Access to healthcare services in resource-constrained environments: Evidence from Zimbabwe

by
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With regard to Chapters 2, 3 and 4, the nature and scope of my contribution were as follows:

Nature of contribution	Extent
Conceptualisation, data collection, data analysis and interpretation and writing	70%

The following co-authors contributed to Chapters 2, 3 and 4 as follows:

Name	Email address	Nature of contribution	Extent
Prof Ronelle Burger		Provide feedback on all the chapters in the thesis Research design	15%
Prof Dieter von Fintel		Provide feedback on all the chapters in the thesis Research design	15%

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1. the declaration above accurately reflects the nature of the contribution of the candidate and the co-authors to Chapters 2, 3 and 4;
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Abstract

Access to healthcare services is fundamental to health and well-being, yet approximately half of the world's population is unable to access healthcare services in times of need, which derails attainment of the Sustainable Development Goals. Weak access to healthcare services is a global health challenge, and is prevalent in Zimbabwe. This weak access is attributed to a fragile and fragmented health system, characterised by weak and ineffective service delivery. The fragmented health system affects particularly the already disadvantaged population through healthcare services that are either unaffordable or unavailable. As part of achieving the global Sustainable Development Goals, Zimbabwe aims to address inequality in and weak access to its healthcare services.

This thesis examined fiscal incidence and inequality in access to healthcare services in Zimbabwe, using 2017 administrative health expenditure data from the Ministry of Health and Child Care and the Prices, Income, Consumption and Expenditure Survey of the Zimbabwe National Statistics Agency. Fiscal incidence was found to be, on average, pro-poor for Zimbabwe's low-level facilities, and pro-rich for high-level facilities. It was further found that availability and affordability are, on average, pro-rich. Thus, differential access to health services between rural and urban areas was contributing to pro-rich inequality. Despite government healthcare expenditure, inequality in availability and affordability of healthcare services remains a challenge. Pockets of inequality persist in the healthcare sector, as the more affluent continue to benefit from well-resourced facilities. The government should, therefore, focus on poor and rural populations, who bear the brunt of weak access to healthcare services.

While the effects and causes of drug stockouts are well articulated, there is a dearth of literature on the link between district-level drug stockouts and poverty. This thesis investigated the spatial inequality of drug stockouts and the relationship between drug stockouts and district poverty in Zimbabwe using data on district-level drug stockouts and poverty. The results showed that spatial inequality in drug stockouts and district poverty exists, while the relationship between drug stockouts and district poverty was weak and insignificant. Spatial interdependence in drug stockouts between districts also exists, indicating hot spots in drug stockouts. In times of drug stockouts, individuals tend to use alternatives to healthcare, some of which pose health dangers, and it is therefore important to improve drug availability in underserved districts by reducing spatial inequality and hot spots in drug stockouts.

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Given the negative effects of malaria on the vulnerable population, this thesis examined the association between malaria prophylaxis stockouts and birth- and maternal outcomes in Zimbabwe. Preventive efforts against malaria are crucial, given that pregnant women and neonates bear the greatest malaria burden. Therefore, it was hypothesised that women who do not receive malaria prophylaxis during pregnancy are at risk of malaria infections, which compromise birth weight and cause maternal anaemia. Combining the administrative data on malaria prophylaxis stockouts and 2015 nationally representative Demographic Health Survey data, the results showed that malaria prophylaxis stockouts occur frequently over time, and have a significant association with birth weight, especially for neonates with an average birth weight. Stockouts are associated with neonates tending towards the lower end of a normal birth weight, compromising their development. Thus, there is a need to invest in pharmaceutical information- and stock-ordering systems to improve drug availability at the point of care.

In conclusion, there is inequality in healthcare services in Zimbabwe, which causes a heavy burden on poor and rural populations. These vulnerable populations have weak access to healthcare services, despite the government's efforts to improve service provision. This thesis sheds more light on access to healthcare services, to enhance relevant stakeholders' understanding of this subject. To achieve an equitable society, policymakers should address the inequalities in access to healthcare services, together with the socio-demographic determinants of health. Policymakers should improve resource management, follow a needs-based approach, invest in pharmaceutical information systems and stock-ordering systems, and foster multi-stakeholder collaboration to ensure improved access to healthcare services.

JEL Classification Codes: I10; I14; I18; H22; H51; H57; R12; P25

Keywords: inequity; inequality; fiscal incidence; access to healthcare services; availability; affordability; drug stockouts; district poverty, spatial inequality, birth outcomes; maternal outcomes; Zimbabwe

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Opsomming

Toegang tot gesondheidsorgdienste is fundamenteel vir gesondheid en welstand, tog is ongeveer die helfte van die wêreld se bevolking nie in staat om toegang tot gesondheidsorgdienste te verkry in tye van nood nie, wat die bereiking van die Volhoubare Ontwikkelingsdoelwitte ontspoor. Swak toegang tot gesondheidsorgdienste is 'n globale gesondheidsuitdaging, en is ooglopend in Zimbabwe. Die swak toegang in hierdie land word toegeskryf aan 'n brose en gefragmenteerde gesondheidstelsel, gekenmerk deur swak en ondoeltreffende dienslewering. Die gefragmenteerde gesondheidstelsel raak veral die reeds benadeelde bevolking deur gesondheidsorgdienste wat óf onbekostigbaar óf onbeskikbaar is. As deel van die bereiking van die wêreldwye Volhoubare Ontwikkelingsdoelwitte, poog Zimbabwe om die ongelykheid in en swak toegang tot gesondheidsorgdienste aan te spreek.

Hierdie studie het fiskale voorkoms en ongelykheid in toegang tot gesondheidsorgdienste in Zimbabwe ondersoek, deur gebruik te maak van 2017 administratiewe gesondheidsuitgawedata van die Ministerie van Gesondheid en Kindersorg en die Demographic Health Survey van Zimbabwe se nasionale statistiese agentskap. Daar is gevind dat fiskale voorkoms gemiddeld pro-arm is vir Zimbabwe se laevlakfasiliteite, en pro-ryk vir hoëvlakfasiliteite. Daar is verder bevind dat beskikbaarheid en bekostigbaarheid gemiddeld pro-ryk is. Dus, dra verskillende toegang tot gesondheidsdienste tussen landelike en stedelike gebiede by tot pro-ryk ongelykheid. Ten spyte van staatsgesondheidsuitgawes bly ongelykheid in beskikbaarheid en bekostigbaarheid van gesondheidsorgdienste 'n uitdaging. Konsentrasies van ongelykheid duur voort in die gesondheidsektor, aangesien die meer welgesteldes steeds voordeel trek uit fasiliteite met goeie hulpbronne. Die regering moet dus fokus op arm en landelike bevolkings, wat die swaarste dra aan swak toegang tot gesondheidsorgdienste.

Alhoewel die gevolge en oorsake van tekorte aan medikasievoorraad welbekend is, is daar 'n gebrek aan literatuur oor die verband tussen distriksvlak-medikasievoorraad en armoede. Hierdie navorsing het die ruimtelike ongelykheid in medikasievoorraad en die verband tussen medikasietekorte en distriksarmoede in Zimbabwe ondersoek, gebaseer op data oor distriksvlak-medikasietekorte en armoede. Die resultate het getoon dat ruimtelike ongelykheid in medikasietekorte en distriksarmoede bestaan, terwyl die verband tussen medikasietekorte en distriksarmoede swak en onbeduidend is. Ruimtelike interafhanklikheid in medikasietekorte tussen distrikte bestaan ook, wat brandpunte in medikasietekorte aandui. In tye van tekorte aan medikasie is individue geneig om alternatiewe vir gesondheidsorg te gebruik, waarvan

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sommige gesondheidsgevare inhou. Dit is daarom belangrik om medikasiebeskikbaarheid in onderbediende distrikte te verbeter deur ruimtelike ongelykheid en brandpunte in medikasietekorte te verminder.

Gegewe die negatiewe uitwerking van malaria op die kwesbare bevolking, ondersoek hierdie tesis die verband tussen malaria-profilakse-tekorte en geboorte- en moederuitkomste in Zimbabwe. Voorkomende pogings teen malaria is van kardinale belang, aangesien swanger vroue en pasgeborenes die grootste malarialas dra. Daarom is die hipotese gestel dat vroue wat nie malaria-profilakse tydens swangerskap ontvang nie, die risiko loop van malaria-infeksies, wat geboortegewig benadeel en moederlike bloedarmoede veroorsaak. Deur die administratiewe data oor malaria-profilakse-tekorte en die data van 2015 se nasionaal verteenwoordigende Demographic Health Survey te kombineer, het die resultate getoon dat malaria-profilakse-tekorte gereeld voorkom met verloop van tyd, en 'n beduidende assosiasie met geboortegewig het, veral vir pasgeborenes met 'n gemiddelde geboortegewig. Medikasietekorte word geassosieer met neonate wat na die onderste punt van 'n normale geboortegewig neig, wat hul ontwikkeling benadeel. Daar is dus 'n behoefte om te belê in farmaseutiese inligting- en voorraadbestellingstelsels om die beskikbaarheid van medisyne by die sorgpunt te verbeter.

Ten slotte, daar is ongelykheid in gesondheidsorgdienste in Zimbabwe, wat 'n swaar las op die arm en landelike bevolking veroorsaak, ten spyte van hul beduidende behoefte aan dienste. Hierdie kwesbare bevolking het swak toegang tot gesondheidsorgdienste, ten spyte van die regering se pogings om dienslewering te verbeter. Hierdie tesis werp meer lig op toegang tot gesondheidsorgdienste, om relevante belanghebbendes se begrip van hierdie onderwerp te verbeter. Om 'n billike samelewing te bereik, moet beleidmakers die ongelykhede in toegang tot gesondheidsorgdienste aanspreek, sowel as die sosio-demografiese determinante van gesondheid. Dus, beleidmakers behoort hulpbronbestuur te verbeter, 'n behoefte-gebaseerde benadering te volg, belê in farmaseutiese inligtingstelsels en voorraadbestellingstelsels, en multi-belanghebbende samewerking bevorder ten einde verbeterde toegang tot gesondheidsorgdienste te verseker.

JEL Klassifikasiekodes: I10; I14; I18; H22; H51; H57; R12; P25

Sleutelwoorde: ongelykheid; fiskale voorkoms; toegang tot gesondheidsorgdienste; beskikbaarheid; bekostigbaarheid; medikasietekorte; geboorte-uitkomste; moederlike uitkomste; Zimbabwe

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Dedication

I dedicate this thesis to my late father, my mother, and my family, who have been my source of inspiration throughout this academic journey.

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First and foremost, I would like to thank God for protecting and guiding me throughout my studies, as well as for granting me the opportunity to do this doctorate. “Being confident of this very thing, that he which hath begun a good work in you will perform it until the day of Jesus Christ” (Philippians 1:6).

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List of Abbreviations

AHFoZ	Association of Healthcare Funders of Zimbabwe
ANC	antenatal care
BMI	body mass index
CI	concentration index
COVID-19	Coronavirus Disease of 2019
DTTU	Delivery Team Topping Up
EMPS	Essential Medicines Pull System
GPS	Global Positioning System
HIV	human immunodeficiency virus
IPTp	intermittent preventive treatment in pregnancy
ITNs	insecticide-treated nets
MoHCC	Ministry of Health and Child Care
NatPharm	National Pharmaceutical Company of Zimbabwe
NGOs	non-governmental organisations
NHA	National Health Accounts
OLS	ordinary least squares
OOP	out-of-pocket
PICES	Prices Income Consumption and Expenditure Survey
RIFs	recentered influence functions
SADC	Southern African Development Community
SAR	spatial autoregressive model
SDGs	Sustainable Development Goals
SDEM	spatial Durbin error model
SDM	spatial Durbin model
SEM	spatial error model
SES	socioeconomic status
SP	sulfadoxine-pyrimethamine
SSA	sub-Saharan Africa
TB	tuberculosis
UHC	Universal Health Coverage
UNDP	United Nations Development Programme
US	United States

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WHO	World Health Organization
ZADS	Zimbabwe ARV Distributing System
ZAPS	Zimbabwe Assisted Pull System
ZDHS	Zimbabwe Demographic Health Survey
ZEPARU	Zimbabwe Economic Planning Analysis and Research Unit
ZIMSTAT	Zimbabwe National Statistics Agency
ZIPS	Zimbabwe Informed Push System
ZIP-PHCP	Zimbabwe Informed Push/Primary Health Care Package
ZSARA	Zimbabwe Service Availability and Readiness Assessment

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Chapter 1

Introduction

1.1 Overview

Ensuring access to healthcare services is fundamental to improving health outcomes, well-being, and economic development. However, in reality, most people fail to access these essential healthcare services when they need them. This derails the attainment of the United Nations Sustainable Development Goals[1] (SDGs), specifically SDG 3, which is to "ensure healthy lives and promote well-being for all at all ages" (United Nations, 2022). It is therefore crucial to understand the factors affecting access to healthcare services.

Access to healthcare services is mainly affected by the health system's demand- and supply factors, including challenges related to the availability and affordability of services (Peters *et al.*, 2008). These challenges comprise poorly functioning health systems, overreliance on out-of-pocket (OOP) payments, and socio-demographic and cultural factors (Rahman *et al.*, 2022).

The majority of individuals who cannot access healthcare services are prevented from doing so due to the high cost of such services. Individuals face a financial burden when accessing healthcare services, due to high OOP payments (Ahmed, 2022). The high OOP expenditure, therefore, increases the incidence of catastrophic health expenditure (Amiresmaili and Emrani, 2019; WHO, 2019b). Almost one billion people globally incur catastrophic health expenditures,[2] whilst 100 million people are driven into extreme poverty as a result of high OOP expenditures (World Health Organization (WHO), 2019a). It is thus important to reduce this financial burden to accelerate Universal Health Coverage (UHC), to ensure access to high-quality healthcare services without ruinous expenditures for everyone (Orjingene *et al.*, 2022; Steele *et al.*, 2022).

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[1] SDGs aim to achieve a conducive environment for everyone to enjoy peace and prosperity by providing strategies to reduce inequalities, improve health, and spur economic growth. This thesis mainly focuses on the first, second, and tenth SDGs. SDG 1 is aimed at "Ending poverty in all its forms everywhere"; SDG 3 is: "Ensure healthy lives and promote well-being for all at all ages"; and SDG 10 is: "Reduce inequality within and between countries" (United Nations, 2022).

[2] Catastrophic health expenditure occurs when an individual's out-of-pocket health expenditure exceeds a specific fraction of household income or expenditure (O'Donnell *et al.*, 2008). Different thresholds are used to determine catastrophic health expenditure, depending on the method used: either total household expenditure or capacity to pay, ranging from 5% to 40% (Mutyambizi *et al.*, 2019; Rahman *et al.*, 2022; Zeng *et al.*, 2018).

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Availability of healthcare services is also a challenge. Many individuals have to travel long distances to access healthcare services, especially in rural and marginalised areas (Burger *et al.*, 2012; Harris *et al.*, 2011). Service availability is limited in resource-constrained environments and poor and vulnerable populations are constrained in accessing the healthcare services they need (Anselmi *et al*., 2015). Even if facilities are nearby, individuals tend to suffer a shortage of health workers and equipment, coupled with drug stockouts (Burger and Christian, 2018). Weak access to healthcare services results in compromised health outcomes and death, as individuals do not receive timeous treatment (Buzuzi *et al.*, 2016; Zimbabwe Economic Policy and Research Unit (ZEPARU), 2014).

Developing countries in particular grapple with weak and ineffective health service delivery, making many of their citizens unable to access the necessary services in times of need. The unavailability and/or unaffordability of healthcare services further compromises their access to essential healthcare services. These challenges increase the inequality in health and healthcare services, which is skewed towards marginalised and poor populations (Atieno *et al*., 2022; Rahman *et al.*, 2022).

The progress towards achieving universal health access was disrupted by the coronavirus of 2019 (COVID-19) pandemic, which exacerbated inequality in access to healthcare services, particularly in developing countries (Steele *et al.*, 2022). This compounded the inequalities in healthcare service delivery in developing countries (Harris *et al.*, 2011). Health systems ought to provide services equally to the population, which requires physical accessibility and services of a sufficient quality (Harris *et al.*, 2011). Therefore, understanding the challenges in access to healthcare services is crucial in realising global and local health goals.

1.2 Access to healthcare services

Tanahashi (1978) provides an extensive framework of access to healthcare services, which explains how health coverage involves the interaction between service providers and the target population. Health coverage comprises several elements, categorised by Tanahashi (1978) as availability coverage, accessibility coverage, acceptability coverage, contact coverage, and effective coverage. The first three coverage elements represent the capacity of the services to reach the target population, while the latter two represent the health outcomes realised through the use of the services (Tanahashi, 1978).

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Availability coverage is the capacity to provide health services to reach the population in terms of health workers, drugs, and facilities (Tanahashi, 1978). Accessibility coverage entails the services that are available and located where everyone can reach them, while acceptability coverage relates to individuals' perceptions of the healthcare services. These perceptions may be influenced by, amongst others, religion and cost. Contact coverage relates to the use of healthcare services; that is, the proportion of the target population who is able to use the services when needed (Tanahashi, 1978). Effective coverage refers to the ability of the healthcare service to improve individuals' health outcomes. All the coverage elements are important in attaining desired health outcomes (Tanahashi, 1978).

The literature on access in the healthcare context describes it as a multidimensional concept (O'Donnell, 2007; Ricketts and Goldsmith, 2005). Ricketts and Goldsmith (2005) divided access frameworks into 'access as use' and 'access as fit'. In Aday and Andersen's (1974) framework, which is viewed as 'access as use' — access is measured according to the use of healthcare services, whereas the framework of Penchansky and Thomas (1981), also termed 'access as fit', measures access based on acceptability, accommodation, availability, affordability, and accessibility of healthcare services. Penchansky and Thomas's (1981) framework, which was updated by McIntyre *et al*. (2009), was used in the current study due to its comprehensiveness in defining access to healthcare services and its relevance to the study context. This framework was built on Tanahashi's (1978) framework.

Penchansky and Thomas' (1981) 'access as fit' framework shows the potential or opportunities to use the services — even if such services are not used in reality, which creates an understanding of the challenges individuals face in accessing healthcare services. A narrow focus on utilisation in resource-constrained environments following an 'access as use' framework may compromise resource allocation and increase inequity in health outcomes (Saurman, 2016). This is because the affluent often use more healthcare services than the poor, and focusing on utilisation is likely to benefit those who already have access to healthcare services, thereby neglecting the poor who need these services. The poor continue to grapple with weak access and the subsequent health outcomes, despite their clear need for such services (O'Donnell, 2007).

A further explanation by Penchansky and Thomas (1981) and McIntyre *et al*. (2009) is that access to healthcare services is a function of compatibility between the individuals who use the services and the providers thereof in the health system. O'Donnell *et al.* (2007) emphasise that

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access depicts opportunities available to people to obtain and use healthcare services in times of need. Penchansky and Thomas (1981) proposed five dimensions to access, namely affordability, availability, acceptability, accessibility, and accommodation, which were combined into affordability, availability, and acceptability by McIntyre *et al*. (2009). In a further development of Penchansky and Thomas's framework (1981), McIntyre *et al*. (2009) combined availability, accessibility, and accommodation dimensions into availability, noting that services should be provided at the right time and place to the right people. In this thesis, I focused on availability and affordability of healthcare services, due to the lack of information on acceptability in Zimbabwe’s Prices, Income, Consumption and Expenditure Survey (PICES). The availability and affordability of healthcare services are discussed below.

Availability of healthcare services considers the physical accessibility of the services at the right time and place to meet people’s needs. The availability of services to individuals relies on proximity. The distance to the closest facility is a significant challenge in accessing healthcare services in marginalised areas (McLaren *et al*., 2013; Rosero-Bixby, 2004), and if people, for example, have to travel long distances to reach healthcare facilities and services, they consider these services unavailable. Availability is also impacted by considerable variation in the availability of drugs, health workers, and equipment at facilities (McIntyre *et al.*, 2009), which is of particular concern in poor and marginalised populations (Harris *et al.*, 2011).

