberikan waktunya untuk anak-anak yang hilang arah. Terimakasih untuk arahannya dan dorongan-dorongan berarti tersebut.

Saya juga mengucapkan terimakasih kepada rekan tim Inklusi saya, Bu Siwi, yang awalnya dari dosen pembimbing dua waktu tesis master saya, dan menjadi Principal Investigator untuk proyek tiga tahun tersebut. Mari kita doakan bersama untuk penulisan paper-paper dari proyek tersebut berjalan mulus dan kita dapat banyak belajar juga dari proses publikasi tersebut. Untuk Mba Tri, terimakasih sudah sabar menanggapi kemauan saya dalam menjalankan riset tersebut, kamu luar biasa dan saya menunggu dirimu kembali dengan PhD dengan waktumu sendiri. Terimakasih untuk teman peneliti lainnya: Naufal, Garin, Karlina, Nita, Mas Yoga, Ika (nanti lagi), Mas Faozi, dan Mba Dina, terimakasih sekali untuk kerja kerasnya.

Untuk Mba Monita selaku kepala divisi Public Health, terimakasih sudah terus melibatkan saya dalam pembicaraan terkait pengembangan divisi. You are doing a very good job. Terimakasih paling banyak juga saya berikan kepada Mba Andri yang telah membantu saya dalam banyak project. Saatnya kita mencari momen untuk pergi ke Happy puppy lagi Kak. Mba Mentari, selamat menikmati perjalanan program doktornya.

Mba Lely, Mba Wiwid, Mba Via, Mas Irvan, Mas Yulis, Mas Agus, Mba Edna, Mba Ega, Mba Ratri, The Euis, Mba Abi, Mba Latifah, Mba Ibeth, Bu Putu, Mas Fajrul, Mas Barkah dan teman-teman lain yang belum sempat saya ingat satu persatu. Terimakasih sudah menunjukkan komitmen kerja keras untuk PKMK dan memberikan suasana kantor yang hangat dan kompak.

Amalia, I am very proud to say that you are not only my friend but also my sister. We experienced difficulties in our PhDs journey together. Although, kamu selalu bilang bahwa doa ibumu supaya kamu kuat menghadapi PhD ini adalah dengan adanya teman sejawat yang peduli dan salah satunya adalah pria dari timur ini, kami juga adalah jawaban dari doa semua jemaat gerejaku untuk dapat menyelesaikan PhD ini. Aku ingat saat pertama kali diminta Maarten untuk menghubungi dirimu dengan memanggilmu “Bu Amalia” (manner matters) dan kamu langsung memberikan nomor WhatsApp kamu ke diriku. To be honest, pertama kali aku ketemu dirimu online, bahkan mencari tahu informasi terkait dirimu lewat google, aku terdiam, dan berkata dalam hati “Matilah aku kalau standar PhDnya Erasmus dan Maarten adalah Amalia Hasnida”. Starting point yang sangat berbeda antara kita berdua, dimana kamu starting dari poin 6 jika aku mulai dari 1, apalagi kalau kita lihat perbedaan metode dalam proyek PhD kita. Terlibat sebagai Mystery Shopper dalam proyek Risk Flaggingmu memberikan kesempatan lari dari metode riset tradisional, dan aku sangat menyukainya. Seringkali, kamu meragukan dirimu sebelum tampil di acara tertentu, terlebih sidang PhD aku dengan berkata “Embus, mudah-mudahan aku gak pepesan kosong”, humble is important, tapi jangan pernah ragu dengan kemampuan akademik dirimu. Momen-momen terbaik kita adalah berbicara Bahasa Indonesia di kantor – We talked about a lot of things. Kita melalui banyak tantangan dan kesempatan bersama termasuk ke Uthrect, dan Bogota untuk bertemu teman-teman all passport kita.. Overall, kami menyelamatkan diriku dari PhD trajectory yang mungkin membosankan. Di sisi lain, aku juga bahagia melihat dirimu dengan Thomas. Aku doakan semoga he is the one for you.

Thank you, Jonathan Berg, for helping me on many occasions, from moving houses to dealing with a very manipulative landlord, recolouring the vibrant sweaters, and for being a paranymph. I remember meeting you for the first time when you were learning to sew, and I asked if I could order a pair from you. You responded kindly, saying, "If you want to get it from someone who just attended three sewing courses, you're welcome." For your information, you were the first guest to enjoy my first homemade dinner. I was worried it was inedible, but you responded, "These are good." You also constantly show patience with beekeeping, which is fantastic—especially when Amalia brought home the harvested honey. We always smile when there are leftover sandwiches and cake from seminars. I am thrilled to see how you and Famke have a house in Amstelveen, surrounded by breath-taking nature and some elite (white) guys, hahaha. You may need to ask them for their votes to support your local politician's campaign. I believe you are born to be a leader.