Affordability refers to individuals’ ability to pay for their health expenditures within their budget constraints. The affordability of healthcare services is important in determining access to healthcare services through the cost of health services and household resources (McIntyre *et al.*, 2009). The payment method used to cover healthcare costs also plays an important role in how affordable the healthcare services are. For example, OOP payments tend to be costly and unaffordable compared to pre-payments (insurance schemes). The OOP payment method constrains affordability due to the uncertainty of the availability of financial resources to cover health costs when needed (McIntyre *et al.*, 2006). Moreover, OOP payments could ultimately impoverish households and lead to a debt trap (McIntyre *et al.*, 2006; Zeng *et al*., 2018).

The dimensions of access to healthcare services are associated with inequity and inequality in health and healthcare. While the terms are often used interchangeably, it is important to distinguish the two concepts.

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1.3 Inequity vs inequality in healthcare

1.3.1 Inequity

Equity refers treating people with different circumstances differently to ensure similar outcomes for all. Luck egalitarianism, a take on distributive justice, holds that individuals with compromised circumstances should receive additional benefits to offset these circumstances (Roemer and Trannoy, 2015). Therefore, equitable distribution of resources should result in those worse off being granted, through a redistribution of resources, opportunities equal to those of the wealthy. However, the notion of luck egalitarianism is criticized by Ekmekçi and Arda (2015) and Anderson (1999) for focusing only on the results of an individual's choices, in this case related to an individual's health status, with little regard for systems and processes that may cause such inequity, such as inequality in the distribution of resources. Relational equity focuses on changing the social norms that contribute to inequality and changing the structure of public goods to reduce inequality, and not the redistribution of resources (Anderson, 1999).

Although the argument of equal opportunity is not morally acceptable when compared to Anderson's (1999) relational equity, it is important to note that people with the same conditions are supposed to be treated equally. Gulliford *et al*. (2002) also stress that to achieve equity in access to healthcare services, people with the same need should be given equal access to such services. The luck egalitarian theory is, therefore, useful in explaining the redistribution of resources to achieve equity in health. The poor tend to have more healthcare needs than the affluent, and the egalitarian view of equity favours the distribution of health resources towards them. Besides socioeconomic status, equity is also considered for people of different age groups, gender, and urban-rural differences. It is difficult to measure inequity directly, due to inadequate information on healthcare needs in household survey data. Therefore, inequity in healthcare services is measured using inequality.

1.3.2 Inequality in health

Health inequality shows disparities in health between different groups and equality entails treating everyone the same. Adam Wagstaff, a well-known researcher in the field of health inequalities, noted that there are disparate health outcomes between groups in both developed and developing countries (Wagstaff, 2002). These outcomes may be related to inequalities in the healthcare services provided or to social determinants of health (McIntyre and Ataguba,

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2015). Poor sanitation, unhealthy living and working environments, poor nutrition, and the prevalence of communicable and non-communicable diseases threaten the health of the majority in developing countries (Deaton, 2003; Lleras-Muney, 2018). Research on health inequality has, therefore, gained momentum in developing countries (Wagstaff, 2002).

Literature on health disparities in developing countries mainly focuses on child health outcomes. These child health outcomes include infant mortality, under-five mortality, malnutrition, diarrhoea, and acute respiratory infections. Existing literature notes that these child health outcomes are prevalent in developing countries, and mainly affect the poor (Lleras-Muney, 2018; Van Doorslaer *et al.*, 1997; Wagstaff, 2002). Wagstaff (2002) noted that several factors contribute to health disparities in developing countries. These factors are discussed below.

Wagstaff (2002) noted that income disparities are associated with concomitant health disparities, but found this relationship to be insignificant in developing countries, while Wagstaff and Van Doorslaer (2000) found a weak relationship between the two variables. Contrary to Wagstaff (2002) and Wagstaff and Van Doorslaer (2000), Van Doorslaer *et al.* (1997) noted that income disparities are positively and significantly related to health outcomes in developing countries.

Another factor is differences in average income per capita. The relationship between income per capita and health outcomes can be explained in different ways. Literature notes that an increase in income per capita increases health disparities, given that income elasticity increases as income increases (Wagstaff, 2002). The affluent are more likely to have the same health disparity as the poor if the income elasticity does not change with income. On the other hand, health disparity is less evident amongst the affluent compared to the poor if income elasticity changes are less than the changes in income. Consistent with Wagstaff (2002), Lleras-Muney (2018) notes that low socioeconomic status is associated with poor health outcomes. Affluent areas are, therefore, likely to have more health disparities than poor areas. Surprisingly, more health disparity is experienced in areas with strong economic growth, due to technological advances in these areas, which the affluent use to their advantage (Wagstaff, 2002). In the long run, the average income ceases to influence mortality, regardless of economic development; what matters is the income disparity (Deaton, 2003, 2013).

Public health expenditure is another factor associated with health disparities in developing countries (Wagstaff, 2002). Health expenditure enables the provision of subsidised or free

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healthcare services. It improves the health of both the affluent and the poor, but the health of the poor shows greater improvement (Wagstaff, 2002). However, Wagstaff (2002) and Van Doorslaer *et al.* (1997) found that, while increasing public health expenditure is expected to reduce health disparities, the relationship is insignificant. This is because subsidies also benefit the affluent, leaving an insufficient portion to significantly improve healthcare services delivered to the poor.

Wagstaff (2002) and Deaton (2003) note that cross-country comparative studies, country-time comparative studies, benefit incidence analysis, and decomposition analysis aid in assessing and devising policies that support the reduction of health inequalities.

Thus far, the chapter provided an overview of access to healthcare services and inequity and inequality in this domain. The following section details the current study's context, Zimbabwe, and the research contributions.

1.4 Study context

Zimbabwe has a unique history of economic and political challenges, which have affected the livelihoods of the majority of the country's citizens. Zimbabwe's myriad economic challenges, including hyperinflation in 2007/2008, have affected service delivery, particularly in the health sector (World Bank Group, 2022). Zimbabwe has a high prevalence of poverty, an erratic climate that affects food security, frequent shortages of foreign currency, and a lack of power and fuel. (Zimbabwe National Statistics Agency (ZIMSTAT), 2019). These economic challenges prevail at a time when the country has a high prevalence of the human immunodeficiency virus (HIV), tuberculosis (TB) and malaria, which are the major contributors to morbidity and mortality (United Nations Development Programme (UNDP), 2020).

The country's health sector was most affected by the 2007/2008 economic and political challenges, which resulted in constrained budget allocations, a brain drain of health workers, use of obsolete equipment, and frequent unavailability of healthcare services (Atieno *et al.*, 2022; World Bank Group *et al.*, 2017; ZEPARU, 2014). These challenges ultimately resulted in a fragmented and poorly functioning health system. Zimbabwe is considered a fragile country, given the public authorities' inability to provide essential services to the population (Atieno *et al.*, 2022). It is, therefore, important to determine the population's levels of access to healthcare services and the effects of weak access in resource-constrained environments, in

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order to address shortcomings and ensure that the population is provided with adequate healthcare services.

Low access to necessary healthcare services remains a concern in Zimbabwe, particularly for the poor and marginalised individuals (World Bank Group, 2015). According to ZIMSTAT (2019), affordability and availability are the major reasons for Zimbabweans not accessing healthcare services when the need arises, with approximately one-third of the population not accessing healthcare services due to high service costs in 2017. The poor face a high burden of diseases and compromised social determinants of health (for example, access to nutritious food, safe housing, water, and sanitation), and are less likely to use services (MoHCC *et al.*, 2015). In the event that they use the services, the poor tend to use public facilities, and are more likely to incur catastrophic health expenditures than the affluent (ZEPARU, 2014).

Despite the challenges outlined above, the government, through the Ministry of Health and Child Care (MoHCC), remains committed to its overall purpose of promoting health and quality of life of Zimbabweans through equitable distribution of health resources (MoHCC, 2017). To ensure a healthy population, there is a need for effective and efficient resource allocation and high-quality healthcare services that are readily available to everyone at an affordable price.

1.4.1 Healthcare service availability and readiness in Zimbabwe

To what extent are the services available and ready to improve service provision and serve the population of Zimbabwe? This question is answered using the information from a Zimbabwe Service Availability Readiness Assessment (ZSARA) survey,[3] conducted in 2014, to examine the service delivery, inclusiveness of service availability, and facilities' readiness to provide basic healthcare interventions. The availability of healthcare services in Zimbabwe is shown in Figure 1.1.

[3] The assessment provides a clear picture of the service availability and readiness in Zimbabwe for both public and private facilities, which is used to determine the level of service delivery in the healthcare sector. An international standard questionnaire was used in the assessment. The assessment is deemed appropriate to generate reliable information on health service delivery, which informs health interventions. The survey used in the current study included 275 facilities in the 10 provinces of Zimbabwe. Three aspects were assessed in the survey: service availability, general service readiness, and service-specific readiness. The data were collected from private, public, and mission facilities.

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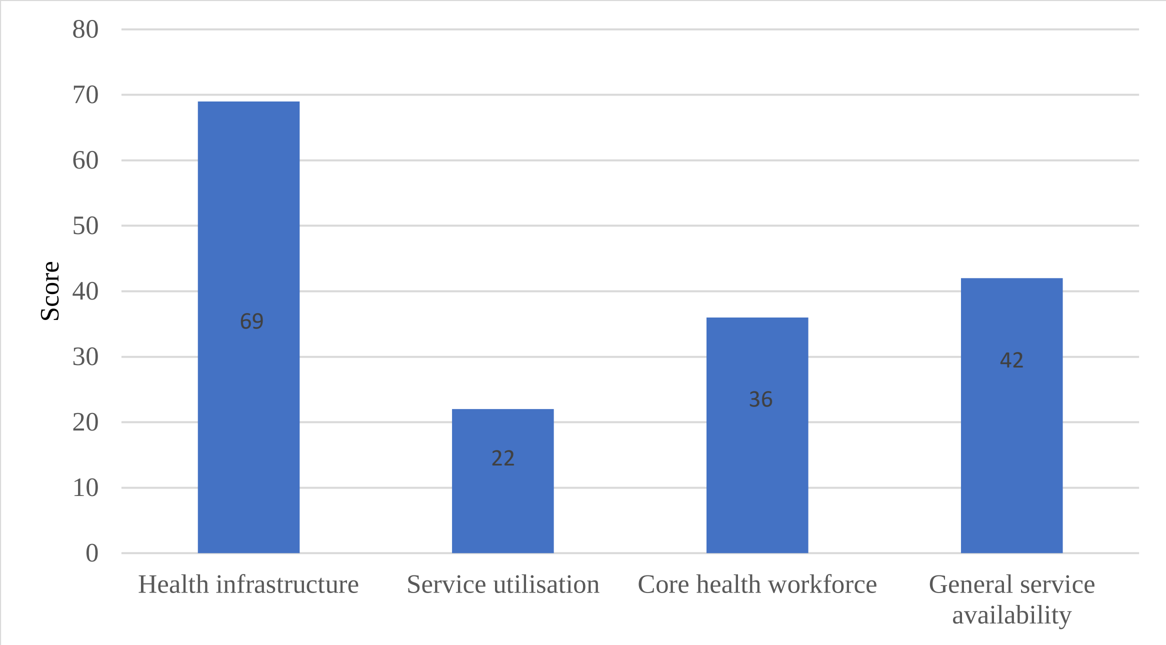

Figure 1.1: Health service availability and its components in Zimbabwe

Source: Illustration using data from ZSARA (2015)

Figure 1.1 shows the extent to which services were available in 2014 in Zimbabwe. General service availability encompasses the physical presence of healthcare service delivery aspects, namely health infrastructure, service utilisation, and core health workers. These three components are averaged to calculate the general service availability score. In the 2015 assessment, the score was 42%, as indicated in Figure 1.1. This shows that healthcare service availability was low, and might have been one of the major factors compromising health service provision. Health infrastructure is the most available element within the health system, followed by the core health workforce and lastly, service utilisation.

Zimbabwe was hard hit by a brain drain that affected the availability of health workers (Osika *et al.*, 2010). The WHO recommends 23 workers per 10 000 people (health worker density), and Zimbabwe had only eight workers per 10 000 people (ZSARA, 2015). According to ZSARA (2015), urban areas had a higher health worker density than rural areas, mainly due to central and provincial hospitals with more workers situated in urban areas. Facility density was also less than what is recommended by the WHO (MoHCC, 2017). This indicated limited health resources in Zimbabwe, compromising adequate service provision to the population.

The general service readiness index also showed how prepared the services (including basic amenities, basic equipment, essential medicines, and diagnostic testing) were to serve the

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population (ZSARA, 2015). According to ZSARA (2015), health services readiness for communicable diseases was relatively high for HIV/AIDS, malaria, TB, and sexually transmitted infections (approximately three-quarters of the facilities had at least one of these services during the survey). However, intermittent preventive treatment in pregnancy (IPTp) and insecticide-treated nets (ITNs) were the least available malaria-related provisions (ZSARA, 2015), despite their importance in improving maternal and child health outcomes. Approximately one-quarter of the facilities had all the standard precautionary items (such as syringes, latex gloves, soap and water, to mention a few), and only 26% of the facilities had all the drugs listed in the survey (ZSARA, 2015). On average, facilities in urban areas had higher service availability and readiness in the form of infrastructure, equipment, essential services, and health workers than in rural facilities.

Shortages of healthcare services compromise the provision of healthcare services to the population. From the above, it is evident that poor service readiness and availability are prevalent in Zimbabwe, and compromise individual health outcomes (Atieno *et al.*, 2022). Zimbabwe did not achieve the Millennium Development Goals in 2015, and is now aiming to achieve the SDGs by 2030 (MoHCC, 2016; UNDP, 2020). However, the attainment of SDGs is threatened by several challenges, despite government efforts. Zimbabwe is amongst the countries with the highest maternal and child mortality in sub-Saharan Africa (SSA) (ZIMSTAT and ICF International, 2016; ZSARA, 2015). In addition, poor nutrition, HIV, TB, and malaria remain major causes of morbidity and mortality in the country (MoHCC, 2017). These concerns, together with poor access to healthcare services, hamper the country's efforts to ensure equal opportunities in healthcare services and to attain the country's Vision 2030: "Towards a Prosperous and Empowered Upper Middle-Income Society by 2030, with Job Opportunities and High Quality Life for its Citizens" (Government of Zimbabwe, 2018:3). To ensure the attainment of health goals, availability and readiness of healthcare services should be complemented by strong health sector financing.

1.4.2 Health sector financing in Zimbabwe

Zimbabwe's weak macroeconomic environment has resulted in a decrease in public health expenditure, weakening the health system (Atieno *et al.*, 2022; ZSARA, 2015). The health system is financed by the government, external funders, private organisations, and households. The health system is fragile and fragmented, with health financing characterised by limited government budget allocations, high OOP expenditure, and an overreliance on external

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funding, which is the case in most developing countries (Kamvura *et al.*, 2022; World Bank Group, 2015). These characteristics limit developing countries from achieving UHC and SDGs, as individuals are often subjected to high health service costs.

Figure 1.2 illustrates Zimbabwe's health expenditure by government, private sector (OOP expenditure and voluntary insurance), and external funders from 2010 to 2019.

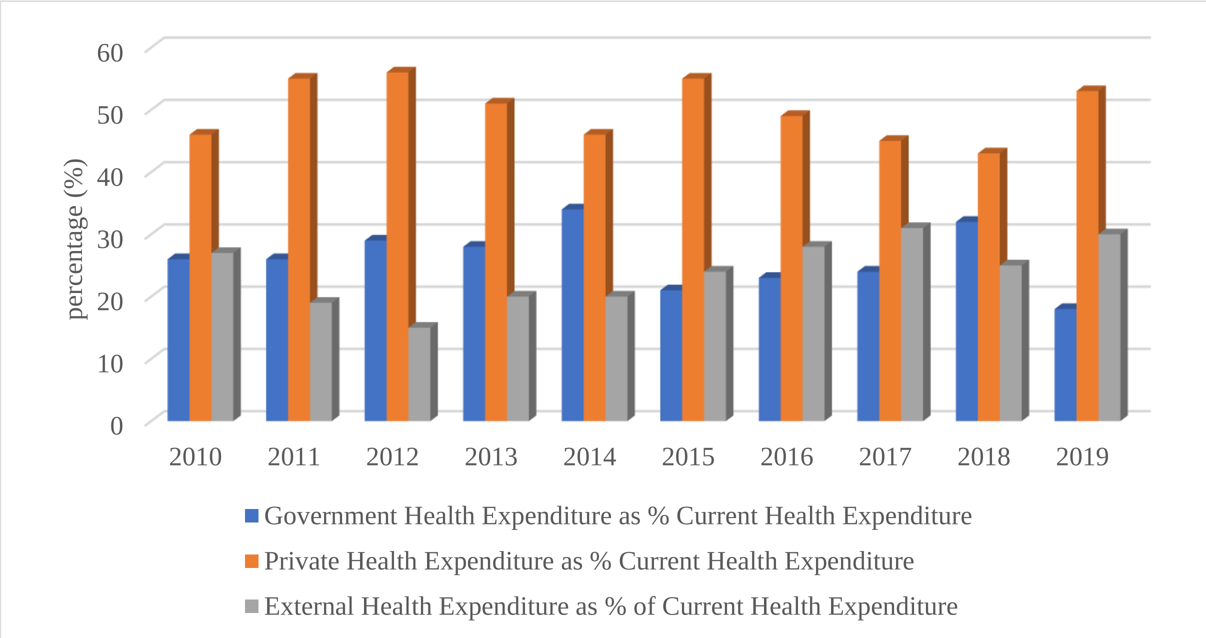

Figure 1.2: Health expenditure in Zimbabwe

Source: Illustration using National Health Accounts (NHA) data. Health expenditures were adjusted for inflation (real values).

Figure 1.2 shows high private sector health expenditure over the period 2010 to 2019, followed by external health expenditure, with government expenditure being the lowest. The private sector contributed more than two-fifths of the total health expenditure, while external funders contributed one-quarter. The government's contribution towards health expenditure was less than one-third of the total expenditure, showing the health sector's dependency on private and external health sources of funding.

In 2019, the government's contribution to the health sector was 18%, the private sector's contribution was 52% (25% OOP expenditure and 27% voluntary prepayments), and external funders contributed 30%. The World Bank Group (2015) noted that 80% of the government expenditure were absorbed by salaries, leaving capital investments and other essential

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healthcare services underfunded. Furthermore, health expenditure was unequally distributed amongst health facilities. Major hospitals received a greater portion of government health expenditure than primary healthcare facilities (Shamu *et al*., 2017; World Bank Group *et al.*, 2017).

Government expenditure in Zimbabwe is disbursed by the National Treasury to the MoHCC. The MoHCC then allocates funds to different regions through the provincial directorate (ZEPARU, 2014). The funds are then distributed to health facilities in different districts, to ensure that everyone benefits from these public resources. In 2015, the government contributed 21% of the total health expenditure, with households contributing 25% through OOP expenditure (AHFoZ, 2016). Zeng *et al*. (2018) and World Bank Group *et al.* (2017) emphasise that the government's contribution to the health sector indicates its commitment to improving healthcare service delivery. Deaton (2013) emphasises that governments do not always allocate sufficient resources to improve individuals' health and well-being, despite the resources being available.

Focusing on formal declarations and health expenditure, Zimbabwe is still behind in the attainment of the 15% contribution stipulated in the Abuja Declaration of 2001 (MoHCC, 2016). The UNDP (2020) noted that governments should increase health sector contributions to attain UHC. The current health expenditure as a proportion of Zimbabwe's gross domestic product did not change significantly between 2015 (7%) and 2019 (8%) (WHO, 2021). The Zimbabwean government's health sector contribution is still low compared to that of its regional peers. However, health expenditure in Zimbabwe was more than that of other low-middle income countries in the Southern African Development Community (SADC) region in 2019, including the Congo Republic (2%), Angola (3%), Tanzania (4%), Zambia (5%), and Eswatini (7%) (WHO, 2021). These figures reflect governments' efforts to reduce the challenges with which the health sector is grappling (Zeng *et al.*, 2018), and that Zimbabwe has made greater investments in improving health service provision than its regional peers with similar incomes. Besides strong health sector financing, efficient health service delivery is also important in ensuring universal access to services in Zimbabwe.