Hi Kyra, how are you today? You are the most helpful friend I have had during my time in the Netherlands. You kept showing us your care and trying to help me as much as you can. Afobaka is our favourite place to eat, so we can chat about our journeys and comment on how other people can be "unique and irritated." I remember you mistakenly caught an Indonesian phrase: "Saya sedih karena kalian miskin" instead of "saya sedih karena kalian bodoh." I was surprised and immediately said, "please, please, you cannot say that." To be honest, it was better than my Dutch, which was only "Jongen" and "Meisje", and you keep learning Bahasa Indonesia. You have achieved many things that many people dream of, such as serving as a student representative in the Second Chamber in The Hague and having mentors with substantial academic achievements. I remember how you were a warm friend by giving us the books for being new parents (We haven't read them yet, since our Nymu was born prematurely). You are the one who continuously pushes me to be affirmed by saying people will appreciate it, as you quote "you always have no, but you can try to have a yes." I thank you for being friends with this guy in the corner, silently working on his PhD to be your friend. I believe you are on the path to becoming a professor in disability studies, both in healthcare and higher education.

Jolien van de Sande, the sweetest, wonderful friend from our department. From the very beginning of my PhD, I've always appreciated how you would invite us all for lunch or ask, "Coffee?" You were always fostering a warm, friendly environment that made the PhD journey feel much less lonely. You listened well to the challenges I faced during this PhD process and were also saddened by these issues, which touches me and shows how you care. Nymu, Ucha, and I enjoyed the gift of the microphone, and it is so cute for Nymu. When you translated your thesis summary into English to ensure that Amalia and I would not be bored during your defence, I was touched. Our holiday to Lille with Amalia was very enjoyable, especially the karaoke part together, hehe. Although you are a very good social researcher, you can also be a very good school teacher.

Azrullah, teman rantau saya yang mendapatkan pujaan hati di Belanda. Terimakasih sudah menekan saya untuk mencoba PhD di Belanda yang mencengkam ini, dan banyak memberikan masukan terkait bagaimana bernavigasi untuk mencari jalan keluar terbaik. Kamu banyak membantu saya saat datang dan pindahan. Dan maaf sekali waktu itu lupa bawa kamera dari Indonesia untuk pernikahanmu, padahal sudah janji. Saya senang melihat kamu bersama Betul dan Zakir berkeluarga dan bahagia. Saya tidak pernah ragu kemampuan akademik kamu dan yakin kamu akan bersinar di dalam maupun di luar Belanda.

Kakak Insan Adi & Mba Fira beserta tambahan Kala, keluarga yang paling perhatian di Belanda terhadap hidup saya. Selalu memasak makanan Indonesia seperti ayam geprek dan tempe goreng yang setidak membuat rasa kangen saya terhadap enaknya makan Indonesia terobati. Saya berterima kasih sekali sudah diberikan kesempatan untuk bersenangsenang dalam pertemanan yang sangat sehat ini. Saya sangat senang mendengar bahwa Kakak Adi mendapatkan pekerjaan sebagai manajer di salah satu perusahaan. Saya menunggu kalian di Yogyakarta, dan saya bertanya apakah kalian akan menunggu saya lagi di Belanda. Transisi hidup saya di Belanda sangat mudah berkat bantuan kalian juga.

Thomas, thank you for always showing your care for Amalia's friend and now also for your own friend. We were very happy to see you in Yogyakarta, and we definitely want to see you around here again. Thanks for helping us as we almost got tricked by the manipulative and narcissistic landlord. Please continue to send me the reels on Instagram; they are funny.

Runnah, our Malawian athlete who never complained about the cold and said this is nothing compared to Sweden, thank you for being a friend with a strong Christian character who always smiles and shows a grateful attitude towards all difficulties and challenges. You are one of my favourite friends. Thank you for introducing me to the church; they were very friendly. Thank you for inviting me to the African dinner; it was lovely. Please tell Mamohaw that it is okay to use Tinder. Hehehe. By the way, I believe you can manage your PhD well, since you are humble in learning and eager to be shaped by mentors.

Edoardo, thank you for patiently introducing how Italians view the proper pasta, carbonara, and many types of pizzas. While I was enjoying my slow living in the Netherlands, you came with a lot of work to be done day and night, and finally forced me to invite Viv to work very hard. Slow living is good, but our ambitions are to be rock stars in our fields, such as primary healthcare centres and market access. I believe you will be an excellent (Associate) Professor at a primary healthcare centre in Italy. You are a very good friend.

Roman, the Empire, among all PhDs and colleagues in HCG, bro, you are the meanest, but you also gave us chills many times. Although you are physically white, your Malukan soul is still there, especially when meeting at the designated time was difficult, hehe, and it opened the door to easy bonding with me (as with other eastern Indonesians by blood). To put it in context, the East Indonesian brotherhood is based on insulting without irritating (though I already forgave you and would apologize if I sometimes cross the line). Thank you for bringing me lunch. Your sambal colo-colo was tasty. Remember, if life after the PhD sucks, we need to push ourselves to the idea of Kapsolan Mushroom rendang for the drunk people at midnight. Milan and Gigi have given feedback on the innovation; did you record it?

Indra, thank you for creating a warm, friendly home environment during our stay, for being a great cook, and for “forcing” me to go to the gym. Sorry for giving up the fight against the greedy landlord who makes it so hard for us to move out and get our deposit back. Kamu orang yang sangat terorganisir dan menikmati kenyamanan tersebut, bahkan Mba Indripun mengangguk setuju untuk itu. Jangan lupa kita masih punya rencana membuka usaha “Basic-Fit pertama di Bandung, Yogyakarta dan menggurita di seluruh Indonesia. Everyone has the right to go to the gym. I hope you succeed with all your dreams.

Viviane, first of all, I need to apologize for the house situation. Everything is just out of my control since I am out of the country. I know you from the pharmaceutical course, and I was happy to have you in Lisbon (it was not easy to convince Indra, but we made a very good decision). I admire your decision to leave the position to pursue a PhD trajectory; I hope you are doing well on the roller-coaster PhD journey, but you are the fittest candidate for doing your research. I wish I could buy the land next to the river you sold, so I can visit Uganda, and do some research or more fun work to do. You pull me back into the path of a hardworking researcher because life outside the Netherlands requires it, thank you. It helps me land well again in Indonesia.

Regiane, thank you for being so friendly and bringing more global vibes to HCG. I still owe you the cake recipe I made by instinct. You can watch this video on YouTube: https://www.youtube.com/watch?v=LeG7gKbFGZ0, titled “Tart susu khas Kupang tanpa sp.” I couldn't figure out the exact measurements, which is why I kept searching until I went home and found nothing in my hand. I should ask my mother the correct standard for this cake. Hehehe.

Ika, dr Ika dari Sumba bukan dari semarang, hehehe. Logat dan cara pikir sudah ada tercampur sedikit. Selamat menikmati kementerian kesehatan, namun kalau tidak cocok offer kami masih solid. Kalau dari Ika yang paling diingat adalah Bakwannya yang gurih dan selalu pas dilidah hehehe. Sa tahu Ika pung Ma pung doa masih banyak buat yang lain tapi tidak perlu dibilang di sini. Wishing you all the best through the grace of Jesus.

Franklin, our boss in the house, since you're always at the meetings and earning more money than we do. Saya doakan semoga keluargamu dan bosku selalu sehat dan terhindar dari mara bahaya di Belanda. Momen paling lucu ketika kamu nyahut si orang Ceko ketika telepon yang sampai berjam-jam tersebut.

Shayan, this Iranian young guy who has already become a man, has always been positive about living in the Netherlands. Thank you for teaming up with me to watch "Friends" during the pandemic. I hope you never come back and have a good life in the Netherlands, or otherwise, you may join the military and won't be able to do Rap anymore. I am happy that you already got your bachelor's degree.

Zahra and Habib, the other Iranian with incredible academic credibility, I thank you for always motivating me to stay focused and believe in my PhD journey. As Zahra knows, sometimes I was lost and doubted myself, but she always cheered me up by saying, "You're almost there."

Juga untuk teman-teman Indonesia saya yang selalu peduli dan ada untuk bercerita. Ibu Pejabat kita, Indri, yang selalu tampak muda bahkan kelihatan lebih muda 6 tahun dari saya. Terima kasih sudah datang dan menjadi panutan serta pemberi nasihat bagi kami yang kadang masih suka bingung. Untuk Mas Iwan, panutan saya, Mba Yun, dan Ibra, terima kasih atas pertemanan yang hangat. Saya doakan Mba Yun segera mendapatkan impian yang tertunda. Tidak lupa juga saya berterima kasih kepada Mas Anso dan Mba Uni yang selalu ceria; nanti aku akan sering ke Malang dan mengunjungi kalian. Demikian juga Mas Rendi dan Mas Riani serta Amanda. Sampai jumpa lagi di Bandung. Untuk Amanda, Rafid, Jasmine, Kadek Hendra, dan Andini yang saya temui di Erasmus, terima kasih banyak sudah menyediakan waktu untuk menjadi teman saya. Untuk Kaka Vidi, pemimpin regu jalan-jalan dan makan enak, tetaplah di Eropa di mana pun itu, sehingga jika kami ke sini lagi, alasan untuk bertemu teman masih berlaku. Untuk Ka Yeti Haning dan Jolie di gereja yang berbeda, terima kasih atas perhatian dan peduli dengan keluarga saya selama di gereja tersebut.