1.4.3 Healthcare services delivery in Zimbabwe

Zimbabwe has a dualistic health sector in the form of public and private health facilities. Public facilities consist of central hospitals, provincial hospitals, district hospitals, rural health centres, village health workers, council clinics, mission facilities, and polyclinics. Private facilities

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include private hospitals, pharmacies, and private clinics. Public facilities are the major providers of healthcare services in Zimbabwe, constituting 70% of facilities; the remaining 30% are provided by the private sector (ZEPARU, 2014). Rural areas have more public facilities and fewer private facilities, while these facilities are more proportionate in urban areas. Urban facilities tend to serve small catchment areas, while rural facilities serve a large catchment area, due to sparse population (Isbell and Krönke, 2018; Osika *et al.*, 2010). Individuals also consult traditional healers and spiritual leaders, which are regarded as unconventional healthcare.

The public health sector in Zimbabwe is four-tiered: quaternary, tertiary, secondary, and primary healthcare, which are linked through a referral system (ZSARA, 2015). Referrals are made from low-rank to high-rank facilities. The quaternary is the highest level of healthcare provision, which consists of six central hospitals offering specialised services and treating patients referred from the tertiary level. Quaternary facilities are located in the two major cities of Zimbabwe: Harare and Bulawayo. These facilities specialise in complex illnesses, such as those that require surgery. As the highest level of referral in Zimbabwe's healthcare sector, quaternary facilities are better equipped than those on other levels, and provide higher-quality healthcare services (Osika *et al.*, 2010). Tertiary facilities offer specialised services at the provincial level that are sometimes not available at the secondary level. These facilities are managed by the provincial medical directorate (Osika *et al.*, 2010). According to Shamu *et al*. (2017), these high-level facilities are located in urban areas, and are more likely to be used by the affluent population. The tertiary level consists of eight provincial hospitals that treat people with complicated ailments referred from the secondary health facilities.

District hospitals are part of the secondary health facilities, and treat patients with emergencies and complicated cases referred from the primary level, although these facilities sometimes act as the point of entry into the health system (Osika *et al.*, 2010). Most of the districts in the country have a district hospital. These facilities are managed by hospital- and district health committees (Osika *et al.*, 2010). The primary level is the lowest level of healthcare, and is the point of entry into the health system. The primary level consists of village health workers, rural health centres, rural hospitals, municipality clinics, and polyclinics. They provide treatment for less complicated ailments, and are usually staffed with nurses and other lower-level health workers (MoHCC, 2017). The majority of health facilities in Zimbabwe offer primary healthcare services (MoHCC, 2017; Osika *et al.*, 2010). Village health workers provide first-aid treatment to community members, and encourage them to consult health workers when ill

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(Osika *et al.*, 2010). The primary healthcare workers are considered the gatekeepers of the health system. However, there are no proper mechanisms to ensure adherence to the referral system; thus, individuals can seek primary care from secondary facilities (Osika *et al.*, 2010).

The majority of Zimbabweans use public over private healthcare facilities for medical attention. Public facilities are affordable and available across the country, offering free services for certain groups of people (ZEPARU, 2014). However, most public facilities are characterised by long waiting queues, shortages of skilled health workers, poor-quality services, and frequent unavailability of medicines (Mangundu *et al*., 2020; ZEPARU, 2014). These facilities are used mainly by low-income earners. Public health facilities in Zimbabwe are located far from the communities within the facilities' catchment areas (ZEPARU, 2014). This is particularly challenging for rural populations, who are affected by poor transport infrastructure, necessitating that individuals travel long distances to access the healthcare services they need (Osika *et al.*, 2010).

Private health facilities complement the services offered by public facilities. These facilities are equipped with state-of-the-art equipment that enables them to offer high-quality services, conveniently, efficiently, and effectively (ZSARA, 2015). Private facilities survive through profit maximisation — charging high prices for healthcare services. Thus, the services offered by private facilities tend to be unaffordable for the majority of Zimbabweans (Osika *et al*., 2010). These services are used mostly by affluent Zimbabweans and those who have health insurance coverage. Private facilities' reliance on high OOP payments excludes the poor from this system (Mugwagwa, 2017; Osika *et al.*, 2010).

Due to frequent drug stockouts in public facilities, individuals, especially those with serious chronic conditions, tend to buy from pharmacies, where the drugs are always available, but are expensive (Buzuzi *et al.*, 2016). As a result, these individuals could incur catastrophic health expenditures, or may opt to forgo the formal treatment they need (Buzuzi *et al.*, 2016; Gilson and McIntyre, 2007). The wealthy benefit from the quality of the service offered in the private health sector, and they often also have private health insurance. Government-managed insurance is available, but is offered mainly to individuals employed in the public sector. Depending on the government-managed health insurance plan, individuals with health insurance can access services through public and private facilities. Only a small proportion of the population — 7% — has private health insurance, while poor, unemployed, and rural populations are exposed to high OOP health expenditures (ZIMSTAT, 2020). Most

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Zimbabweans pay for their services using OOP expenditures, which can be catastrophic, leading to poverty and a debt trap.

The government of Zimbabwe has implemented several health reforms to improve access to healthcare services. These reforms include the user-fee exemption; support for those with HIV, malaria, and TB; decentralisation of healthcare provision and delivery; the use of results-based financing;[4] and providing primary healthcare (MoHCC, 2017; MoHCC *et al.*, 2015; ZEPARU, 2014). The health reforms are aimed at reducing the persistent maternal, infant-, and under-five mortality; increasing the use of healthcare services; and reducing disparities in health outcomes. However, these government reforms, particularly user-fee exemptions, are not always backed by sufficient resources, resulting healthcare service providers charging a fee for the service (MoHCC *et al.*, 2015).

The government has also improved services such as immunisation, antenatal care (ANC), skilled birth attendance, and malaria and HIV care (MoHCC *et al.*, 2015; World Bank Group, 2015). According to the MoHCC *et al.* (2015), the introduction of primary healthcare after independence in 1980 improved the availability of healthcare resources in Zimbabwe. This improved healthcare coverage and reduced inequalities in access to healthcare services. The removal of user fees for pregnant women's and children's healthcare services at the point of care also improved access to these services (MoHCC *et al.*, 2015). However, despite these improvements, access and equality in healthcare services remain a challenge (MoHCC, 2016). The situation is exacerbated by compromised access to water and sanitation, low government health financing, persistent inequality in HIV services uptake, and late access to healthcare services (MoHCC, 2017; MoHCC *et al.*, 2015), leading to, amongst others, high maternal and child mortality. The fragile and fragmented health system worsens these challenges, and more needs to be done to attain UHC (UNDP, 2020).

In conclusion, despite the implementation of user-fee exemptions and results-based financing reforms, many Zimbabweans still fail to access healthcare services, and face catastrophic health expenditures if they do access the services (Zeng *et al.*, 2018). Maternal and child health outcomes are compromised notwithstanding various reforms implemented by the authorities to safeguard this vulnerable population (MoHCC, 2016). Although results-based financing has increased access to healthcare services, the programme has not yet been implemented on the

[4] Results based financing involves the user fee exemption for the specific groups to increase to health care services at an affordable cost, especially the pregnant women and under five children.

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national level, and is still donor-dependent (MoHCC, 2016). In addition, results-based financing only covers a few healthcare services. Therefore, despite efforts to improve the health system's performance, inclusiveness and quality of healthcare services remain a challenge. This study, therefore, focused on the public health sector, given its prominent role in providing healthcare services in Zimbabwe. In addition, data on private sector services are not available, making it difficult to fully assess access to these services in Zimbabwe.

1.4.4 The data

Many developing countries grapple with data challenges that limit research to devise evidenced-based and effective policies and interventions. Zimbabwe is also faced with limited availability of data, which has a detrimental effect on research in the healthcare environment. Due to these challenges, few studies have been conducted in Zimbabwe on access to healthcare services and fiscal incidence (Agere, 1990; Makate and Makate, 2017; Mangundu *et al.*, 2020; Matshalaga, 2000; Shamu *et al.*, 2017; Zeng *et al.*, 2018).

The data used in this thesis are not publicly available, but were requested from respective government authorities, specifically MoHCC and ZIMSTAT. Bureaucracy was a major challenge, despite the data being available. It took approximately a year to get the data needed to conduct the analysis. I started requesting the data from the responsible authorities in April 2020, when I sent the first letter requesting the data and other documents to the authorities via DHL from South Africa to Zimbabwe. I followed up on the request through emails and telephone calls, and was redirected from one office to another, with no success. This process was further hampered by the COVID-19 lockdown regulations, as most individuals worked remotely. My study supervisors then encouraged me to attempt gathering the necessary data physically, in Zimbabwe. I attempted to do so in December 2020, to no avail. I only received the data in March 2021, after numerous follow-ups, physically and virtually, with the help of individuals in respective departments. Needless to say, the process of gaining authorisation was complicated.

To the best of my knowledge, no study has been conducted using these datasets. The novelty and contribution of the thesis are based on the use of rich data sources that are not publicly available. Given a clear background of the health sector and data challenges in Zimbabwe, the thesis was aimed at elucidating some of the challenges that the health sector experiences, as well as their implications for individuals’ health outcomes.

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1.5 Research aims and contribution

While many governments strive to ensure universal access to healthcare services, the costs are often prohibitive. Access to healthcare services remains a challenge, which, in developing countries, is exacerbated by the high prevalence of diseases. Weak access to healthcare services increases the number of people dying from preventable and treatable diseases, and derails the attainment of health goals. Several studies have examined access to healthcare services in developing countries, and found that access is still a challenge for the majority (Agere, 1990; Burger and Christian, 2018; Harris *et al.*, 2011; McIntyre and Ataguba, 2015; Zeng *et al.*, 2018). The affluent tend to benefit more from better access to services than the poor, and the health benefits of systems mostly accrue to individuals who have less need for these services. This inequality in health access will continue increasing if the necessary policies are not put in place. Although there is extensive literature on fiscal incidence and access to healthcare services, a reinvestigation of the subject using recent datasets is needed to determine if countries are still on track to attain United Nations Vision 2030.

Empirical evidence on fiscal incidence and inequality in access to healthcare in Zimbabwe is limited. The existing literature on inequality in incidence of fiscal expenditure in Zimbabwe was conducted using a 2010 NHA dataset and analysing the subject using a recent PICES dataset is helpful given the deterioration of the country’s economic situation. Most studies conducted in Zimbabwe have focused on inequality in specific maternal and child health outcomes, and less on access to healthcare services in general. This thesis, therefore, examined inequality in access to general healthcare services.

Developing countries face a high prevalence of diseases like malaria, HIV, and TB. Given the inefficient health systems in these countries, frequent shortages of crucial healthcare services are rampant, including drug shortages. Prior studies examined the causes of antiretroviral or anti-tuberculosis drug stockouts and their effects on health outcomes in developing countries (for example, Koomen *et al*., 2019; Pasquet *et al.*, 2010; Qiu and Dungca, 2015; Seunanden and Day, 2014). However, studies that have examined the health implications of drug stockouts paid less attention to the association between malaria prophylaxes stockouts and health outcomes, despite these drugs' importance in improving maternal and birth outcomes.

While drugs may be available when looking at the national level, regional drug stockouts could be cause for concern, and focusing on regional inequality will enable more effective allocation and distribution. Different regions suffer from drug stockouts differently, according to their

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level of development or wealth. Thus, it was expected that affluent regions would have a lower prevalence of drug stockouts compared to poor regions. It was, therefore, considered important to investigate if regional wealth influences the magnitude and extent of drug stockouts in that region. Although some studies investigated spatial inequality in regional wealth and healthcare services separately, the existing literature pays little attention to spatial inequality in drug stockouts and the association between drug stockouts and poverty at the regional level.

This thesis, therefore, addressed the outlined gap in the form of three separate papers, each presented in a chapter. The thesis contributes to the existing body of knowledge by investigating: (1) fiscal incidence and inequality in access to healthcare services in Zimbabwe; (2) the spatial inequality in drug stockouts and the relationship between drug stockouts and district poverty in Zimbabwe using spatial analysis; and (3) the association between malaria prophylaxis stockouts and birth- and maternal outcomes in Zimbabwe.

The first paper (in Chapter 2) examines fiscal incidence and inequality in access to healthcare services (for availability and affordability) in Zimbabwe. After that, the paper examines the determining factors of inequality in the availability and affordability of healthcare services. The 2017 government health expenditure and PICES data were used in the analysis. The paper notes that the poor more often use healthcare services from low-level facilities, while the affluent frequently visit high-level facilities in Zimbabwe. In addition, fiscal incidence is pro-poor for public clinics, and pro-rich for public hospitals. Although government health expenditure is pro-poor for public clinics, access to healthcare services remains a challenge in Zimbabwe, particularly for poor and rural populations. Urban–rural differences in development contribute to pro-rich inequality in the availability and affordability of healthcare services.

The second paper (in Chapter 3) focuses on spatial inequality in drug stockouts, and explores the relationship between district-level drug stockouts and poverty in Zimbabwe. Using thematic maps, drug stockouts are shown to be highly prevalent, and these have increased over time. Spatial inequality in drug stockouts and poverty also exists. The correlation between drug stockouts and district poverty varies across districts using descriptive statistics. Some districts showed a strong relationship, while others showed a weak relationship. However, using the spatial autoregressive (SAR) model, the national association between drug stockouts and district poverty was negative and insignificant. The reason is that the majority of the districts in Zimbabwe have high levels of poverty, making it difficult to explain the relationship between stockouts and poverty prevalence. Positive spatial autocorrelation in drug stockouts (hot spots)

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also exists, evident in a more intense clustering of districts with a high prevalence of drug stockouts. This shows that drug stockouts occur at a higher level than district level. Furthermore, healthcare resources are not proportionate to the population in need. Warehouses and health facilities are located in districts with a lower population density, and show few resources and backup in times of drug stockouts. Individuals, therefore, tend to opt for alternative mechanisms to smooth their access to healthcare services during drug stockouts at the point of care.

The third paper (in Chapter 4) focuses on the health outcomes of weak access to healthcare services due to unavailability of drugs. Against this backdrop, the third paper examines the association between malaria prophylaxis stockouts and birth- and maternal health outcomes in Zimbabwe. Linking the Zimbabwe Demographic Health Survey (ZDHS) and drug stockout data using Global Positioning System (GPS) coordinates, the results showed the presence of regional disparities in stockouts, low birth weight, and maternal anaemia. Malaria prophylaxis stockouts are prevalent, and have increased over time, with the malaria-endemic and less malaria-endemic districts facing stockouts. Malaria prophylaxis stockouts are significantly associated with the birth weight of neonates, especially neonates with average birth weight. These neonates tend towards the lower end of normal birth weight (2.5 kg to 3.0 kg), making them prone to various developmental disabilities.

Chapter 5 provides a summary of the results and the conclusions of the thesis, together with policy recommendations. Weak access to healthcare services is prevalent in Zimbabwe, skewed towards poor, marginalised, and rural populations. The weak access to healthcare services indicates a need to improve health resource allocation to enhance the provision of healthcare services. Policymakers should strive to reduce inequalities in the health system. The thesis provides policymakers and other stakeholders an empirically grounded understanding of inequality and access to services, to assist in the attainment of SDGs 1, 3, and 10. The thesis reveals spatial inequalities in healthcare service provision (drug stockouts), to inform the appropriate allocation of resources to those who need them, and to eliminate disparities. Moreover, the research adds to the existing literature on inequality and access to healthcare services in resource-constrained environments, specifically in the context of Zimbabwe. The research provides empirical evidence that could inform policies aimed at attaining equitable distribution of healthcare services in resource-constrained environments. The chapter also highlights the limitations of the study and avenues for further research.

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1.6 Summary

Zimbabwe is highly burdened by communicable diseases, which can be prevented and treated at a low cost, at low-level facilities. However, Zimbabwe's citizens face challenges in access to such care, hampering the attainment of universal health access. This chapter provided an overview of access to healthcare services, inequity and inequality, healthcare services' availability and readiness, healthcare financing and healthcare service delivery. The research aims and contributions were also explained in this chapter.

The outline of the rest of the thesis is as follows: Chapter 2 examines fiscal incidence and inequality in access to healthcare services in Zimbabwe. Chapter 3 examines spatial inequality in drug stockouts and the relationship between drug stockouts and district poverty in Zimbabwe. In Chapter 4, the thesis focuses on the relationship between drug stockouts and birth weight and haemoglobin levels in Zimbabwe, as pregnant women and neonates are vulnerable to malaria. The thesis provides a concluding section in Chapter 5.

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Chapter 2

Fiscal incidence and inequality in access to healthcare services in Zimbabwe

2.1 Introduction

Understanding inequalities and contributing factors in the health sector is crucial to making informed decisions and accelerating UHC (Cai *et al.*, 2017). Disparities in access to healthcare services are preventable and unjust, and disadvantage vulnerable and marginalised groups (Harris *et al.*, 2011). Evidence from previous studies has shown that, although access to healthcare services is deemed everyone's right, the majority of people suffer inequality in access (Ahmed, 2022; Matshalaga, 2000). According to the WHO (2019a), approximately half of the world's population does not have access to basic healthcare services when ill and, without remedial action, this share is expected to reach two-thirds by 2030. The weak access to healthcare services is attributed to long distances to the health facilities, high service and transport costs, unpredictable waiting times, and the opportunity cost of accessing the services (Peters *et al.*, 2008). Similarly, it is crucial to understand inequality and the contributing factors in Zimbabwe's health sector in order to attain UHC.

Access to healthcare services is still a challenge in Zimbabwe (Isbell and Krönke, 2018; Mangundu *et al.*, 2020; Matshalaga, 2000). This is amidst a high disease burden, including a high prevalence of HIV (12.7%) and malaria (29%). Zimbabwe also has a higher incidence of TB than other SSA countries (210/100 000) (The Global Fund, 2020). Together, HIV, TB, and malaria are responsible for about one-fifth of morbidity and mortality in Zimbabwe (MoHCC, 2014, 2017), and these diseases are also major contributors to inpatient and outpatient treatment (MoHCC, 2014). The diseases can be treated and prevented if healthcare services are accessed early. To ensure access to healthcare services by everyone, and to protect citizens from catastrophic and debilitating health expenditures, the government adopted UHC in 2009 (MoHCC, 2017). Notwithstanding these attempts, access to healthcare services for all remains a public health challenge in Zimbabwe.

ZIMSTAT notes that high poverty prevalence worsens access to healthcare services, as individuals struggle to make a living from limited available resources (ZIMSTAT, 2019). Individuals are forced to make trade-offs between healthcare and other basic services when ill, and eventually forgo the medical attention they need. Furthermore, the fear of expensive services reduces access, and individuals then pay very high costs and higher risks of mortality

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when only accessing treatment in the later stages of illness (ZEPARU, 2014). The access challenge is exacerbated by the fact that few individuals have insurance coverage in Zimbabwe (ZIMSTAT, 2020), with the majority of the population reliant on OOP payments. In addition to the cost of treatment, distance to the facilities is also a challenge in accessing essential services, with more than 60% of the population having to travel at least 5 km to the nearest health facility (ZIMSTAT, 2019). These access challenges are concentrated amongst the poor, who represent a greater than proportional share of the country's health needs.

Apart from the above, differences in development between rural and urban areas contribute to disparities in access to healthcare services. Rural areas are underdeveloped and mostly suffer from rudimentary infrastructure, and shortages of health workers, drugs, and medical equipment (Burger and Christian, 2018; MoHCC, 2017). According to Isbell and Krönke (2018), rural populations tend to reside much further from the facilities, and also have fewer transport options than the urban population of Zimbabwe, making it difficult for them to use healthcare services when needed. Therefore, rural households suffer from weak access to services due to unaffordable services and long distances to the nearest facility (Isbell and Krönke, 2018; ZEPARU, 2014).

To improve healthcare service provision, the government has to manage scarce resources in contributing to the health sector (Castro-Leal *et al.*, 2000). The distribution of government health expenditure to different people is referred to as 'fiscal incidence'. Fiscal incidence is aimed at ensuring that the poor and vulnerable benefit from healthcare services, to improve their health outcomes, productivity, and living standards (Castro-Leal *et al.*, 2000; O'Donnell *et al.*, 2007). The government health expenditure specifically aims to benefit the needy, to reduce inequality in access to healthcare services and health (Ataguba and McIntyre, 2012; Shamu *et al*., 2017). However, in reality, fiscal incidence analysis often shows that government health expenditure benefits the affluent at the expense of poor households, who tend to have a greater need for such care.