Di kota lain, saya berterima kasih untuk kesempatan belajar dan mengembangkan diri bersama Elizabeth Pisani. Kamu membantu aku berpikir secara kritis dan memiliki perilaku bertanggung jawab terhadap setiap perkataan dan statement yang dikeluarkan. Terima kasih telah memberikan kesempatan ini, sungguh sangat berarti bagi seseorang seperti saya, untuk belajar dari mega bintang Global Health. Saya juga berterima kasih kepada Mba Yunita yang telah menyediakan waktunya untuk berdiskusi dengan saya tentang paper yang mandek tersebut. Hehehe. Mba Yun adalah pribadi yang sangat humble meskipun banyak sekali plus point-nya. Terima kasih pula kepada BuMil Aksari Dewi yang selalu wise dalam memberikan pendapatnya. Kamu membuat NTT bangga. Ada juga Faradiba, Bu Dosen, semoga segala yang diimpikan dapat terwujud.

Those whom I have met since high school, Pak Dokter kribo – Chris Bola, Bapak Family men kita – Raymond Nalle dan Audrey Doko, beta harap basong semua bahagia dalam keadaan apapun. Sischa, Adi Faah, Natalia, Melysa, Cintya Djira, dan teman-teman lain dari Undana, terimakasih dan sampai jumpa. Untuk Kaka Mei (& Kaka dede), terimakasih untuk doa dan dukungannya, dan terimakasih sudah memberikan perhatian kepada kami selayaknya adik kandung sendiri. Pertolongan Tuhan paling nyata selama program master saya adalah bertemu dengan Kaka Mei, terlalu sinkron kita dua punya otak. Untuk Kaka Maris yang sedikit lagi jadi Bupati Sumba Timur, nanti kita bantu cari suara kah? Kaka Vina dan Kaka Tia, selalu bahagia dimanapun. Hehehe. Untuk Ibu pejabat Papua, Kaka Yeni, salam Papua, sampai jumpa disana. Mba Fury, teman jalan ke Paris, kapan lagi ke Yogya, dan ku tengok-tengok gak kasih info juga, aku dan Dian butuh ditengok.

Daniel Pianka, Mas Bro di Vila Gading, saya sangat senang kamu sudah kembali dan punya pekerjaan yang tetap di Jerman meskipun pasti akan menyenangkan kalau kamu selalu di Yogyakarta, kita bisa minum bir tiap hari. Kami mulai menjadi “Putih” kembali, hahaha. Tidak usah menabung dan sering-seringlah ke Yogyakarta. Terlalu banyak hal baik yang saya alami bersama kamu, dan tidak mungkin saya tulis satu per satu, namun secara keseluruhan, kamu adalah sosok Pak Pendeta yang bekerja tanpa khutbah. I hope we can maintain this friendship. Untuk keluarga Quislan, terima kasih atas dukungan sejak tahun 2015 dari makan malam gratis di Bible study, sampai pada family consultation during the first month of being a parent for our amazing daughter, Nymu. Saya doakan yang terbaik untuk kalian semua di Amerika, dan good luck with Donald Trump, hehehe. Terimakasih juga untuk Kaka Eve dan Kaka Meta yang selalu di YIC Young Adult, selalu hangat apalagi memikirkan masa depan kita di era sekarang ini. I wish well for all of you.

Untuk Jonathan Smith, yang membantu saya di awal dan akhir studi PhD saya. Kamu membantu dengan email aplikasi PhD saya sehingga saya bisa menarik perhatian peneliti di ESHPM, serta memberikan koreksi selama sesi ini. Terima kasih, dan saya sangat senang berteman denganmu.

Untuk keluarga besar, Fanda dan Mone, terima kasih atas dukungan dan doa kalian semua sehingga saya dapat menyelesaikan buku ini. Doa kalian dijawab dengan baik oleh Tuhan, dan terima kasih sudah menjaga keluarga Kupang.

Untuk Kungkung dan Titi, terima kasih banyak sudah membantu mengawasi dan melindungi Nymu dan Ibunya selama saya di luar negeri. Saya sangat diberkati dengan mendapatkan orang tua yang sangat perhatian dan memahami kesulitan yang sedang kami alami. Terima kasih dan maaf belum bisa menjadi anak yang berbakti seutuhnya akibat PhD ini. Meskipun demikian, Kung dan Titi tidak pernah marah. Nymu sangat bahagia dan sayang terhadap Kungta dan Tia, kapan-kapan kita jalan-jalan lagi ketika keadaannya anak ini sudah mulai membaik. Terima kasih juga Bubi yang telah menunjukkan cinta kasihnya kepada keluarga kami. Tetap bertahan di Ibukota, Everything is gonna be alright.