Gwatkin *et al*. (2004) note that health systems in developing countries are almost universally inequitable, with the affluent benefitting more from health resources. Very few studies have found that the poor benefit more than the affluent from government health expenditures. Studies by Akazili *et al.* (2012) on Ghana, Chuma *et al*. (2012) on Kenya, Ataguba and McIntyre (2012) on South Africa, Mtei *et al.* (2012) on Tanzania, O'Donnell *et al.* (2008) on Vietnam, O'Donnell *et al.* (2007) on Asia, Chakraborty *et al*. (2013) on India, and Shamu *et*

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al. (2017) on Zimbabwe found that government health expenditure in low-level and high-level facilities benefits the affluent population. However, Van der Berg (2009) and Burger *et al.* (2012) found that public health expenditure benefits the poor in public facilities in South Africa. This may be due to the affluent in South Africa having high private medical insurance coverage, and therefore tending not to use public facilities. In addition, the latter studies focused on primary healthcare services, which are targeted at poor households. This indicates the need for further investigation of the conditions under which health services can be pro-poor.

Extant literature also notes that challenges in access to healthcare services include availability, affordability, and accessibility, which affect mostly the poor and rural populations in developing countries (Burger *et al.*, 2012; Burger and Christian, 2018; Harris *et al.*, 2011; McIntyre *et al.*, 2006; Rosero-Bixby, 2004; Zeng *et al.*, 2018).

Several studies have been carried out on fiscal incidence (Akazili *et al.*, 2012; Ataguba and McIntyre, 2012, 2013; Burger *et al.*, 2012; Castro-Leal *et al.*, 2000; Chakraborty *et al*., 2013; Macha *et al.*, 2012; Mtei *et al.*, 2012; O'Donnell *et al.*, 2007; Shamu *et al.*, 2017; Van der Berg, 2009) and access to healthcare services (Burger and Christian, 2018; Harris *et al.*, 2011; Rosero-Bixby, 2004). However, most of these studies addressed only one aspect, either fiscal incidence or access. Burger *et al.* (2012) and Macha *et al.* (2012) investigated inequality in both fiscal incidence and access to healthcare services. Analysing both fiscal incidence and access will better inform effective and equal resource allocation to achieve UHC (Orjingene *et al.*, 2022). This follows the notion that benefit incidence analysis and decomposition analysis help inform the reduction of the health inequalities that exist in developing countries (Wagstaff, 2002). This chapter examines both fiscal incidence and inequality in access to healthcare services, as well as the factors contributing to inequality in access in Zimbabwe.

To the best of my knowledge, only the study by Shamu *et al.* (2017) has investigated fiscal incidence in Zimbabwe, using 2010 NHA data, which provide comprehensive health information appropriate for benefit incidence analysis. However, the economic situation in Zimbabwe has deteriorated since 2010, and a reanalysis of the subject using a recent dataset was considered useful to determine whether disparities have become starker or not in this financially constrained environment. Shamu *et al.*'s (2017) findings provided a baseline in determining whether fiscal incidence had changed over time in the country. Prior studies on inequality in access to healthcare in Zimbabwe focused specifically on targeted maternal and

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child healthcare access (Lukwa *et al.*, 2022; Makate and Makate, 2017). Therefore, the present chapter explored inequality in health access for the general population, which takes a less targeted approach, and where inequities are expected to be larger. This approach also aligned with the government's and international organisations' agenda to achieve equitable access to healthcare services for everyone, and not only specific groups.

This chapter provides an empirical assessment of fiscal incidence and inequality in access to healthcare services in Zimbabwe. The chapter contributes to the existing body of knowledge through a determination of inequality in the affordability and availability of healthcare services in Zimbabwe, including urban–rural differences. The results could assist policymakers in making informed decisions to alleviate disparities in access to healthcare.

The subsequent section provides a review of the conceptual framework used in the current chapter. Section 3 provides information on the data sources used, and Section 4 details the measures and methods used. The estimated results are presented in Section 5 and discussed in Section 6. Section 7 concludes the chapter.

2.2 Conceptual framework

Figure 2.1 shows a conceptualised framework of access to healthcare services, adapted from Peters *et al.* (2008), with equality at the centre of the framework. The ultimate goal of the framework is to ensure that everyone has equal access to healthcare services, based on their needs and without challenges. To achieve substantive equality, access to healthcare services is assessed using three criteria, namely its availability, affordability and acceptability to users. These dimensions are, in turn, influenced by individual and household factors and government health expenditure. The individual and household factors include, but are not limited to, age, gender, urban–rural differences, marital status, socioeconomic status, household size, employment, education, and health insurance. Policymakers pursue greater equality in service delivery by addressing the availability, affordability, and acceptability of health services either directly or via policies to boost the amenable individual characteristics influencing access, such as educational attainment and employment (Aday and Andersen, 1974).

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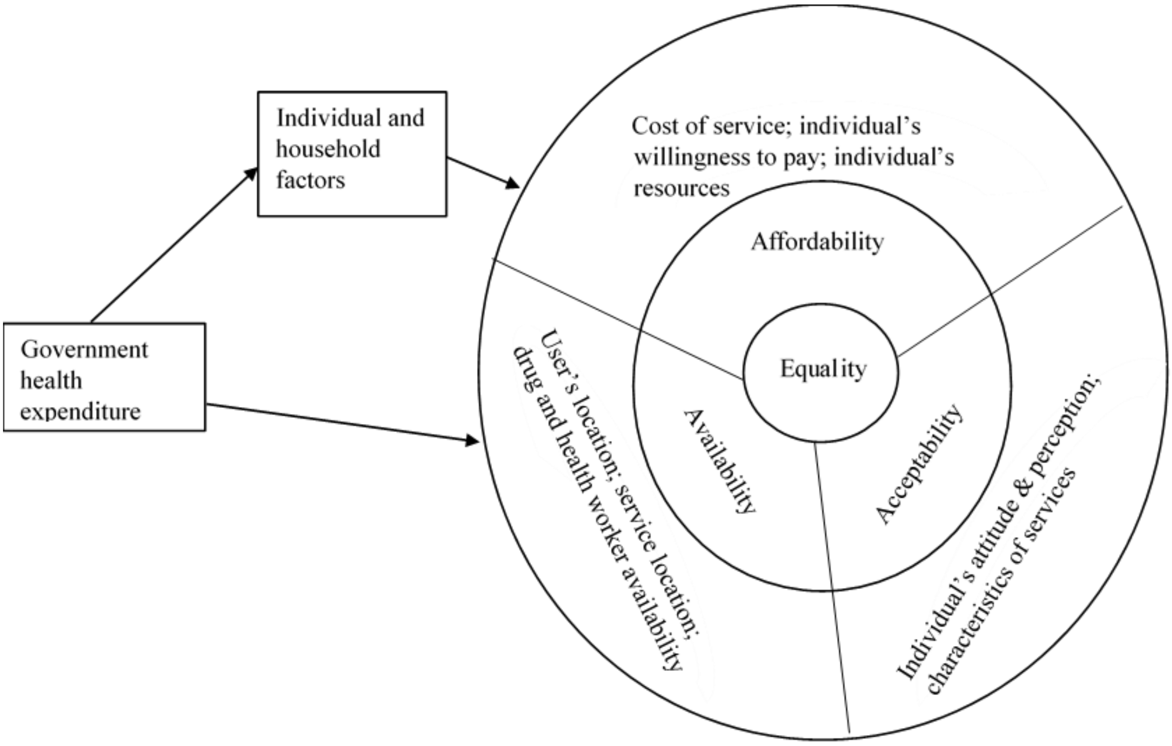

Figure 2.1: Conceptual framework of access to healthcare services

Source: Adapted from Peters et al. (2008)

2.2.1 Individual and household factors

Focusing on individual and household factors of access, Anselmi *et al.* (2015) posit that inequality in health and healthcare services is strongly related to household socioeconomic indicators, which vary across regions. Affluent households are more likely than poor households to access healthcare services (Peters *et al.*, 2008). This is because affluent households have more financial resources than the poor to acquire services, even if these are far away or are offered by the more expensive private sector. The poor face service- and transport costs that are beyond their financial capacity. This view is supported by Burger and Christian (2018) and Harris *et al.* (2011) in South Africa. Uninsured, unemployed, uneducated, and rural populations are also likely to have weak access to healthcare services, due to high OOP expenditures and transport costs. However, Ataguba and Goudge (2012) found that those with health insurance are more likely to incur high OOP expenditures with increased utilisation of healthcare services in private facilities not covered by insurance, and also due to high co-payments, compared to the uninsured.

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Urban–rural differences also affect access to healthcare services. Rural areas are more likely to be underdeveloped, and are associated with long distances to the closest facility than urban areas. The remoteness of the rural areas is also associated with rudimentary infrastructure, which increases the travel time and cost, thereby reducing access to healthcare services (Burger and Christian, 2018; Harris *et al*., 2011). Aday and Andersen (1974) and Gilson and McIntyre (2007) note that rural and urban populations have unequal access to healthcare services, as rural facilities frequently grapple with shortages of health workers, equipment, and drugs. Transport availability remains a challenge even when healthcare services are provided for free (Rosero-Bixby, 2004), as the urban population is more likely to have access to private vehicles than those in rural areas (Harris *et al*., 2011).

Penchansky and Thomas (1981) note that men and younger individuals are more likely than women and older individuals to be satisfied regarding affordability of healthcare services, and educated individuals are less likely than uneducated individuals to consider the services acceptable. As less educated people are not aware of the quality of the services they receive, they tend to accept inferior services. Marital status and household size also affect access to healthcare services, with married individuals and small households having better access than unmarried individuals and large households (Penchansky and Thomas, 1981).

2.2.2 Government health expenditure

The government channels expenditures towards the health sector to ensure that everyone has access to the required services without facing catastrophic expenditures (Castro-Leal *et al*., 2000; O'Donnell *et al*., 2007). Government expenditure is justified based on the assumption that government health expenditure improves efficiency by producing external benefits or correcting market failures, thereby promoting equality through the distribution of economic welfare (Castro-Leal *et al.*, 2000; McIntyre and Ataguba, 2011). Government expenditure also enhances health inputs, including health manpower, which further improves individuals' health outcomes (Filmer *et al*., 2002).

Government subsidises public services that are not optimally provided by the market, given that the marginal cost for these services is zero (Demery, 2000). These public services have external benefits (Castro-Leal *et al.*, 2000), for example, treating communicable diseases not only benefits one individual, but reduces the probability of other individuals contracting the disease. Thus, government health spending has significant external benefits; it enables prevention and treatment of diseases, improves health outcomes, and enhances living standards

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through the effective use of healthcare services. Government spending can either be monetary or in-kind transfers. In-kind transfers tend to improve individuals' wellbeing and potential long-run income (Castro-Leal *et al.*, 2000; Demery, 2000). These benefits from government expenditure are evaluated by comparing the cost of providing health services with individuals' use of these services. Inefficiencies in the health sector result in misallocation and mismanagement of government expenditure, with the target populations ultimately receiving less than what they were supposed to receive (Demery, 2000).

From the equality point of view, the government subsidises healthcare services because the poor have limited capacity to access healthcare services. However, these subsidies do not always benefit the poor as intended. Existing literature established that government health subsidies tend to benefit the affluent, who have less health needs than the poor (for example, Ataguba and McIntyre, 2012; Chakraborty *et al.*, 2013; Gwatkin *et al.*, 2004; Macha *et al.*, 2012; Mtei *et al.*, 2012; O'Donnell *et al.*, 2007, 2008; Shamu *et al.*, 2017), and that this phenomenon is evident in both low-level and high-level facilities (Gwatkin *et al.*, 2004). Rudasingwa *et al.* (2022) found pro-poor fiscal incidence in low-level facilities while high-level facilities are pro-rich in Zambia. However, Van der Berg (2009) and Burger *et al.* (2012) found a pro-poor fiscal incidence in both low-level and high-level facilities in South Africa. Contrary to Van der Berg (2009) and Burger *et al.* (2012), Roemer and Trannoy (2015) emphasise that government health expenditure does not usually benefit the target population, due to the unfair distribution of benefits. Government health expenditure that is unequally distributed thus leads to missed opportunities to achieve universal access to healthcare services and realise good health and well-being for everyone.

Using concentration indices and -curves and share of total benefits per quintiles, Akazili *et al*. (2012), Ataguba and McIntyre (2012), Mtei *et al*. (2012), Shamu *et al*. (2017), Burger *et al*. (2012), Macha *et al*. (2012), O'Donnell *et al*. (2007), and Castro-Leal *et al*. (2000) investigated the distribution of government health expenditure amongst different groups of people. Concentration indices are widely used in measuring healthcare inequalities, as they show socioeconomic distributions for the entire population.

2.2.3 Equality

Some authors argued that equal opportunity through egalitarianism should be deemed morally unacceptable (Anderson, 1999), given the need to change the structure of public goods to reduce inequality not redistribute the resources. Nevertheless, inequity in access to health care

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services and health remains prevalent in developing countries. In line with egalitarianism, Gulliford *et al.* (2002) posit that equal chances should be presented to people with the same need to achieve equality in access to healthcare services. Equity requires that resources be distributed according to need, thus focusing more on those with a greater need for healthcare services. The poor are more likely to be burdened by diseases than the affluent, and present a greater need for healthcare services. The affluent are more likely to afford private services; hence, it is important to ensure that the poor are able to afford the necessary services. As the literature cited earlier indicates, despite their clear need for improved access to healthcare services, the poor continue to suffer low access to such services in resource-constrained environments.

2.2.4 Access to healthcare services

Access to healthcare services does not have a universally agreed-upon definition. For example, Aday and Andersen (1974) define access as the use of services to improve health outcomes, while Penchansky and Thomas (1981) define access as the interaction between healthcare providers and users in the health system. These are termed ‘access as use’ and ‘access as fit’, respectively. Tanahashi (1978) also proposed a health coverage framework, which provides a detailed explanation of access to healthcare services. This particular framework explains the coexistence of health services and the target population to achieve better health outcomes, effectively. Like Aday and Andersen (1974) and Penchansky and Thomas (1981), Tanahashi's (1978) focused on potential and actual coverage of healthcare services.

Applying the concept of ‘access as use’ of Aday and Andersen (1974) in a resource-constrained environment may result in the misallocation of healthcare resources, leading to more and greater disparities in the healthcare system, as the affluent continue to benefit from healthcare services because they use the services more frequently than the poor. However, Penchansky and Thomas's (1981) ‘access as fit’ concept was used in the current chapter to determine the opportunities that are available to individuals to use healthcare services when the need arises. Penchansky and Thomas (1981) propose that access to healthcare services can be defined and measured via five underlying dimensions, namely affordability, availability, acceptability, accessibility, and accommodation. McIntyre *et al*. (2009) reduced these five dimensions to three, namely affordability, availability, and acceptability. Accessibility, availability, and accommodation in Penchansky and Thomas' (1981) framework were aggregated into

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'availability' by McIntyre *et al.* (2009), who argue that this ensures that services are provided at the right time and place to the right people. These three dimensions are discussed below.

Affordability of healthcare services is an access dimension defined as the extent to which individuals can pay for healthcare services (McIntyre *et al.*, 2009). Affordability is also known as 'financial access' to healthcare services. Burger and Christian (2018), Harris *et al.* (2011), and Macha *et al.* (2012) emphasise that affordability of healthcare services is a challenge that constrains individuals from accessing healthcare services when needed, especially the poor and the rural population. Affordability is framed broadly as individuals' ability to pay for healthcare services, given their available financial resources. Health costs can be either direct or indirect, with indirect costs including opportunity cost (for example, the income not received due to sacrificing a day's work when ill), transport cost to get to the facility, and output forgone (for example, in farming).

The methods of paying for healthcare services further determine the affordability of these services. For example, people who have insurance coverage deem health services affordable, as their health costs are covered by a third party, which could help protect them from incurring catastrophic health expenditures and financial burdens. It is important, however, to acknowledge that health insurance does not always provide its members full financial protection. Co-payments can be hefty, and insurance products differ in the comprehensiveness of their coverage of treatments and procedures (Garcia-Diaz, 2022). For instance, Ataguba and Goudge (2012) used propensity score matching analysis to compare OOP payments of individuals with and without health insurance in South Africa, and found that those with health insurance coverage had higher OOP expenditures than those without such insurance.

This chapter focused on the fact that the majority of Zimbabweans do not have insurance coverage, and have to make OOP payments when using healthcare services, making services unaffordable.

McIntyre *et al.* (2006), Perera *et al*. (2007), and Zeng *et al.* (2018), using descriptive analysis and logistic regression, examined OOP health expenditure as an access challenge, and found that it drives poor people into deprivation. Garcia-Diaz (2022), using multinomial probit analysis to analyse OOP payments in Mexico, found that high OOP payments lead to catastrophic health expenditures.

Availability is another access dimension, and represents the proximity of health products or services to those in need (Silal *et al.*, 2012; Steele *et al.*, 2022). Availability is also known as

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'geographical access' or 'spatial access' (Ricketts and Goldsmith, 2005). It includes the provision of healthcare services at the right time and place, and to the right people (McIntyre *et al.*, 2009). Availability considerations include the distance to the health facility, opening time, and the presence of healthcare services and health workers (Binyaruka and Borghi, 2022). In most cases, distance to the nearest health facility is used to measure the availability of healthcare services (McLaren *et al.*, 2014; Perry and Gesler, 2000; Rosero-Bixby, 2004). However, it is important to note that having health facilities close to the community is not enough if other health products and services, such as health workers and essential medications, are not available (Burger and Christian, 2018).

Literature on this dimension shows that the availability of healthcare services is a challenge. Perry and Gesler (2000) showed that availability affects access to healthcare services in Bolivia. Rosero-Bixby (2004) used conditional logistical regression to show that the availability of services has improved over time in Costa Rica, which was attributed to health reforms that reduced the distance to the nearest facility. McLaren *et al*. (2014) also found that distance to the health facility constrains access to healthcare services in South Africa. Burger and Christian (2018) and Macha *et al.* (2012) note that availability challenges constrain individuals from accessing healthcare services when they are in need. Using descriptive analysis, Harris *et al.* (2011) also indicated that inequities in the availability of healthcare services exist and disproportionately affect the poor and marginalised in South Africa. Burger *et al.* (2012) considered all constraints to healthcare access, and did not find the availability of healthcare services to be a major constraint to healthcare access in South Africa.

Acceptability of healthcare services is another access dimension, also known as 'cultural access' (McIntyre *et al.*, 2009), which is defined as an individual's perception of the healthcare service. Given the subjectivity of this dimension, it is difficult to measure. Acceptability of healthcare services is mainly determined by cultural values and health workers' attitudes (McIntyre *et al.*, 2009; Penchansky and Thomas, 1981). Both the individual's perception of the services and the provider's perception of patients affect the acceptability of healthcare services (Burger and Christian, 2018). Cultural values may make certain services unacceptable, for example, when women are not supposed to be treated by male health workers and there are no female health workers available. Alternatively, health workers might mistreat patients if they discriminate against people who have diseases such as TB or HIV, because they assume that these individuals are ill due to negligence.

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Reviewed studies on access to healthcare services set a foundation for estimating inequality in access to healthcare services in Zimbabwe. Most of these studies examined the challenges in access to healthcare services and contributing factors based on access dimensions, with a few focusing on inequality in access to the services. In the current chapter, I examined inequality in access to healthcare services in Zimbabwe using two dimensions: affordability and availability. It was not possible to study the third dimension, due to a lack of data. Nevertheless, the results enable a better understanding of the sources of inequality, which could inform decision-making and policy formulation aimed at addressing inequality.

2.3 Data sources

2.3.1 Government health expenditure

The Department of Finance and Administration of the MoHCC is responsible for the compilation of information on government health expenditure, both recurrent and capital expenditure. Recurrent expenditure was used in the current chapter, as it benefits only the current generation, rather than capital expenditure benefits multiple generations. Government health expenditure data are collected from all 10 of the country's provinces: Bulawayo, Harare, Manicaland, Mashonaland Central, Mashonaland East, Mashonaland West, Masvingo, Matabeleland North, Matabeleland South, and Midlands. These data represent government health expenditures channelled towards public clinics and hospitals.

The government health expenditure for public hospitals and clinics was aggregated at the district level. The MoHCC uses the ratio of 4:6 to allocate health expenditure between public clinics and public hospitals in Zimbabwe. This ratio was used to determine fiscal incidence across these two facility types. Authorities tend not to apply this ratio in times of disease outbreaks, as they mainly focus on containing the epidemic. However, in this study, the disaggregation using the ratio was justified, given the stable disease environment during the period under study.

2.3.2 Poverty, Income, Consumption, and Expenditure Survey

The PICES gathers information on socioeconomic and demographic characteristics of households and individuals, poverty, consumption, expenditure, and agricultural production. The data were collected over 12 months, from January to December 2017. The survey used a sample of 32 256 households, drawn from administrative districts using a two-stage sampling

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technique. Thus, enumeration areas were selected first from rural and urban areas,[5] and households were then allocated to their respective enumeration areas. The data comprised 2 304 enumeration areas, which were selected from 2012 population census data. A total of 1 894 enumeration areas were selected in the rural areas and 410 enumeration areas in urban areas.

PICES data are representative of the Zimbabwean population at the district level. Of the 32 256 households which were selected for an interview, 31 198 were successfully interviewed, yielding a 96.7% response rate. The data comprised 136 799 individuals. Each district had 36 enumeration areas and 508 households. Harare and Bulawayo, the largest administrative districts and urban provinces, had double the enumeration areas and households, to ensure representativeness at the district level. Rural households had a higher response rate than urban households. Sample weights were also used to ensure population representativeness. The PICES consists of household questionnaires and individual questionnaires, each collecting different information.

I used the sample of people who reported any illness in the previous 30 days for the analysis; 14 320 individuals were included in the analysis. This tended to eliminate individuals who were ill at least one month before the survey, as well as those with chronic conditions, who may not have responded 'yes' to the question. This survey question may have caused underestimation of illnesses. In addition, the data were prone to non-response bias, as individuals who did not use healthcare services did not respond to certain questions despite being ill. This might, therefore, have resulted in underreporting of challenges in access to healthcare. This study, therefore, used the imputed values of affordability and availability of healthcare services based on information from individuals who had used the services, to ensure unbiased and consistent estimates.

Information on the utilisation of healthcare services in PICES was based on whether the individual had been ill in the month prior to the survey.[6] I, therefore, aggregate utilisation rates per socioeconomic group and district, given the data limitations in the PICES. The data

[5] According to the PICES, rural areas comprise communal areas, small- and large-scale commercial areas, and resettlement areas, while urban areas comprise urban council areas, administrative centres, growth points, and other urban areas.

[6] Individuals who participated in the PICES were asked if they were ill in the previous month and if they used healthcare services during this time, to determine healthcare utilisation. Specifically, the questions asked during data collection were as follows: "Was (name) ill/sick in the last 30 days?" and "Did (name) visit a health care provider for services in the last 30 days?".

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comprise only services used when an individual was acutely ill, and not the use of services for chronic conditions and prevention (Alaba and McIntyre, 2012). The PICES also asks respondents about only one facility visit if an individual had been ill in the 30 days prior to the interview, although individuals may have undertaken multiple visits to a health facility, or accessed multiple services from different health facilities for an episode of illness. As strongly argued by Alaba and McIntyre (2012), general household surveys are prone to the abovementioned data deficiencies, which result in underreporting of the need and utilisation of healthcare services.

Due to the nature of the PICES data, it was not possible to classify facilities into primary, secondary, tertiary, and quartenary facilities. I therefore disaggregated facilities that respondents accessed into public clinics and public hospitals. Although healthcare services comprise preventive, curative, and palliative services,[7] the study focused on curative healthcare services, due to the unavailability of data on preventive and palliative services. While the data might underestimate the utilisation of healthcare services and need in Zimbabwe, they provide up-to-date healthcare information necessary for analysing fiscal incidence and inequality in access to healthcare services. The data provide crucial information on inequality in healthcare service provision in Zimbabwe, which could inform policies.

The administrative health expenditure data were then merged with the individual PICES data to enable estimation of fiscal incidence. The district health expenditure for public clinics and public hospitals was carefully aligned to the individuals who had used the services in the PICES data from the same districts. After merging the datasets, the fiscal incidence was calculated. The following sections report the results of fiscal incidence and inequality in access to healthcare services and the contributing factors.

2.4 Measures and methods

2.4.1 Fiscal incidence

As noted by O'Donnell *et al.* (2008), the benefit of government spending is determined chiefly by the utilisation of healthcare services and the share of government healthcare spending. Data on healthcare services utilisation are collected from household survey data, and data on

[7] Preventive services are healthcare services aimed at preventing people from getting ill, while curative services are provided to those who are already ill. Palliative care is specialised care for individuals with serious or terminal illnesses.

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government health spending are gathered from the Ministry of Health or other government departments, such as the Ministry of Finance (O'Donnell *et al.*, 2007). Constant unit subsidy across healthcare levels and health services was assumed.[8]

Fiscal incidence was calculated in five steps: first, unit costs were estimated. After that, users of the services were identified and then aggregated into groups. Lastly, incidence and target distribution were estimated sequentially. Each step was explained in more detail below.

Step 1: The unit cost of providing healthcare services was calculated by dividing the total government health expenditure[9] by the total number of users of healthcare services in a district (see Chakraborty *et al*., 2013). As stated by Castro-Leal *et al.* (2000) and O'Donnell *et al.* (2007), the calculation of the unit cost includes only real users of the healthcare services for respective facilities, not the entire population. User fees are supposed to be subtracted from the unit cost to obtain a unit subsidy. However, I did not subtract the user fees in this analysis, as the amount was too small to affect the unit subsidy. Based on household survey data, it was estimated that user fees represent less than 1% of total household expenditure.

Step 2: The next step was to assign the unit cost to users of public healthcare services in a district. Users of healthcare services benefit from the in-kind transfer of government health expenditure (Castro-Leal *et al.*, 2000). In the current study, these were individuals who had used public healthcare facilities in the month preceding the PICES. Assignment of different unit costs amongst the users of healthcare facilities was done per district and facility type (public clinic or public hospital).

Step 3: The users were aggregated into socioeconomic groups by ranking individuals from poorest to richest using quintiles. Socioeconomic groups can be constructed using either consumption expenditure, income, and/or household characteristics (O'Donnell *et al.*, 2008). O'Donnell *et al.* (2008) support the use of per capita total household consumption expenditure as a measure of standard of living. I classified the users into five socioeconomic groups, from the poorest (Quintile 1) to the richest (Quintile 5), to examine the distribution of public

[8] Constant unit subsidy assumption entails that the subsidy is different for hospitals and clinics. However, average subsidy does not vary according to the length of hospital stay and quality of healthcare (O'Donnell *et al.*, 2007).
[9] Current health expenditures are used for the calculation of fiscal incidence, as these benefit the current generation, while capital health expenditures benefit also future generations. For example, medicines bought today are used by the current generation, but hospitals built today also benefit future generations.

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spending. I used per capita household expenditure[10] to aggregate individuals into quintiles.[11] Consumption expenditure is the recommended measure to rank individuals into groups, as this data are easier to collect than data on income, with a lower risk of bias (O'Donnell *et al.*, 2008).

Step 4: The incidence of government health expenditure was calculated as follows:

$$X_{jp} = \sum_{i=1}^{n} \frac{S_{ip}}{H_{ip}} \times H_{ijp} = \sum_{i=1}^{n} \frac{Hijp}{Hip} S_{ip} = \sum_{i}^{n} h_{ijp} S_{ip} \quad (2.1)$$

where:

X_{jp} was the total subsidy socioeconomic group j in district p receives as government health expenditure, H_{ijp} was the number of health visits by socioeconomic group j to a facility at level i in district p (public clinics and hospitals), H_{ip} represented the total number of visits (for all the groups) to level i facility in district p, and S_{ip} was the subsidy, that is the total government expenditure less the household spending on healthcare services in district p (OOP payments). $\frac{S_i}{H_i}$ was the unit subsidy of the government expenditure at level i across all the individuals, and h_{ijp} was the share of utilisation of facility-level i by a socioeconomic group j in district p.

Step 5: The last step is target distribution, but this does not apply to this analysis, due to a lack of available data. This step compares the distribution of the share of subsidy against the share of need per socioeconomic group (McIntyre and Ataguba, 2011). Thus, the comparison demonstrates if the distribution of subsidy benefits is aligned with the health needs of these groups. It is expected that people in the lower socioeconomic group would have more health needs than those in higher socioeconomic groups; hence, they should receive a greater share of subsidy allocation.

[10] Upper poverty line is used to deflate household expenditures. Harare and June 2017 are used as the reference period and area, respectively (ZIMSTAT, 2019).

[11] This was used to reduce bias, as poor households tend to have more individuals within the household than rich households, which might result in underestimation of the poor people in the community (O'Donnell *et al.*, 2008). The household expenditure comprises food- and non-food expenditure, with the exclusion of intermediate expenditure from consumption expenditure. Furthermore, food expenditure includes all the consumption of the household for one month from own production, gifts, purchases, or barter trade.

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2.4.2 Access to healthcare services

2.4.2.1 Affordability

Affordability refers to the cost of the services charged by the health providers and individuals' ability to pay for the services (McIntyre *et al.*, 2009), but, more substantively, it reflects the extent to which the cost of services prohibits access. Although the PICES data provide information on the subjective response to lack of access to healthcare services, I used objective responses.[12] Given that access to healthcare services shows the opportunities available to use the services, including only individuals who used the services might lead to underreporting of affordability challenges. With an assumption that individuals in the same cluster (enumeration area) would be more likely to suffer from almost the same acute illnesses and pay almost the same healthcare costs, I calculated the average health expenditure within a cluster as total health expenditure paid within a cluster, divided by the total number of individuals who were ill in that specific cluster in the month before the survey. The clustered health expenditure was then imputed to individuals within different clusters. The imputation of health expenditure was done following ZIMSTAT's (2019) computation of school fees for students with missing information during the survey. Instead of using individual health expenditure, I used cluster-level health expenditure to measure health expenditure.

I used cluster-level health expenditure as a proportion of total per capita non-food consumption expenditure to measure the affordability of healthcare services. High health expenditure as a proportion of the household budget is referred to as 'catastrophic' expenditure (Ahid, 2022). A value of less than 40% of cluster-level health expenditure as a proportion of total per capita non-food consumption expenditure is considered affordable, and thus not catastrophic (Zeng *et al.*, 2018). In this analysis, a value of *1* was assigned when services are affordable, and *0* otherwise.

2.4.2.2 Availability

I used distance to the health facility as a proxy for the availability of healthcare services, as done by Perry and Gesler (2000) and Rosero-Bixby (2004). PICES data include the distance travelled by individuals to the nearest health facility when ill or injured, meaning that the

[12] The use of objective rather than subjective responses in measuring affordability reduces bias and improves the accuracy of the results. In the case of subjective responses, individuals wre asked about the reason why they did not access health services when ill and this was only asked to individuals who did not consult health workers.

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question is only posed to those who had consulted a health worker in the month before the survey. Therefore, I used the average cluster distance,[13] assuming that individuals in the same cluster would tend to use the same facility. The WHO recommends a distance of 5 km when accessing healthcare services. If people had to travel a distance of, at most, 5 km to the facility, I considered the service available. A value of *1* was assigned for individuals with available services, and *0* otherwise.

2.4.2.3 Factors contributing to inequality

The contributing factors were taken from the conceptual framework in Figure 2.1, and included age, gender, household size, marital status, education, health insurance, transport availability, and urban–rural differences. *Gender* was a binary variable, represented by *0* for *Female* and *1* for *Male*, while *Age* was a continuous variable, measured in years. These variables were included because men and younger individuals tend to have better access to healthcare services than women and older individuals. *Education* was a categorical variable, coded *0* for *No and primary education*, *1* for *Secondary education*, and *2* for *Tertiary education*. *Marital status* was also a categorical variable, represented by *0* for *Never married*, *1* for *Married or cohabitating*, and *3* for *Divorced or widowed*. *Household size* was the number of individuals in a household. Based on previous research, it was assumed that being educated, married, and having a small household size improves access to healthcare services (Penchansky and Thomas, 1981). *Transport availability* was represented by owning or having free access to a motor vehicle or motorcycle, which improves access to healthcare services (Harris *et al.*, 2011). Given the difference between urban and rural development, urban populations are more likely than their rural counterparts to access healthcare services when needed (Burger and Christian, 2018; Harris *et al.*, 2011). *Health insurance* was a dummy variable, represented by *1* for *Yes* and 0 for *No*. It was assumed that having health insurance coverage improves access to healthcare services in times of need.

2.4.3 Concentration indices

The Gini coefficient, the slope index of inequality, and the concentration index (CI) are used to assess inequality in healthcare (Wagstaff *et al.*, 1991). There are many options, but it is

[13] Average cluster distance in the present chapter was measured as the sum of the distance reported by the individuals who were treated in a cluster divided by the total number of households in the area. The same method was used to measure the affordability of healthcare services.

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crucial to choose an approach that shows the socioeconomic dimensions of health, represents the experiences of the entire population, and is sensitive to changes in the distribution (Umuhoza and Ataguba, 2018). The CI satisfies these requirements, and has been widely used, including in the analyses of Akazili *et al.* (2012), Burger *et al.* (2012), and Shamu *et al.* (2017). Therefore, the CI was used to estimate fiscal incidence and inequality in access to healthcare services. CIs were disaggregated by urban and rural areas to examine the origins of inequality.

The CI reflects the gap between an equal allocation (45-degree line) and the concentration curve. The CI lies between –1 and +1. A positive value of the CI was interpreted as pro-rich distribution of resources, with the concentration curve lying below the 45-degree line. When the CI is negative, the distribution was pro-poor and the concentration curve lies above the equality line. The larger the absolute value of the CI was, the greater the inequalities in fiscal incidence and access were.

The standard CI was specified as follows:

$$C = {}^{2}/_{\mu}\, cov(h, r) \qquad (2.2)$$

where C was the standardised CI, h was the healthcare variable (*Fiscal incidence*), μ was the mean of the *Healthcare* variable, and r is the ith-ranked individual in the socioeconomic distribution from the poorest to the richest.

Due to the binary nature of the *Availability* and *Affordability* predictors, I used the Erreygers (2009) CI to measure inequality in access to healthcare services. Erreygers's (2009) CI is mostly used for binary variables, and is an improved version of standard concentration indices. Furthermore, the CI is only appropriate when the *Healthcare* variable used has a lower and upper bound (Ataguba, 2022; Erreygers, 2009). Given the binary nature of the *Healthcare* variable, the lower bound was *0* and the upper bound was *1*.

According to Ataguba (2022), interpreting the normalised CI as the standard CI leads to misinterpretation of results. The Erreygers CI addresses the shortcoming of the standard CI, and is interpreted as follows: the index is pro-poor when the poor have maximum health benefits and the affluent have the bare minimum benefits; beyond that, the index is pro-rich. The Erreygers CI shows the concentration of the healthcare amongst a specific socioeconomic group (O’Donnell *et al*., 2016).

The Erreygers CI was computed as follows:

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$$E_C = \left({}^{4\mu_y}/_{b\,-\,a} \right) C \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(2.3)}$$

where *C* was the standardised concentration index, and *a* and *b* were the upper and lower bounds, respectively, of the *Healthcare* variable. The size and extent of E_C showed the strength and variability of access to healthcare services. The Erreygers CI incorporates the 'mirror property' assumption, which states that inequalities in health should mirror variations in ill health that are different from the standard CI (Erreygers *et al*., 2012; Erreygers *et al.*, 2018). The Erreygers CI is not overdependent on the mean of the healthcare variable, as in the case of the standard CI. In addition, the Erreygers CI is closer to the Wagstaff CI than the standard CI (Erreygers, 2009).

2.4.4 Recentered influence functions and Oaxaca-Blinder-RIF decomposition

Recentered influence functions (RIFs) were used to explain the contribution of explanatory variables to inequality in access to healthcare services. The main aim of decomposition analysis is to evaluate the distribution of the outcome variable as explained by changes in the explanatory variables (O'Donnell *et al.*, 2008). Here, the RIF decompositions were employed to examine how urban–rural differences contributed to inequality in access to healthcare services. The contribution of urban–rural differences is important, considering the different levels of development between rural and urban areas in Zimbabwe (Isbell and Krönke, 2018). The decomposition of the inequality is crucial for policymakers to understand the sources of inequalities.

Heckley *et al.* (2016) note that RIFs have fewer and less restrictive assumptions than Wagstaff *et al*.'s (2003) decomposition method. According to Heckley *et al.* (2016), RIF analysis relaxes assumptions about the rank ignorability (decomposing inequality using health whilst ignoring the correlation between health and rank) and weighting function ignorability (determinants do not determine weighting function), to enable easy and clear interpretation of the results. As noted by Heckley *et al.* (2016) and Wagstaff *et al.* (2003), decomposition is difficult to interpret when one worries about assumptions.

Additionally, RIFs are deemed more appropriate for bivariate rank-dependent indices, given that they are used to decompose all forms of CIs (Heckley *et al.*, 2016; Rios-Avila, 2020). The other reasons why RIFs are more relevant for decomposition analysis are that they are flexible, easy to interpret, and show a clear contribution of the covariates to inequality, which is important for decision-making (Heckley *et al.*, 2016; Rios-Avila, 2020). Rios-Avila (2020) and

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Firpo *et al*. (2018) state that the simple approach to estimating RIF regressions is to assume linearity in parameters and the error term, and also assume linearity in the RIF's dependent variable and independent variables. Thus, a slight change in the CI can be explained by the change in the independent variables (Heckley *et al.*, 2016). I therefore used RIFs to decompose contributing factors to inequality. The RIF was specified as follows:

$$RIF\{y, v(F_Y)\} = X^{`}\beta + \varepsilon_i, \quad E(\varepsilon_i) = 0 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(2.4)}$$

where $RIF\{y, v(F_y)\}$ was the dependent variable used for each observation y_i for RIFs, y denoted inequality in availability and affordability of healthcare services, X was the matrix for independent variables (*Age*, *Marital status*, *Urban–rural differences*, *Health insurance*, *Transport*, *Gender*, *Household size*, and *Education*), β was the parameters to be estimated, and ε_i was the error term.

The unconditional partial effects showed the change in the independent variables with unconditional mean increasing by one unit associated with a β_k change in the CI of availability and affordability of healthcare services. RIF regressions measure the unconditional partial effects of the influence of the independent variables on availability and affordability CIs (Firpo *et al*., 2009; Firpo *et al.*, 2018). However, Rios-Avila (2020) noted that the direction of change can be interpreted regardless of the magnitude.

I also used the Oaxaca-Blinder-RIF decomposition, which is the combination of RIF regression and Oaxaca-Blinder decomposition (Zhao, 2020), to decompose the differences in CIs between urban and rural populations into explained and unexplained components (see Nghiem *et al*., 2022). The unexplained component (structure effect) shows the differences in inequality due to differences in coefficients of the characteristics between urban and rural populations, while explained component (composite effect) represents differences in inequality between urban and rural populations due to differences in characteristics (Firpo *et al*., 2018; Rios-Avila, 2020). The decomposition analysis shows the contribution of differences in observed characteristics and differences in coefficients of characteristics towards differences in inequality in affordability and availability between urban and rural populations (Firpo *et al*., 2018). According to Rios-Avila (2020) and Nghiem *et al*. (2022), Oaxaca-Blinder-RIF decomposition is simple to implement, provides a comprehensive contribution of each independent variable to differences, and can be applied for other RIF functions. Inequality in affordability and availability was decomposed as follows:

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$$v(F_Y^u) - v(F_Y^r) = \underbrace{(\bar{X}_u - \bar{X}_r)'\hat{\beta}_p}_{Explained} + \underbrace{\bar{X}_u(\hat{\beta}_u - \hat{\beta}_p) + \bar{X}_r'(\hat{\beta}_p - \hat{\beta}_r)}_{Unexplained} \quad (2.5)$$

$v(F_Y^u)$ and $v(F_Y^r)$ represented availability and affordability CIs indices for urban and rural populations, respectively; and $\hat{\beta}_u$, $\hat{\beta}_r$ and $\hat{\beta}_p$ denoted the parameters to be estimated for urban, rural and pooled populations, respectively.