Keluarga utama Melkes Fanda, Opa, Oma, Bapa Ani, Ma Ani, Bapa Epen, Ma Nita, Bapa Ichi, dan Oma Io, terima kasih untuk semua doa dan sumbangan dalam bentuk apa pun, baik dari materi maupun rohani. Nanti kalau sudah selesai dan normal kembali, Tuhan berikan berkat agar kitab bisa pergi melihat Oma, Opa, dan Bapa Mama semua. Semangat dan sabar, Opa dan Oma, untuk perawatan kesehatan yang harus dilaksanakan tiap minggu. Jangan lupa sering-sering ke Yogyakarta. Untuk Ma Ani, Bapa Ani, Abang Nano, dan Abang Gawen, terima kasih sudah membantu mengarahkan Anak Nymu dan membuat Nymu merasa punya kakak-kakak dan tidak kesepian. Dan untuk sepatunya, keren sekali, Nymu pakai tiap hari. Untuk Bapa Epen dan Ma Nita, terima kasih sudah berkunjung berkali-kali dan mau membantu sebagai back-up finansial yang luar biasa. Tuhan berkati usaha dan keluarganya, dan semoga cepat bergabung dalam satu keluarga secara utuh dalam waktu yang telah ditetapkan. Untuk Bapak Ici terima kasih sudah menjadi Bapa Ici yang selalu luar biasa sayang ke anak Nymu dan orang tuanya. Untuk Oma Io, terus semangat cari ayam bersama Nymu. Hehe, nanti Nymu kesana cari yang lain lagi.

Terus kasih untuk Nymu dan Ibunya yang paling Bapak sayang. Terima kasih untuk menjadi hebat dalam keadaan-keadaan yang sulit. Puji Tuhan kita lalui satu per satu. Tinggal bagaimana kita mempersiapkan Ibu untuk sekolah lagi. Bapak sangat sayang Nymu dan selalu berharap Nymu mendapatkan yang terbaik untuk masa depan Nymu. Doakan Bapak punya kerja terus, biar bisa beli baju Natal dan pulpen warna-warni untuk menggambar. Masih ingat ketika Nymu di Belanda yang cara main sama Nymu adalah dengan memberi anggur, kamu suka banget nak. Ternyata nak, dari kamu dalam kandungan hingga TK Bapak selesai PhD-nya, lama sekali yah. Bapak sangat terkesima dan tidak berhenti bersyukur melihat bagaimana kamu menggunakan kata-kata yang tepat dan kadang sulit untuk dipercaya kalau kamu belum 4 tahun. Apalagi pada umur tiga tahun sudah bisa memimpin doa makan untuk keluarga. Semoga semangat kamu, untuk bersosialisasi dan belajar terus dipelihara sehingga dapat menjadi modal ke depan. Untuk Istri tersayang, Uchamani, terima kasih banyak sudah menjadi partner yang sepadan. Terlalu banyak kisah yang kita lalui bersama sejak 2016 dan tidak terasa sudah hampir 10 tahun. Paling terpenting adalah terima kasih sudah menjadi Ibu buat Nymu. Hamil tanpa hadirnya suami tentu sangat berat, meskipun ada bantuan KungTa dan Titia, tetap kamu butuh dukungan sempurna dari suami yang tidak didapatkan waktu itu. Terima kasih juga sudah konsisten dalam perawatan dan membesarkan Nymu. Membesarkan anak prematur dengan banyak tuntutan layanan kesehatan adalah kesempatan yang diberikan Tuhan, hanya kepada ibu yang hebat dan sayang membuktikan hal tersebut. Bapak doakan agar mendapatkan sekolah cepat yah sayang, terus yakin dan andalkan Tuhan. Sepertinya kata yang tepat untuk mengakhiri ucapan terima kasih ini adalah semua perjuangan ini adalah perjuangan bersama dari Ibu, Nymu, dan Bapak untuk menyelesaikan PhD ini. Ijazah ini memang tertulis nama Bapak, namun pengorbanan dan cinta kasih kalian yang menguatkan dan membuat semuanya mungkin, oleh karena itu, ijazah ini milik kita semua. Bapak selalu sayang Ibu dan Nymu.

Thank you, Lord Jesus. I praise and thank You for every event that shapes Your servant's character and abilities. May Your name be glorified through these achievements.

Curriculum vitae

Name : Relmbuss Biljers Fanda
Department : Healthcare Governance
School : Erasmus School of Health Policy and Management
PhD Period : 2021 -2025
Promotors :

1. Prof. Dr. Roland Bal
2. Prof. dr. Ari Natalia Probandari, Ph.D.

Co-Promotor :

3. Dr. Maarten Oliver Kok

PhD Research title:
The role of sub-national level pharmaceutical systems in ensuring access to quality assured medicine: developing an index and assessing its consequences.