2.5 Estimated results

Table 2.1 summarises the means of rural and urban populations for relevant demographic and socioeconomic variables. T-statistics were used to determine whether there were significant differences between the means for the rural and urban subpopulations. I also included a comparison between descriptive statistics of missing observations and non-missing observations in Table A.1 of Appendix A. This analysis confirmed that missing observations from different variables did not result in biased estimates.

Table 2.1: Descriptive statistics

	Urban		Rural			
Variables	mean	std dev	mean	std dev	difference	t-statistic
Gender (ref: female)	0.388	0.487	0.407	0.491	-0.019	(-1.570)
Age	27.462	20.636	30.808	22.517	-3.345***	(-6.345)
Marital status						
Never married	0.284	0.451	0.245	0.430	0.039***	(2.003)
Married or cohabitating	0.513	0.500	0.526	0.499	-0.013	(-0.609)
Divorced or widowed	0.202	0.402	0.229	0.421	-0.027	(-0.019)
Household size	4.542	1.930	5.223	2.215	-0.682***	(-13.731)
Education						
Primary	0.381	0.486	0.660	0.474	-0.279***	(-13.786)
Secondary	0.533	0.499	0.325	0.468	0.208***	(10.167)
Tertiary	0.086	0.280	0.015	0.122	0.071***	(4.784)
Socioeconomic status						
1	0.015	0.121	0.268	0.443	-0.253***	(-24.496)
2	0.053	0.225	0.252	0.434	-0.199***	(-17.505)
3	0.140	0.347	0.215	0.432	-0.075***	(5.087)
4	0.285	0.451	0.168	0.411	0.117***	(6.829)

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5	0.507	0.500	0.096	0.374	0.411***	(22.883)
Per capita non-food consumption exp	78.619	75.303	25.011	29.000	53.608***	(29.388)
Affordability	0.546	0.498	0.642	0.479	-0.096***	(-7.214)
Availability	0.577	0.494	0.281	0.449	0.296***	(23.490)
Observations	1 799		12 521		14 320	

*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$
std dev represents standard deviation

Men represented a significantly large share of the population in rural areas, compared to urban areas. The urban population was, on average, significantly older than the rural population. With regard to household size, on average, rural areas had significantly more members in a household than urban areas. In addition, the rural population was less educated than the urban population, as reported in Table 2.1. Urban inhabitants had a higher average monthly non-food consumption expenditure per household member than their rural counterparts. Fewer urban respondents, on average, deemed the health services affordable, compared to the rural populace. The urban population had a higher availability of healthcare services than their rural counterparts. Rural populations were poorer than urban populations. The Chi-square of association in Table B.2 of Appendix B showed that there is a significant association between the access to healthcare barriers (affordability and availability) and urban-rural differences.

Table 2.2 shows the share of respondents who were ill in the 30 days prior to the survey and the share of those who had consulted a health worker.

Overall, 11.1% of the sample reported being ill in the month before data collection; 9.5% and 11.8% of the people were ill in the month before the survey in urban and rural areas, respectively. The poor reported less ill health than the affluent, as indicated by 7.1% and 9.4% for the respective bottom and top quintiles of the urban areas, and 10.5% and 15.1% for the bottom and top quintiles of the rural areas. Rural inhabitants reported more illness than their urban counterparts.

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Table 2.2: Share treated when ill

	Share ill/injured in last 30 days				Share consulted when ill			
Socioeconomic status	Total	Urban	Rural	Urban-Rural	Total	Urban	Rural	Urban-Rural
1	0.104	0.071	0.105	-0.034***	0.645	0.463	0.648	-0.185
	(0.002)	(0.019)	(0.002)		(0.010)	(0.134)	(0.010)	
2	0.111	0.096	0.112	-0.016***	0.637	0.619	0.639	-0.020
	(0.002)	(0.013)	(0.002)		(0.010)	(0.068)	(0.010)	
3	0.117	0.092	0.124	-0.032***	0.655	0.673	0.673	0.000
	(0.003)	(0.008)	(0.002)		(0.011)	(0.039)	(0.010)	
4	0.119	0.100	0.136	-0.036***	0.602	0.551	0.636	-0.085***
	(0.003)	(0.005)	(0.003)		(0.014)	(0.027)	(0.012)	
5	0.107	0.094	0.151	-0.057***	0.649	0.645	0.648	-0.003
	(0.003)	(0.004)	(0.005)		(0.015)	(0.021)	(0.017)	
Total	**0.111**	**0.095**	**0.118**	**-0.023*** **	**0.637**	**0.614**	**0.645**	**-0.031*** **
	(0.001)	**(0.003)**	**(0.001)**		**(0.005)**	**(0.010)**	**(0.004)**	

standard errors in parentheses
*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

On average, 63.7% consulted a worker at a healthcare facility when ill, with healthcare facilities including public clinics, public hospitals, private clinics, private hospitals, and pharmacies. Thus, almost two-fifths of Zimbabweans did not consult health workers when they were ill. In urban areas, the poor (46.3%) were less likely than the affluent (64.5%) to seek treatment when ill. Surprisingly, there was no noticeable difference in the proportion of the people who consulted health workers when ill between the poorest and the richest in rural areas. However, on average, rural inhabitants were significantly more likely than their urban counterparts to consult health workers when ill. There was no significant difference between individuals consulting health workers in urban and rural areas by socioeconomic group, except in the fourth quintile.

I also included information on the proportion of individuals using public facilities, private facilities, and other alternatives, disaggregated by urban and rural areas and socioeconomic status in Table B.1 of Appendix B. In that regard, the majority of individuals consulted health workers in public facilities, with a few individuals using private facilities and other alternatives. As expected, affluent individuals were using private health services more than their poor counterparts, and poor individuals were using public health services more than affluent individuals.

Figure 2.2 illustrates the barriers to consulting a health worker when ill, disaggregated by urban and rural areas.

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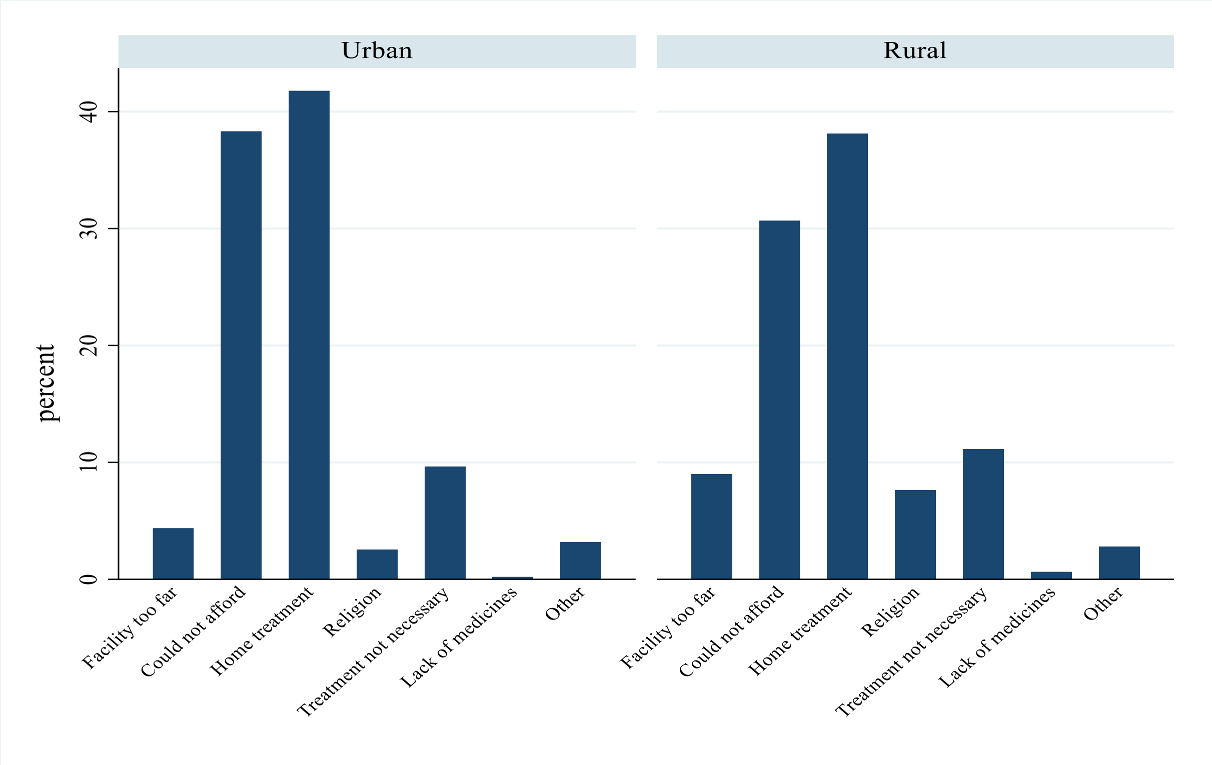

Figure 2.2: Reasons for not seeking treatment

Home treatment and the inability to pay for treatment were found to be the most significant reasons for not receiving formal treatment when ill or injured, in both urban and rural areas. More individuals in urban areas than in rural areas did not consult health workers due to healthcare services costs, and used home treatments. A considerable share of respondents reported not accessing healthcare services due to long travelling distances to the facilities, treatment not being necessary, or for religious reasons. Distance to the health facility and religion were more frequently cited as a barrier to healthcare service access by the rural population compared to the urban population. Almost the same proportion of urban and rural populations reported that treatment was not necessary, despite indicating that they had been ill. In both urban and rural areas, lack of medicines was the least frequently cited reason for not consulting health workers.

Figure 2.3 shows the utilisation of public clinics and hospitals by socioeconomic status for urban and rural populations.

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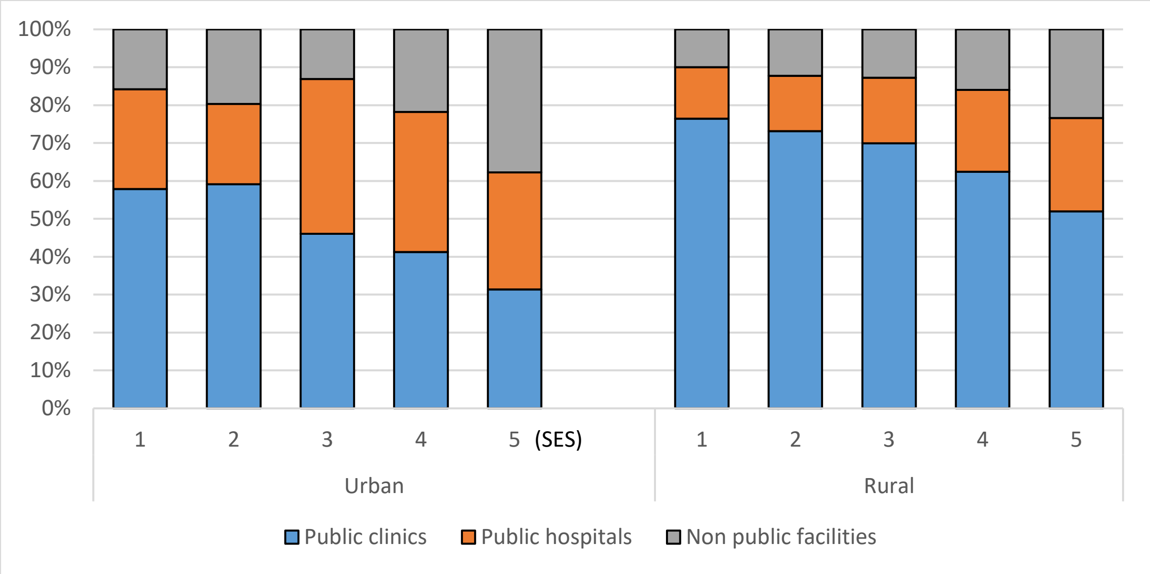

Figure 2.3: Public health facility utilisation by location and socioeconomic status

Note: Share of utilisation of public clinics and hospitals in urban and rural areas by socioeconomic status.

A socioeconomic gradient was evident in the share of the utilisation of public facilities. The share of the poor using public clinics in rural and urban areas was high compared to the affluent. The share of the affluent using better-resourced public hospitals was higher than that of poor in both urban and rural areas. On average, more affluent significantly use non-public facilities than their poor counterparts in both urban and rural areas. In addition, a large share of the population uses public clinics compared to public hospitals and non-public facilities in urban and rural areas.

Table 2.3 reports the standard CIs for fiscal incidence, disaggregated by urban and rural areas. The table shows the CIs for public clinics and public hospitals. A negative CI indicated that the fiscal incidence was pro-poor.

Table 2.3: CIs for fiscal incidence

Facilities	Public clinics	N	Public hospitals[14]	N

[14] The results show differences between subpopulation CI (positive) and population CI (negative) for fiscal incidence in public hospitals. This is referred to as Simpson's paradox, where an association between variables disappear or reverses after separating subpopulations. The difference in the sign of the overall CI and those stratified by urban and rural areas for public hospitals might be attributable to the overlap in the income ranking variable between urban and rural areas (Clarke *et al.*, 2003). Urban and rural areas contain both affluent and poor people; however, more affluent people reside in urban areas, with fewer in rural areas. Since income-related inequity can be positive or negative, subgroup decompositions also revealed whether the within and between components were of the same type as the overall inequality; that is, whether the within-location index and/or

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Urban CI	-0.299***	510	-0.101	447
	(0.078)		(0.100)	
Rural CI	-0.114***	5 9641	-0.108	1 441
	(0.010)		(0.197)	
Total CI	-0.207***	6 451	0.298***	1 888
	(0.012)		(0.110)	

Robust standard errors in parentheses
*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

Table 2.3 reports a significant negative CI for public clinics (-0.207), while public hospitals had a positive CI (0.298). This suggests that, on average, government health expenditures were pro-poor for public clinics and pro-rich for public hospitals. Subsequently, the CI for rural and urban areas were estimated. The CI for urban areas was negative and significant for public clinics (-0.299), but not for public hospitals. For the rural areas, the CI was negative and significant for public clinics, and not for public hospitals. The public clinic CI was more negative for urban areas than for rural areas.

Table 2.4 shows the Erreygers CIs for access to healthcare services for rural and urban areas. The positive CI showed that access to healthcare was pro-rich.

Table 2.4: CIs for access to healthcare services

Predictors	Affordability Proportion of health and per capita non-consumption expenditure < 40%	N	Availability Distance < 5 km	N
Urban CI	0.234***	1 593	-0.103**	1 658
	(0.060)		(0.049)	
Rural CI	0.165***	11 198	-0.023	11 601
	(0.024)		(0.024)	
Total CI	0.114***	12 791	0.085***	13 259
	(0.029)		(0.029)	

Robust standard errors in parentheses
*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

between-location were/was of the same sign as the overall index. The within-location index shows inequality amongst the people in the same subpopulation group (urban or rural), while the between-location index shows the inequity between two subpopulation samples. This is important, given that the total CI is determined by within-location index, between-location index, and residuals (Clarke *et al*., 2003). The residuals, therefore, are non-zero if there is income overlap between subgroups, which contributes to different signs of population and subpopulation CI (Clarke *et al*., 2003). This explanation also applies to the results in Table 2.4.

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Overall, the affordability of healthcare services was found to be pro-rich. Affordability favoured the affluent more than the poor in both rural and urban areas, with CIs of 0.165 and 0.234, respectively. The affluent benefitted more from affordable services in urban areas than their rural counterparts. Concerning the availability of healthcare services, a negative CI indicated that availability was in favour of the poor in urban areas. The inequality of availability was pro-poor in the urban areas, and rural areas. Differences in availability rates were large between the urban and the rural areas, which resulted in a positive national CI for availability. I also included concentration curves for fiscal incidence and access to healthcare services in Figures D.1 and D.2 in Appendix D.

I examined the sensitivity and robustness of CIs for fiscal incidence and access to healthcare services to differences in household sizes and composition, using equivalence scales (OECD-modified, OECD, and square root scale). These equivalence scales are used for countries without established equivalence scales, such as Zimbabwe (OECD, 2011). Equivalence scales are the deflators needed to adjust the expenditures for different households (Pollak and Wales, 1979). This is based on the fact that different households face different consumption expenditures, depending on the number of people and age groups within the household (Newhouse *et al*., 2016; Pollak and Wales, 1979). For example, households with two adults and one child incur different expenditures from households with three adults and two children. Using equivalence scales, therefore, relaxes the assumption that adults and children have equal cost needs (Newhouse *et al*., 2016). The above results using per capita household consumption expenditure were not significantly different from the results using equivalence scales, reported in Tables C.1 and C.2 in Appendix C.

Table 2.5 shows how the RIFs varied according to age, gender, education level, health insurance status, marital status, household size, and availability of transport.

Table 2.5: RIF of covariates on inequality in affordability

	(1)	(2)	(3)
Variables	Full sample	Urban	Rural
Age	0.000	0.001	-0.002*
	(0.001)	(0.005)	(0.001)
Gender (Male = 1; Female = 0)	0.050	-0.015	0.074**
	(0.038)	(0.112)	(0.034)
Location (Rural = 1; Urban = 0)	0.135**		

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	(0.057)		
Education (ref: Primary)			
Secondary	-0.012	-0.140	-0.004
	(0.037)	(0.115)	(0.034)
Tertiary	0.341***	-0.036	0.447***
	(0.127)	(0.168)	(0.113)
Health insurance (Yes = 1; No = 0)	-0.040	0.557***	-0.213
	(0.202)	(0.176)	(0.219)
Transport (Yes = 1; No = 0)	1.047***	1.255***	0.861***
	(0.220)	(0.169)	(0.216)
Household size	-0.032***	-0.021	-0.016**
	(0.009)	(0.024)	(0.008)
Marital status (ref: Never married)			
Married or cohabitating	0.009	-0.038	0.044
	(0.057)	(0.169)	(0.052)
Divorced or widowed	-0.004	-0.315	0.126*
	(0.082)	(0.238)	(0.071)
Constant	0.141*	0.518***	0.253***
	(0.081)	(0.176)	(0.059)
Observations	8,150	987	7,163
R-squared	0.012	0.023	0.007

Robust standard errors in parentheses
*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

In the full sample, an increase in the share of the population who lived in rural populations made the inequality in affordability more pro-rich. An increase in household size made affordability significantly more pro-poor, while more individuals with access to transport and tertiary education were significantly pro-rich. Age, gender, secondary education, health insurance status, and marital status were found to be insignificant. In urban areas, more people with access to transport and health insurance made the inequality more pro-rich, inequality in affordability for the divorced or widowed was pro-poor. For rural areas, older individuals and greater household sizes had significant pro-poor inequality, while men, those with tertiary education, the divorced or widowed, and transport availability showed pro-rich inequality. I also included robustness check results for inequality in affordability in Table E.1 of Appendix E, which included an analysis of the full sample and a small sample with missing observations. Only the urban–rural difference was not statistically significant after including the large sample in the analysis. However, the results in Table E.1 are not different from the results in Table 2.5.

Table 2.6 shows how RIF for inequality in availability varied according to age, gender, educational attainment, health insurance, and access to transport.

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Table 2.6: RIF of covariates on inequality in availability

Variables	(1) Full sample	(2) Urban	(3) Rural
Age	-0.002**	-0.005**	-0.001
	(0.001)	(0.002)	(0.001)
Gender (Male = 1; Female = 0)	-0.049	-0.167*	-0.010
	(0.030)	(0.092)	(0.027)
Location (Rural = 1; Urban = 0)	0.088*		
	(0.049)		
Education (ref: Primary)			
Secondary	0.002	-0.000	0.003
	(0.031)	(0.097)	(0.027)
Tertiary	-0.056	-0.166	0.215
	(0.113)	(0.156)	(0.163)
Health insurance (Yes = 1; No = 0)	0.688***	0.742***	0.643***
	(0.156)	(0.212)	(0.229)
Transport (Yes = 1; No = 0)	0.678	1.590***	0.053
	(0.428)	(0.213)	(0.282)
Constant	-0.022	0.146	0.018
	(0.056)	(0.107)	(0.031)
Observations	10,470	1,272	9,198
R-squared	0.008	0.033	0.003

Robust standard errors in parentheses
*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

An increase in rural population shares shifted the distribution of inequality to become significantly more pro-rich. More people with health insurance coverage made the availability inequality more pro-rich. An increase in the number of older individuals enhanced more pro-poor inequality in the availability of healthcare services. Education level and transport availability had no significant influence on inequality in available health services. In the urban model, more people with health insurance coverage and better access to transport enhanced availability of healthcare services for affluent populations, whilst an increase in men or older individuals made inequality more pro-poor. An increase in insurance coverage made the distribution more pro-rich in rural areas. However, age, gender, transport availability and educational attainment had no impact on the relationship between income and the availability of healthcare services for rural inhabitants. I also included robustness check results for inequality in availability in Table E.2, which included analyses of the full sample and a small sample with missing observations. These results were not statistically different from the results in Table 2.6, showing that missingness did not bias the estimates.

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Table 2.7 decomposes the differences in the distribution of inequality in availability and affordability of healthcare services in rural and urban areas.

Table 2.7: Oaxaca-Blinder-RIF decomposition of CI in access to healthcare services

	(1) Affordability	(2) Availability
Urban	0.371***	-0.058*
	(0.034)	(0.032)
Rural	0.149***	-0.011
	(0.013)	(0.011)
Total difference	0.222***	-0.047
	(0.036)	(0.034)
Total explained	0.018*	0.015*
	(0.011)	(0.008)
Total unexplained	0.204***	-0.062*
	(0.038)	(0.035)

Robust standard errors in parentheses
*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

The results showed that inequality in affordability was significantly higher in urban areas than in rural areas, with a gap of 0.222. Urban populations had high inequality in the affordability of healthcare services, which is attributable to differential health prices in urban areas where most affluent individuals reside (Osika *et al.*, 2010). Insignificant lower availability inequality was evident in urban, compared to rural areas, with a difference of 0.047.

The composition effect of inequality in affordability was positive and insignificant. Despite the significant differences in inequality in the affordability of services between urban and rural areas, adjusting rural endowments decreased the difference by 1.8%. However, 20.4% of the difference remained unexplained for inequality in affordability. The unexplained difference in inequality in the affordability of health services was significantly positive. On the other hand, the composition effect significantly contributed very little to the gap in inequality in availability between urban and rural areas. Availability inequality between the urban and rural populations decreased by 1.5% if the rural endowments were adjusted. The structure effect was significant, showing that 6.2% of the inequality in availability of healthcare services between urban and rural areas remained unexplained.

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2.6 Discussion of results

Given the need to attain UHC, it is crucial to understand the inequalities in the health sector and to ensure that the poor and vulnerable benefit from healthcare services. In this chapter, fiscal incidence and inequality in access to healthcare services were examined using CIs. Considering social and economic differences between urban and rural Zimbabwe, the analysis also identified contributors to access inequality in these areas separately.

The results showed no difference between affluent and poor individuals who had reported illness in the PICES; thus there was no socioeconomic gradient. This result was unexpected. The poor are expected to report illness, given their living conditions and great risk of disease (Ahmed, 2022; O'Donnell, 2007). Rossouw *et al*. (2018) also posit that poor people have less access to healthcare services, and are less likely to report chronic illness, compared to the affluent. The share of people who are ill or injured is expected to follow a socioeconomic gradient, due to different perceptions of illness (Ataguba and McIntyre, 2013).

Overall, almost two-fifths of Zimbabweans do not consult health workers when ill (ZIMSTAT, 2019). This is consistent with earlier results of Filmer *et al*. (2002). In that regard, men, unemployed, and urban populations were less likely to use healthcare services when ill. Reasons for not consulting health workers when ill are: expensive services, treatment not being necessary, home treatment, the facility being too far, a lack of medication, and religious reasons. This was also emphasised in Filmer *et al*.'s (2002) paper. Not consulting health workers when ill may result in high treatment costs in the long run; if treatment is sought at a later stage, the person's health status may have deteriorated significantly, which may result in death (Buzuzi *et al.*, 2016; ZEPARU, 2014). Also, as noted by Gilson and McIntyre (2007) and Mangundu *et al.* (2020), people tend to substitute conventional healthcare with unconventional practices, for example, using herbs, previously unused drugs, and drugs borrowed from neighbours.

Regarding fiscal incidence, the health facilities were disaggregated by type, i.e., public clinics and public hospitals. The estimated CI showed that the poor received more government health expenditure through public clinics than the affluent did. This result is consistent with the results of Van der Berg (2009) and Burger *et al.* (2012) for South Africa, Rudasingwa *et al.* (2022) for Zambia, and Castro-Leal *et al.*'s (2000) results for South Africa and Kenya. The result is also in line with that for Zimbabwe obtained by Shamu *et al.* (2017), who used the constant unit subsidy. The present study found that the urban population received more from the subsidy

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than the rural population. This could be attributed to public clinics in urban areas serving a small catchment area, compared to rural areas. As posited by Filmer *et al.* (2002), government health expenditure on primary healthcare is more effective in improving health outcomes than expenditure on secondary and tertiary care.

The results also indicated a pro-rich inequality in public hospitals. This result is consistent with those of Castro-Leal *et al.* (2000), Macha *et al.* (2012), Shamu *et al.* (2017), and Rudasingwa *et al.* (2022). However, the result is contrary to those of Van der Berg (2009) and Burger *et al.* (2012). Despite the government's efforts to improve benefits for the poor, health expenditure continues to benefit the affluent using public hospitals, which are mainly located in urban areas (Shamu *et al.*, 2017; World Bank Group *et al.*, 2017). Given that public hospitals receive more government expenditure, the affluent mostly use public hospitals in urban areas, and receive high subsidies, compared to their poor counterparts (Shamu *et al.*, 2017; World Bank Group *et al.*, 2017). Public hospitals are mostly located in urban areas where affluent people reside, thus resulting in the affluent receiving more government health expenditure than the poor (Shamu *et al.*, 2017).

Despite government health expenditure, people grapple with weak access to healthcare services due unavailability and unaffordability (Rudasingwa *et al.*, 2022). Contradicting the results of Burger *et al.* (2012), but in line with those of Harris *et al.* (2011) and Burger and Christian (2018), the current study found that availability and affordability contribute significantly to unequal access in Zimbabwe. While expenditure is pro-poor, the benefits accrue disproportionately to the affluent.

The analysis showed a positive CI for affordability, thus indicating a pro-rich distribution of affordability in Zimbabwe. This shows that the affordability of healthcare services remains a challenge for poor people in Zimbabwe. The results corroborate those obtained by Burger and Christian (2018), Gilson and McIntyre (2007), Harris *et al.* (2011), and Zeng *et al*. (2018). It is also in line with the literature on child- and maternal health that posits that these services benefit the affluent more than the poor (Makate and Makate, 2017; Nkonki *et al.*, 2011). The results of the current study showed a noticeable difference in the affordability CI for rural and urban areas. Affordability of healthcare services was pro-rich in both urban and rural areas. Thus, inequality in affordability of healthcare services is more pronounced in urban than in rural Zimbabwe.

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In addition, I found a pro-rich availability of healthcare services in Zimbabwe. The results are consistent with those of Rosero-Bixby (2004) for Costa Rica and Perry and Gesler (2000) for Bolivia, where distance was found to hamper access to healthcare services, especially for the poor. In the current study, the CI was significantly negative for the availability of healthcare services in urban areas. This shows that the affluent in urban areas struggle with long distances to health facilities in Zimbabwe, possibly because more affluent individuals stay in low-density neighbourhoods with few public facilities, compared to high- and medium-density neighbourhoods. Another contributing factor may be that the affluent tend to use private services more often than the poor, and because there are fewer of these, visits may entail a longer travel time to the facility (ZIMSTAT, 2019). Affluent individuals tend to substitute private- for public facilities based on distance to the facility (Filmer *et al.*, 2002).

After estimating the inequality in access to healthcare services, decomposition analysis was conducted, using RIFs. Surprisingly, the data showed that, despite user-fee exemption, people still struggled to afford healthcare services in Zimbabwe. The inequality in affordability was found to be pro-rich in rural areas. The results are contrary to those of Silal *et al.*'s (2012) study on South Africa. The results may be due to individuals in rural areas having few facilities within their community, and they thus have limited choices at similar prices, whereas their urban counterparts can choose from a variety of facilities offering services at different prices. Therefore, the rural population being served by few facilities with fewer price differentials are more likely to spend the same amount on healthcare services than the urban population (Osika *et al.*, 2010). Moreover, there were no or few private facilities in rural areas, and individuals used only public facilities. As shown in Table 2.1, urban populations have more money and, hence, more expenditures.

It is also noteworthy that transport availability increased pro-rich inequality in affordability of healthcare services. This indicates that travel is an important consideration in the cost of healthcare. It was found that having access (or free access) to a motor vehicle or motorcycle reduced the affordability challenges in urban areas in seeking healthcare services, thereby improving access to healthcare services. This result is consistent with that of Perry and Gesler (2000), who found that transport costs deter individuals from accessing health services in Bolivia. Harris *et al.* (2011) also noted that urban populations in South Africa are more likely to own or have free access to motor vehicles, and this increased their access to healthcare services. People who have access to free transport are likely to experience lower costs, as they

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do not need to pay for public transport to visit the health facility. This indicates pro-rich inequality.

With regard to the availability of healthcare services, a greater share of the population living in rural areas increased pro-rich inequality. This result is in line with that of Harris *et al.* (2011), who found that rural populations experience inequality in the availability of healthcare services in South Africa. This is attributable to the geographical layout of rural areas, where people are widely dispersed and live far away from facilities, unlike those in urban areas (Isbell and Krönke, 2018; Mangundu *et al.*, 2020; O'Donnell, 2007). Therefore, poorer individuals in rural areas face significant differences in distance to a facility, resulting in pro-rich inequality in the availability of healthcare services.

Health insurance was found to be significantly pro-rich for availability of healthcare services. Increasing the number of people with medical insurance thus results in pro-rich inequality. Health insurance reduces catastrophic health expenditures and helps improve access to healthcare services (Buzuzi *et al.*, 2016; Gilson and McIntyre, 2007; Harris *et al.*, 2011). Affluent people are more likely to have insurance coverage than their poor counterparts (ZEPARU, 2014); thus, an increase in insurance coverage is pro-rich in access to healthcare services in Zimbabwe.

Notably, transport was found to affect the inequality in the availability of healthcare services. Having more individuals with access to or owning a motor vehicle or motorcycle strengthens the pro-rich inequality in availability. Access to transport was found to be concentrated amongst the affluent, resulting in more pro-rich availability inequality. This result is in line with those of Burger and Christian (2018) and Harris *et al.* (2011) in South Africa. It is also in line with Binyaruka and Borghi's (2022) results for Tanzania. In Zimbabwe, some people still walk at least 30 minutes or 5 km to the facility, and rudimentary infrastructure hampers access to healthcare services (Isbell and Krönke, 2018). Even when healthcare services are free, individuals struggle to meet the transport costs, resulting in weak access to healthcare services (Perry and Gesler, 2000).

In the same vein, it was found that having more people with a tertiary education significantly increases how pro-rich the inequality in the availability of healthcare services is in rural areas. People with a tertiary education are likely to be more affluent, and are likely to have better access to health services; thus, increases in tertiary education make this type of health inequality more pro-rich.

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Similar to affordability, good health outcomes are skewed towards the affluent in the SADC (Umuhoza and Ataguba, 2018), who have access to affordable services. Even though public facilities are deemed cheaper than those in the private sector, the poor struggle to afford healthcare services when the need arises. This might be attributable to economic challenges in the country, which is characterised by high informal employment and high inflation, which reduces households' disposable income (ZIMSTAT, 2019; ZIMSTAT and World Bank, 2020). Poor households have lower disposable incomes than the affluent, and when a health crisis hits, they have to trade off healthcare services against essential services such as food and shelter (World Bank Group, 2015). According to the United Nations (2015), these economic challenges in Zimbabwe result in unaffordable healthcare services.

I identified several factors associated with inequality in access to healthcare services. However, addressing these constraints that create differences between affluent and poor individuals and regions may not reduce overall health inequality in Zimbabwe. The decomposition analysis showed that most of the inequality in affordability and availability of healthcare services between urban and rural populations in Zimbabwe was not explained using marital status, gender, age, education, transport availability, health insurance, and household size. More research on supply-side and demand-side factors of inequality is therefore required to determine the factors that should be addressed, as these are not included in the traditional set of variables included in household surveys.

2.7 Conclusion

Pockets of inequality in fiscal expenditure and access to healthcare services are evident in Zimbabwe, with the urban and affluent benefiting more than the rural and poor populations from better-resourced facilities. Zimbabwean authorities should focus on the poor and the rural populations, who, despite their acute needs, often struggle to access healthcare services. The poor continue to suffer from compromised access to healthcare services, despite the government's attempt to achieve UHC in Zimbabwe. Therefore, future research should further interrogate factors contributing to differences in inequality in access to healthcare services between urban and rural populations.

There is still room to improve and augment efforts to achieve equality in incidence of fiscal expenditure and access to healthcare services. Health resources should be distributed more equitably in Zimbabwe. Policymakers should consider equal urban–rural budget allocations and strengthen user-fee exemption, to enable the attainment of UHC and the SDGs. There is

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also a need to improve the physical availability of healthcare facilities, especially in underserved areas. Such initiatives could improve access to healthcare services for all, ultimately improving health and well-being.

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Chapter 3

Drug stockouts and district poverty in Zimbabwe: A spatial analysis approach

3.1 Introduction

Adequate access to essential healthcare services is crucial to achieving good health and well-being for everyone. Most communicable diseases and maternal and child health conditions are inexpensive and easy to prevent if diagnosed and treated early (Raikabakaba *et al.*, 2022; WHO, 2017b). According to Amstislavski *et al.* (2012) and Raikabakaba *et al.* (2022), existing mortality and morbidity would be reduced significantly if people had reliable access to life-saving drugs. However, according to the WHO, approximately two billion people do not have access to essential drugs, due to challenges related to access to healthcare facilities or availability of drugs, often referred to as 'drug stockouts'[15] (WHO, 2017). These drug stockouts are considered a social justice concern, as they often worsen the already existing inequities in developing countries (Vahapoğlu and Bhattacharya, 2020).

In the context of Zimbabwe, drug stockouts are occurring at a time when the country is burdened with a fragile health system and a high disease burden. Malaria is one of the major diseases in Zimbabwe burdening the health system, and is responsible for an increasing proportion of outpatient and inpatient admissions (MoHCC, 2014, 2020a). The high malaria burden contributes significantly to morbidity and mortality, and antimalarial drugs are important in reducing these effects. Frequent drug stockouts, therefore, compromise the effectiveness of the antimalarial drugs in enhancing health outcomes. Despite progress in reducing malaria transmission, Zimbabwean health facilities grapple with antimalarial stockouts (Sande *et al.*, 2017). These drug stockouts impede the fulfilment of the MoHCC's mandate to achieve equality in health by directing resources to the most vulnerable populations.

Drug stockouts are widespread in Zimbabwe, with three-quarters of facilities experiencing stockouts of at least one drug in 2014 (ZSARA, 2015). According to The Global Fund (2020), these drug stockouts mainly occur at the health facility level, and as a result of improper drug storage (proper storage entails drugs kept in a cool and dry place), which damages the drugs before use. Drug stockouts are also a result of low buffer stock of drugs at health facilities. Zimbabwe's MoHCC notes that the drugs at the health facility level are not always sufficient

[15] Drug stockouts are defined as the absence of specific drugs at the point of care for at least one day (Hwang *et al.*, 2019; Medecins Sans Frontieres, 2015).

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to cover the necessary period of six months, indicating inadequate drugs at a facility in times of disease outbreaks (MoHCC, 2011).

Faced with drug stockouts, individuals may resort to purchasing drugs from the private or informal sector, forgoing treatment, using traditional medicines, borrowing drugs from friends or relatives, and using previously unused drugs (Gilson and McIntyre, 2007; Mangundu *et al*., 2020; Ndejjo *et al.*, 2021; Ng *et al.*, 2021). With the growing informal sector in Zimbabwe, alternative mechanisms increase the probability of using falsified and substandard drugs that further compromise health outcomes (Gwatidzo *et al*., 2017). Besides drug stockouts, individuals are also overwhelmed by expensive health services, long waiting times, long travelling distances to facilities, and a lack of experienced health workers, to mention only a few of the pertinent constraints (Kamvura *et al.*, 2022; Mangundu *et al*., 2020; Ndejjo *et al.*, 2021).

Inequalities could still exist at the regional level despite countries achieving health goals at the national level. Thus, presenting data at the national level could mask regional inequalities in healthcare resources and provision (Manda *et al.*, 2020). Unmasking these regional inequalities is important in reducing spatial inequalities in resource allocation and distribution, given that access to healthcare services is determined by socioeconomic and demographic variables at the regional level (Zamfir *et al.*, 2015). The lack of spatial assessment of health provision and needs compromises the planning and distribution of resources, making it difficult to identify underserved areas. Spatial information on drug stockouts is vital, as it can inform policies to support and improve resources channelled to regions that need them the most and improve access to healthcare services. Against this backdrop, this chapter examines the spatial inequality in drug stockouts, as well as the spatial relationship between drug stockouts and district poverty in Zimbabwe. The chapter also discusses coping mechanisms noted in extant literature as a response to stockouts.

The chapter proceeds as follows. The following section provides more detail on drug distribution networks and malaria transmission in Zimbabwe, to provide the context. After that, the literature on district poverty and healthcare services is reviewed, in Section 3. The data sources and the estimation techniques are explained in Section 4. The results are presented and discussed in the following two sections, and Section 7 concludes the chapter.

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3.2 Background

3.2.1 Pharmaceutical distribution networks in Zimbabwe

The National Pharmaceutical Company of Zimbabwe (NatPharm) is a government-owned entity that provides public health facilities with pharmaceutical services and some private health facilities, for a fee (Osika *et al.*, 2010). NatPharm is responsible for the procurement, storage, and distribution of drugs in Zimbabwe, and is mandated to deliver drugs to all health facilities and ensure reliable availability of drugs (Osika *et al.*, 2010; ZEPARU, 2014). NatPharm has six pharmaceutical warehouses. The central warehouse is located in Zimbabwe's capital city, Harare, and the other five provincial warehouses are located in Bulawayo, Gweru, Masvingo, Mutare, and Chinhoyi. These warehouses service the districts within their catchment areas. The districts, therefore, have relatively similar supply chain management with regard to procurement, logistics, and distribution of healthcare resources.

Storage, distribution, and forecasting of future needs of drugs are managed by NatPharm and the MoHCC (UNDP, 2015). The Medicine Control Association of Zimbabwe ensures that the drugs comply with quality standards and pharmacovigilance, while the MoHCC is responsible for the quantifying and supply planning of drugs (MoHCC, 2020a). The MoHCC, through its national malaria control programme also oversees government policies to eliminate malaria transmission in the country (MoHCC, 2020a; Mundagowa and Chimberengwa, 2020).

With regard to distribution, the facilities usually report, order, and receive medication quarterly or monthly, depending on the distribution system. There are several drug distribution systems for primary health services in Zimbabwe. These include Delivery Team Topping Up (DTTU), Zimbabwe Informed Push/Primary Health Care Package (ZIP/PHCP), Zimbabwe Assisted Pull System (ZAPS), Zimbabwe ARV Distribution System (ZADS), and Essential Medicines Pull System (EMPS) (Rosen *et al*., 2015). Malaria and TB products are managed through ZAPS and ZIP/PHCP distribution systems. In these systems, facilities are expected to place orders when left with one month's supply of drugs. Authorities collect data from the facilities and supply new orders to the facilities at quarterly intervals (Rosen *et al.*, 2015).