Courses

Start date	Course name	Organiser	No. ECTS
31-05-2021	Pharmaceutical policies in health systems	ITM	5,0
21-02-2023	Data Carpentry for Social Sciences	EGSH	0,0
03-04-2023	Maximise your visibility as a researcher	EGSH	1,0
04-07-2023	English academic writing for PhD candidates	EGSH	2,5
10-10-2024	Geographical Information Systems	EGSH	2,5
04-11-2024	Mixed-method research: how to combine diverse quantitative and qualitative methods	EGSH	2,5
06-11-2024	Creating societal impact	EGSH	2,5
18-11-2024	Professionalism and Integrity in Research	EGSH	1,5
22-11-2024	Qualitative coding with ATLAS.ti	EGSH	1,5
27-11-2024	Public Speaking	EGSH	2,5

10-12-2024	Visual exploration of scientific literature with VOSviewer	EGSH	1,5
07-01-2025	Philosophising your research	EGSH	2,5
13-01-2025	Open Science and Research Transparency	EGSH	2,5
Total			28

ITM = Institute of Tropical Medicines Antwerp, Belgium

EGSH = Erasmus Graduate School of Social Sciences and the Humanities, Erasmus University Rotterdam, The Netherlands

Peer-reviewed academic publications

- Kok, M. O*., **Fanda, R. B*.,** Lubbers, R. U., van Gurp, M., Ravinetto, R., & Probandari, A. (2025). Assessing the performance of local pharmaceutical systems: an analytical approach to improve access to medicine. The Journal of Medicine Access, 9, 27550834251371502. M.O.K. and R.B.F are the joint first authors.
- **Fanda, R.B.**, Probandari, A., Yuniar, Y., Hendarwan, H., Trisnantoro, L., Jongeneel, N. and Kok, M.O., 2024. The availability of essential medicines in primary health centres in Indonesia: achievements and challenges across the archipelago. The Lancet Regional Health-Southeast Asia, 22.
- **Fanda, R.B**., Probandari, A., Kok, M.O. and Bal, R.A., 2025. Managing medicines in decentralization: discrepancies between national policies and local practices in primary healthcare settings in Indonesia. *Health Policy and Planning*, *40*(3), pp.346-357.
- Sulistiawan, D., Lazuardi, L., **Fanda, R.B**., Asrullah, M., Matahari, R. and Arifa, R.F., 2021. Who experiences out-of-pocket expenditures for modern contraceptive use in Indonesian universal health coverage system. *Med-Leg Update*, *21*(3), pp.193-200.
- Pisani, E., **Fanda, R.B**., Hasnida, A., Rahmi, M., Nugrahani, Y., Ihsan, B.R.P., Lawuningtyas, A., Hariadini, D.L. and Dewi, A., 2021. Pill pushers: politics, money and the quality of medicine in Indonesia. *In sickness and in health: diagnosing Indonesia [internet]. Singapore: ISEAS-Yusof Ishak Institute*.

- **Fanda, R.B**., Hasanbasri, M. and Padmawati, R.S., 2016. Respon Spesifik Puskesmas Terhadap Kebutuhan Sanitasi Penduduk Permukiman Kumuh Di Bantaran Sungai Code, Kota Yogyakarta. Jurnal Manajemen Pelayanan Kesehatan (The Indonesian Journal of Health Service Management), 19(4).

Other publications

- **Fanda, R.B**., Salim, A., Muhartini, T., Utomo, K.P., Dewi, S.L. and Abou Samra, C., 2020. A policy brief: Mengatasi tingginya konsumsi minuman berpemanis di Indonesia - - Tackling High Consumption of Sugar Sweetened Beverages (SSB) in Indonesia. *Pusat Kebijakan dan Manajemen Kesehatan*.
- Pisani, E., **Fanda, R.B.,** Dewi, A., Nugrahani, Y., Hasnida, A., Mawaddati, R., 2021. Taking a Cut: Investigating incentives in Indonesia's medicine supply chain. Indonesia medicine_quality. Ternyata Organization – CHPM UGM. UK.
- Listyadewi, S., Sulistiawan, D., **Fanda, R.B.,** Frans, S., Nurfadillah, S., 2019. Study on Health Seeking Patterns of Youths (15-24) in the Special Region of Yogyakarta Final Report. UNFPA – CHPM UGM.
- Trisnantoro, L., Marthias, T., Aktariyani, T., Kurniawan, M.F., **Fanda, R.B.,** Cintyamena, U., Dilla, A.N, Rahma, P.A., Hasri, E.T., Chandra. 2018. Working Paper: *Evaluasi 8 Sasaran Peta Jalan JKN dengan Pendekatan Realist Evaluation* – Evaluation of eight objectives in the Indonesian National Health Insurance Roadmap Using Realist Evaluation. Knowledge Sector Initiative – CHPM UGM.
- Trisnantoro, L., Marthias, T., Aktariyani, T., Kurniawan, M.F., **Fanda, R.B.,** 2018.
  Apa Opsi-Opsi Kebijakan JKN saat ini? – What are policy options for better the Indonesian National Health Insurance? Knowledge Sector Initiative – CHPM UGM.

Research activities

- ***Principal Investigator*** (PhD Project)- Strengthening local pharmaceutical system to ensure equal access to medicine in Indonesia, Erasmus School of Health Policy and Management, The Netherlands, funded by the LPDP, Indonesia: March 2021 – Feb 2025.
- ***Individual Consultant*** for the Ministry of Health, Republic of Indonesia - Developing ASEAN Leadership Declaration Action Plan on The Reformulation and Production of Healthier Food and Beverage Options, funded by The Ministry of Health, Republic of Indonesia: Octo – Nov 2022.
- ***Co-Principal Investigator*** - Taking a Cut: Investigating incentives in Indonesia's medicine supply chain, funded by Ternyata Organisation, The United Kingdom: June – March 2021.
- ***Co-principal investigator*** - Strengthening and Accelerating Access of Marginalized Groups to Health and Knowledge Services (SAMA-HAK), funded by The Australia-Indonesia Partnership Towards an Inclusive Society (Inklusi): Feb 2023 – Feb 2026 (Present),
- ***Co-principal investigator*** - Institutionalizing Community Health Workers in NTT Province, Indonesia, funded by UNICEF Indonesia: July – December 2025.
- ***Co-principal investigator*** - Accelerating equity benefit packages in health services for vulnerable communities through supply-side readiness and financing analysis of cardiovascular disease, funded by the Indonesian Ministry of Research, Technology, and Higher Education: March – December 2018.
- ***Programme manager from Indonesia site*** - Building institutional capacity for HPSR and delivery science, mentored by Knowledge to Policy (K2P) American University Beirut, Lebanon, funded by WHO Alliance: Feb 2020 – June 2021,
- ***Lead Researcher*** - Evaluation of the Indonesian National Health Insurance roadmap using a realist evaluation approach collaborating with eight local universities, funded by Knowledge Sector Initiative - DFAT Australia: January 2019 – Dec 2020,

- ***Programmer Manager*** - Study on health-seeking patterns of youth (15-24) in Yogyakarta, funded by UNFPA: Jan 2019 – June 2019,
- ***Researcher*** - Strengthening health workforce availability, equity, and quality (As Input for National Medium-Term Development Plan/RPJMN 2025-2029 Background Study), funded by WHO Indonesia: Nov 2022 – Apr 2023,
- ***Researcher*** - Enhancing domestic medicines Production (As an Input for The Background Study for the National Medium-Term Development Plan 2025-2029), funded by WHO Indonesia: Nov 2022 – Apr 2023,
- ***Researcher*** - Optimizing local government roles in Indonesia National Health Insurance, funded by the BPJS Kesehatan: Nov 2021 – Feb 2022,
- ***Researcher*** - Health security financial assessment in Indonesia, funded by World Bank: March – Oct 2019,
- ***Researcher*** - Capacity building needs assessment of Puskesmas (primary healthcare) and Posyandu (Integrated Service Post) cadres in delivering quality nutrition services and other health services related to nutrition in Indonesia, funded by Nutrition Indonesia and Save The Children; November 2020 – Feb 2021,
- ***Researcher*** - Towards malaria elimination by 2030: certification for the Malaria diagnostic training program through interactive eLearning, funded by WHO: July 2019 – Nov 2019,
- ***Data Manager*** - Analysis of the appropriateness of the subsidized Indonesian Universal Health Coverage (JKN) participants in Riau Province, funded by Riau Provincial Government: July 2018 – October 2018, and
- ***Research assistant*** - Indonesia implementation research on universal Health Coverage at the primary care level, funded by USAID: Aug 2017-Sept 2018.

Contributions to conferences, seminars and webinars

- **International Health Economics Association:**
  19/06/2025 – 23/12/2025 - Bali, Indonesia. Participated as a speaker in the preconference section titled "One Decade of Indonesia's National Health Insurance." Delivered an oral presentation at the main conference event: "Achieving UHC with Disability Inclusion in Indonesia: A Mixed-Method Study to Explore Access to Healthcare for People with Disabilities."
- **Winter meeting 2023 - Utrecht WHO Collaborating Centre for Pharmaceutical Policy and Regulation: Evidence generation along the drug life cycle:** 11/01/2023 – 12/01/2023 in Utrecht, The Netherlands. Delivered an oral presentation: Determinants of medicines availability in 9831 Indonesian primary health centres: Spatial autocorrelation and multilevel analyses to inform policymaking processes in strengthening access to medicine.
- **European Congress on Tropical Medicine and International Health (ECTMIH): Shaping the future of equitable and sustainable planetary health:** 20/11/2023 – 23/11/2023 in Utrecht, The Netherlands. Presented two studies:1). Using a composite index to prioritise Indonesian districts with high constraints to ensure access to medicine while directing them to achieve universal health coverage, and 2). Is having national health insurance protecting youth from out of pocket? A study of youth healthcare-seeking behaviour in a province in Indonesia.
- **Rotterdam Global health Initiative: Reshaping economic evaluation for global health:** 12/09/2023 – 12/09/2023 in Rotterdam, The Netherlands. Presented a study: The availability of essential medicines in primary health centres in Indonesia. *Win the prize for the best presenter.*
- **Global Symposium on Health Systems Research (HSR): Health Systems Performance in the Political Agenda: Sharing lessons for current and future global challenges:** 31/10/2022 – 01/11/2022 in Bogota, Colombia. Presented a study: What and where should we invest in improving equal access to medicines? Identifying factors

driving a local pharmaceutical system performance and essential medicine availability.

- **InaHEA Annual Scientific Meeting (ASM): (Political) Economics of Non-Communicable Diseases in Indonesia-Gathering Evidence for National Action Plan:** 06/11/2019 – 08/11/2019 in Bali, Indonesia. Presented a study: Policy Analysis on Cardiovascular Diseases in Indonesia.
- **Global Symposium on Health Systems Research (HSR):** 08/10/2018 – 10/10/2018 in Liverpool, The United Kingdom. Presented a study: How far will a financial incentive system motivate health workers in Indonesia's universal health coverage system?
- **Postgraduate Forum on Health Systems and Policies: Using Big Data for Health Policy and Management:** 02/07/2018 – 03/07/2019 in Kuala Lumpur, Malaysia. Presented a study: Researching Human Resource for Health: How Indonesian Health Worker Attendance and Their Performance were Affected by The Financial Incentive System?

Education

- **Master of Public Health – Universitas Gadjah Mada.** 2014 – 2016. Yogyakarta Indonesia.
- **Bachelor of Public Health – Universitas Nusa Cendana.** 2007 – 2011. Kupang, Indonesia.

Other educational activities

- **Certified Facilitator:** Evidence-based policy making. The Center for Health Policy and Management, Universitas Gadjah Mada: 2017 – 2025.

Other work experience:

- **Freelance Photographer: 2014 – 2017;**
- **Front office Assistant -** Bank Negara Indonesia. 2012 – 2014;
- **Front office Assistant -** Bank Danamon Indonesia: 2011 -2012;

Voluntary works:

- **Secretary Assistant -** Gereja Masehi Musafir Indonesia. 2016 – 2017;
- **Mobilisation Officer -** Persatuan Tuna Daksa Kristiani (Christian Disability Association), Kupang, Indonesia: 2017;
- **Treasurer of Graduate Christian Student Fellowship -** Universitas Gadjah Mada, Yogyakarta: 2015 -2016.
- **The head of Student Association –** Health Promotion and Behaviour Science program, Universitas Nusa Cendana, Kupang, Indonesia: 2009-2010.

About the Author

Relmbuss Biljers Fanda, whom you may know as Embus, is an Indonesian researcher at the Center for Health Policy and Management, Universitas Gadjah Mada, and an external PhD student with a scholarship at Erasmus School of Health Policy and Management, Erasmus University Rotterdam. He is an awardee of a scholarship program from the Indonesia Endowment Fund for Education Agency.

With an eastern Indonesian background, an area with the least development in the health system and other sectors, in this research, he emphasizes that those districts require more than a single standardised development program. He emphasizes lessons from how local systems operate within their structural limitations and other contexts, yet still achieve a certain degree of success. Born and growing up in those areas led him to the spirit that variations of challenges exist, and so are the solutions. Until now, his research experience has focused on strengthening the Indonesian political agenda to achieve universal health coverage with an inclusion agenda by enhancing district government capacity through a bottom-up approach and by contributing to the development of the local pharmaceutical system.

He plans to keep addressing the issue of advancing health equity by strengthening the health system to ensure access to healthcare, education, and information across the country, especially in eastern Indonesia. At the same time, he aims to encourage all researchers to focus their work on public or community benefits. He will continue supporting them through capacity-building programmes and knowledge translation efforts to inform policymakers about potential changes needed to achieve a better outcome at the community level.

Systems in Between

A Mixed-Methods Study Developing and Using a Local Pharmaceutical System Approach in Indonesia

Variations in subnational needs and capacities within larger countries pose challenges for the national government's efforts to develop and bolster policies that balance the conflicting interests of all actors in ensuring access to medicines. Existing frameworks to ensure access to medicines rarely focus on the organisation of medicine supply at more local levels within a country. I aim to understand how local systems operating within a national system work to ensure equal access to medicines for all the citizens of the country. A local approach provides a better understanding of fundamental pharmaceutical system dynamics and challenges across a country, as it functions as a "system in between". In Indonesia, decentralisation was implemented by delegating responsibility to local governments—including primary health centres (PHCs) and their associated District Health Offices (DHOs)—to manage the provision of medicines in public sector facilities. This thesis, therefore, focuses on understanding variations in the availability of essential medicines in PHCs in Indonesia and answers the main research question: "How do insights into the functioning of the local pharmaceutical system in Indonesia lead to a better understanding of efforts to improve access to medicines?"

Relmbuss Biljers Fanda