Concerning funding for drugs, NatPharm is financed by MoHCC and non-governmental organisations (NGOs). Antimalarial drugs are mostly funded by NGOs through the Global Fund to Fight AIDS, Tuberculosis and Malaria, the Roll Back Malaria Partnership, and the US President's Malaria Initiative. NGOs supply a considerable portion of the preventative

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healthcare services in Zimbabwe, with a smaller contribution from the government (Sande *et al.*, 2017). There is, therefore, an overreliance on donors to provide healthcare services in Zimbabwe (Parliament of Zimbabwe, 2019; World Bank Group *et al.*, 2017). Given that antimalarial drugs are funded by NGOs, these drugs are provided for free in public facilities, and drug stockouts are mainly due to poor coordination between the health facilities and NatPharm management, as well as a mismatch between the supply and demand of drugs at the facility level. This is not the case with drugs that are not funded by NGOs, where the stockouts are a result of both financial and distribution constraints, due to the government's financial constraints in providing essential services.

The private sector also provides antimalarial drugs. Individuals tend to access services from the private sector as a coping mechanism and last resort during drug stockouts in the public sector.

3.2.2 Malaria in Zimbabwe

According to the MoHCC (2020a), malaria transmission is seasonal in Zimbabwe, with the highest transmission occurring during rainy and hot seasons (October to May), putting over two-thirds of the population at risk. Malaria-endemic areas have an annual parasite incidence of at least five per 1 000 people. However, areas with low malaria transmission have an annual malaria parasite incidence of less than five (MoHCC, 2020a). In 2017, the malaria mortality rate was approximately four per 100 000, against a target of two per 100 000 (MoHCC, 2020a). In that regard, the authorities have implemented policies to reduce the mortality rate and malaria prevalence, as well as to eliminate malaria transmission. However, despite these efforts, transmission is not stable, and continues to increase, due to human migration, health-related beliefs, and weak coverage of preventive resources (MoHCC, 2020a; Mundagowa and Chimberengwa, 2020).

According to the MoHCC (2020a) and Dube *et al.* (2019), the plasmodium falciparum parasite is responsible for the majority of malaria infections in Zimbabwe. To detect malaria infections, rapid diagnostic tests or blood smears are used, and if the test is positive, antimalarial drugs are administered (MoHCC, 2015, 2020a). Artemether drugs are used to treat uncomplicated malaria in Zimbabwe, and the recommended dosages vary based on body weight and age group (MoHCC, 2015). The full course of first-line antimalarial treatment is taken for three days. If the symptoms continue, drugs for severe malaria are administered. In addition to that, indoor residual spraying and ITNs are used to prevent malaria infections.

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Table 3.1 shows the changes in the number of districts with high or low malaria burdens from 2012 to 2017. A total of 39 districts with a low malaria burden in 2012 were still at this level in 2017, while nine districts still had a high malaria burden in 2017. Only seven districts with high malaria burden in 2012 changed to a low malaria burden in 2012, while 33 districts still had a high malaria burden in 2017.

Table 3.1: Transition matrix for malaria burden, 2012–2017

Year	Districts with a low malaria burden 2017	Districts with a high malaria burden 2017	Total
Districts with low malaria burden 2012	39	9	48
Districts with high malaria burden 2012	7	33	42
Total	46	44	90

3.3 Literature review

Unequal health provision compromises access to quality healthcare services by those in need (Wigley *et al.*, 2020). Therefore, underserved areas tend to have higher rates of mortality and morbidity, which are exacerbated by economic deprivation due to a high unemployment rate, as well as poor water- and sanitation services (Zamfir *et al.*, 2015). Consequently, people with a great need for healthcare services tend to benefit less from these services, creating considerable health inequalities (Ataguba and McIntyre, 2013; Castro-Leal *et al.*, 2000).

Drug stockout challenges amplify cross-regional inequalities. While the effects and causes of drug stockouts are well articulated, less is known about the relationship between drug stockouts and district poverty. Most studies examined spatial inequality in availability of healthcare services (for example, Amstislavski *et al.*, 2012; Tandi *et al.*, 2015; Ward *et al.*, 2014; Wigley *et al.*, 2020; Zamfir *et al.*, 2015), and there is a dearth of literature on the spatial relationship between drug stockouts and district poverty, particularly in developing countries. Specifically, no studies have focused on the spatial inequality in drug stockouts and the spatial relationship between drug stockouts and poverty in Zimbabwe. There is also little literature on the health mechanisms available to individuals during drug stockouts.

Amstislavski *et al.* (2012), using thematic maps, investigated community-based inequalities in the availability of drugs in different pharmacies. The study found that drug unavailability was prevalent in the US, with pharmacies in poor communities more prone to limited drug availability and operating hours, compared to affluent communities (Amstislavski *et al.*, 2012).

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Although the findings noted the relationship between poverty and drug availability, Amstislavski *et al.* (2012) focused only on urban areas, and not on rural areas, which are likely to be poor and underdeveloped. The study also focused on privately operated pharmacies, and the findings may not be generalisable to developing countries, where public facilities are dominant. Similarly, Pednekar and Peterson (2018) mapped pharmacy density in the US and found evidence of spatial inequality in pharmacy density. Pednekar and Peterson (2018), using Getis-ORD Gi* statistics, also indicated that spatial autocorrelation in low pharmaceutical density exists in the US where low pharmaceutical density is clustered in rural areas with racial majority groups.

Spatial autocorrelation analysis of pharmaceutical services enables the identification of clustered regions with a high prevalence of drug unavailability, and could inform appropriate policies to improve drug availability in these regions. Amstislavski *et al.* (2012) and Pednekar and Peterson (2018) found spatial inequality in health services in the US, but the US is a high-income country. Far fewer studies have examined these inequalities in low- and middle-income countries.

Using thematic maps, Zamfir *et al.* (2015) investigated spatial inequalities in health workers and health infrastructure in Romania, and found evidence of spatial inequality, with healthcare resources more concentrated in urban areas than in rural areas. Healthcare resources are thus concentrated in highly developed areas. Wigley *et al.* (2020) found spatial disparities in maternal service availability and accessibility in SSA. Although there was an improvement over time in availability and accessibility of healthcare services, within-country disparities remain prevalent. Tandi *et al.* (2015), using descriptive analysis, identified disparities in the regional distribution of health workers in Cameroon.

Considering spatial differences in the access to drugs in low- and middle-income countries, Ward *et al.* (2014) also used descriptive analysis to consider the location of South African pharmacies, and found that they are more likely to be in affluent than poor provinces. Kuwawenaruwa *et al.* (2020) and Wagenaar *et al.* (2014) note that drug stockouts are more prevalent in poor and rural areas due to rudimentary infrastructure. Individuals residing in these areas frequently face unavailability of services, compared to those residing in affluent areas.

According to Bhattacharya *et al.* (2020) and Wagenaar *et al.* (2014), drug stockouts mainly occur at the health facility level — the so-called ‘last mile’, and constitute a public health

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challenge in developing countries.[16] The literature reports that the main reasons for facility-level drug stockouts are a lack of coordination between the facilities and the warehouse, as well as poor logistical planning and management (Munedzimwe, 2017; Sintayehu *et al.*, 2022). Additionally, Koomen *et al*. (2019) and Seunanden and Day (2014) found that districts with higher poverty often had no warehouse, and that this correlated with a higher likelihood of stockouts.

Most of the studies investigating access to drugs used descriptive analysis and thematic maps to illustrate spatial inequality, but did not apply spatial regression models to verify the significance of these spatial relationships. This leaves a gap in the literature, which this study sought to address.

3.4 Measures and methods

3.4.1 Data sources

In the current study, data on drug stockouts and PICES data obtained from the MoHCC and the ZIMSTAT were used.

The MoHCC collects information on availability of antimalarial drugs at quarterly intervals for each health facility. The 2012 and 2017 drug stockout data used for this analysis included information on the province, district, facilities, stock in hand, date when the data were collected, the name of the drug, and the number of days the drugs were stocked out at the facility. The Department of Pharmaceutical Services in the MoHCC is responsible for the compilation of stockout information for all facilities. The information on drug availability is crucial in identifying underserved regions and making informed decisions to ensure that drugs are distributed to populations with great need. Antimalarial drugs were reported for different age groups (0.5 <= age < 3 years, 3 years <= age < 8 years, 8 years <= age <14 years, and at least 14 years). Each facility has information on drug stockouts, which is then aggregated at the district level for analysis.

The current study made use of PICES data that were collected using a two-stage sampling method. Enumeration areas were selected first, and households were then allocated to their respective enumeration areas (ZIMSTAT, 2019). The survey was stratified by land use:

[16] The last mile is the last stage in the process of distribution of drugs from the warehouses to primary healthcare facilities. This is where the drugs reach the final user at the point of care.

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communal land, commercial farming, resettlements, and large-scale and small-scale areas. Sample weights were used to create district poverty rates.

The 2011/2012 PICES data were based on the 2002 Zimbabwe population census master sample. Probability to proportion size was used to ensure representation at the provincial and district level (ZIMSTAT, 2018). A total of 2 220 enumeration areas were selected, with 36 enumeration areas per district, and double for Harare and Bulawayo municipalities, as they are largest administrative districts and urban provinces. The data were collected over 12 months, and 29 765 of the 31 248 households initially sampled were successfully interviewed, yielding a 95.3% response rate.

The 2017 PICES data were based on a sample of 32 256 households selected from 2012 national census data. A total of 2 304 enumeration areas were selected using the probability proportional to size, which determined the size of enumeration areas. A total of 31 195 households were interviewed, yielding a response rate of 96.7%.

PICES is used by ZIMSTAT to calculate the official consumer price index. The PICES dataset contains information on demographic variables, agriculture production, living conditions, poverty prevalence, and the informal sector in Zimbabwe. Data on socioeconomic and demographic variables, income, consumption expenditure, and receipts were collected weekly and monthly to ensure information adequacy (ZIMSTAT, 2013). The expenditure and income information was recorded in a daily record book and later transcribed into the household questionnaire. Adjustments were made for inflation using Harare’s June 2011 prices for the 2011/2012 PICES and Harare’s June 2017 prices for the 2017 PICES (ZIMSTAT, 2013, 2019).

Drug stockout data were merged at the district level with PICES household data for 2011/2012 and 2017, to examine the relationship between drug stockouts and district poverty in Zimbabwe.

The Zimbabwe subnational administrative boundaries were extracted as shapefiles from Human Data Exchange's (2018) website. The subnational administrative boundaries are disaggregated at different levels: ward, district, provincial and national levels, but district level was the lowest level of geographic analysis that was feasible with the data available. The shapefiles enable the generation of thematic maps that illustrate the spatial distribution of drug stockouts and district poverty in Zimbabwe for both 2012 and 2017, similar to those used by Pednekar and Peterson (2018) and Zamfir *et al*. (2015).

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Table 3.2 shows the provinces and their respective districts in Zimbabwe. There are 10 provinces and 91 districts in the country, including urban and rural districts. A Zimbabwean map with labelled districts is included in Figure N.1 of Appendix N.

Table 3.2: Provinces and districts in Zimbabwe

Province	District
Bulawayo	Bulawayo
Harare	Harare (urban and rural), Chitungwiza, Epworth
Manicaland	Buhera, Chimanimani, Chipinge (urban and rural), Makoni, Mutare (urban and rural), Mutasa, Nyanga, Rusape
Mashonaland Central	Bindura (urban and rural), Guruve, Mazowe, Mbire, Mount Darwin, Muzarabani, Mvurwi, Rushinga, Shamva
Mashonaland East	Chikomba, Goromonzi, Hwedza, Marondera (urban and rural), Mudzi, Murehwa, Mutoko, Ruwa, Seke, Uzumba Maramba Pfungwe
Mashonaland West	Chegutu (urban and rural), Chinhoyi, Hurungwe, Kadoma, Karoi, Kariba (urban and rural), Makonde, Mhondoro-Ngezi, Norton, Sanyati, Zvimba
Matabeleland North	Binga, Bubi, Hwange (urban and rural), Lupane, Nkayi, Tsholotsho, Umguza, Victoria Falls
Matabeleland South	Beitbridge (urban and rural), Bulilima, Gwanda (urban and rural), Insiza, Mangwe, Matobo, Plumtree, Umzingwane
Masvingo	Bikita, Chiredzi (urban and rural), Chivi, Gutu, Masvingo (urban and rural), Mwenezi, Zaka
Midlands	Chirumhanzu, Gokwe North, Gokwe South, Gokwe Centre, Gweru (urban and rural), Kwekwe (urban and rural), Mberengwa, Redcliff, Shurugwi (urban and rural), Zvishavane (urban and rural)

Source: ZIMSTAT (2018)

3.4.2 Definitions of variables

Drug stockouts were measured as the proportion of days in a year during which district facilities experienced stockouts of Artemether. The analysis focused on the Artemether drug because it is widely used for first-line antimalarial treatment (MoHCC, 2015). The facility-level quarterly drug stockouts were calculated for each of the four Artemether drugs (dosage-specific for age groups) as the share of days per quarter that the antimalarial drug was not in stock at a specific

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facility.[17] Facility-level aggregation across the four drug dosages was done by selecting the drug dosage with the highest share of stockout days, to represent facility-level stockouts for the quarter. Yearly averages were calculated by summing quarters and adjusting denominators for quarters where data were missing. District-level aggregates were then generated by averaging the annual facility-level stockout estimates. Due to a lack of data on feeding areas of facilities, all facilities (including clinics and hospitals) were weighted equally in this district averaging.

Drawing on the empirical literature, four independent variables were included in the analysis: *Poverty prevalence*, *Malaria-endemic*, the logarithm of *Population per facility*, and the logarithm of *Distance to closest warehouse*.

Poverty prevalence shows the share of households with consumption expenditure per capita less than the total consumption poverty line, while extreme poverty refers to households with consumption expenditure below the food poverty line (ZIMSTAT, 2019). The total consumption poverty line and food poverty line were US$76.7 and US$32.7 per person per month, respectively, in 2012. In 2017, total consumption poverty line and food poverty line were US$70.36 and US$31.2 per person per month, respectively (ZIMSTAT, 2013, 2019).[18] Districts were classified as poor when most of the household's per capita total consumption expenditure was below the total consumption poverty line.[19] Poor districts were expected to have more stockouts than affluent districts.

Malaria-endemic was a dummy variable, which was coded *1* if the district had a high prevalence of malaria cases, and *0* if the district had few malaria cases. According to the MoHCC (2020a), districts with an annual parasite incidence of at least five per 1 000 people have a high malaria prevalence, while those with an annual malaria parasite incidence of less

[17] The four products are for different age groups: 1*6 dosage (0.5 <= age < 3 years), 2*6 dosage (3 years <= age < 8 years), 3*6 dosage (8 years <= age <14 years), and 4*6 dosage (at least 14 years) (MoHCC, 2015).

[18] Poverty datum line measures the cost an individual or household must meet to not be deemed poor. The poverty lines include the food poverty and the total consumption poverty line, also known as the 'upper line', and comprise both food consumption and non-food consumption expenditure. ZIMSTAT uses total consumption poverty line to determine poverty prevalence, whilst the food poverty line is used to measure extreme poverty (ZIMSTAT, 2019). The national mean consumption per person per month was US$78.94 in 2012 and US$85.2 in 2017.

[19] Due to high collinearity between poverty prevalence and urban–rural differences (greater than 0.8, as shown in Table H.1 of Appendix H), urban–rural differences were excluded from the analysis.

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than five have a low malaria prevalence. High malaria-endemic districts were expected to be less prone to stockouts, given that authorities prioritise these districts in times of need.

Population per facility shows the average share of individuals using health facilities in a district. This was calculated by dividing the district population by the number of health facilities in a district. A high district-level population per facility was expected to have a high prevalence of stockouts due to increased demand for the services.

With regard to *Distance to closest warehouse*, warehouse GPS coordinates were compared to district coordinates to calculate the distance between the warehouse and the district. Districts far away from a warehouse were expected to experience more frequent drug stockouts than districts close to a warehouse. The distance between warehouses and districts was constant.

3.4.3 Spatial regression analysis

Following Amstislavski *et al.* (2012), Pednekar and Peterson (2018), and Zamfir *et al.* (2015), I used thematic maps to depict the spatial distribution of drug stockouts in Zimbabwe. Thematic maps are useful in providing a visual picture of spatial inequality and thus determining underserved districts in a country. The Getis-ORG Gi* statistic was also used to determine spatial autocorrelation in drug stockouts. This chapter goes beyond the analyses of the aforementioned papers, as I also included spatial regression analysis to examine the significance of the relationship between drug stockouts and district poverty.

Spatial regression models are used to analyse the spatial elements of data. Spatial regression models are an extension of linear regression models, but relax the assumption of no spatial interdependence, and incorporate spillover effects between neighbouring districts (Bose, 2015; Jeetoo, 2020; Steenbeek and Ruiter, 2021).

There are several spatial models that can be used to analyse data, namely (i) the spatial error model (SEM), which contains spillover effects for the error term, (ii) the SAR model, which focuses on the spillover effects of the dependent variable, (iii) the spatial Durbin model (SDM), which has the spatial dependence for the dependent and independent variables, and (iv) the Spatial Durbin error model (SDEM), which focuses on spillover effects across adjacent regions for the independent variables and error term (Astuti *et al.*, 2020; Bose, 2015; LeSage, 2008; Ragoubi and Mighri, 2021).

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Comparing spatial regression models, the SAR model shows the relationship between a dependent variable and independent variables, with the spatially lagged dependent variable. This shows correlations between the dependent variable in the focal district and neighbouring districts, which are explained using the spatially lagged dependent variable (Rüttenauer, 2019). Using SAR models implies that stockouts in one district are likely to be associated with stockouts in the neighbouring districts. The SEM shows the relationship between dependent variables and the lagged error term, and is used when spatial error dependence is present in the model (Ragoubi and Mighri, 2021; Rüttenauer, 2019). The SEM shows that stockouts in one district are mainly affected by unobservable shocks from its neighbouring districts. Moreover, the SDM focuses on the relationship between the dependent variable in a district with a weighted average of the dependent and independent variables in the neighbouring districts (Ragoubi and Mighri, 2021; Rüttenauer, 2019). Stockouts and poverty prevalence in the focal district affect stockouts in the neighbouring districts. In addition, the SDEM shows that poverty prevalence and unobservable shocks in the focal district do not only affect stockouts in the focal districts, but also stockouts in the adjacent districts.

Each of these approaches has its own strengths and weaknesses. Neglecting spatial error dependence in the model results in inefficient standard errors, while ignoring spatial lag leads to inconsistent and biased estimates, because the correlation in the error term across space acts similarly to spatial fixed effects. Using the SAR model eliminates bias and inconsistency in ordinary least squares (OLS) estimates, while the SEM improves the efficiency of the standard errors. The SAR model and SEM show global autocorrelation, and using these two models in the presence of local spillovers yields biased estimates (Rüttenauer, 2019). The SAR model is also more likely to suffer from biased results if autocorrelation in disturbances is present. The SDM and SDEM yield biased estimates when the value weighted independent variables are too high (Rüttenauer, 2019). According to Rüttenauer (2019), the SDEM shows that the local spillover effects underestimate the indirect effects of independent variables in the presence of global autocorrelation in the model. The SAR model and SEM are the most commonly used models in spatial regression analysis. It is important to use an appropriate method of estimation with the appropriate characteristics to ensure unbiased and consistent estimates.

The SEM, SAR model, SDM, and SDEM models were expressed as follows:

SEM

$$y_{it} = x_{it}\beta + \phi W_{ij}\varepsilon_{jt} + \mu_i + \delta_t + \varepsilon_{it} \quad (3.1)$$

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SAR model

$y_{it} = x_{it}\beta + \rho W_{ij} y_{jt} + \mu_i + \delta_t + \varepsilon_{it}$ …………………………………... (3.2)

SDM

$y_{it} = x_{it}\beta + \rho W_{ij} y_{jt} + \theta W x_{jt} + \mu_i + \delta_t + \varepsilon_{it}$ ………………………... (3.3)

SDEM

$y_{it} = x_{it}\beta + \theta W_{ij} x_{jt} + \phi W_{ij} \varepsilon_{jt} + \mu_i + \delta_t + \varepsilon_{it}$ … … … … … … … … …. (3.4)

where $i\ and\ j$ represented spatial units $(i \neq j)$, t represented time, y_{it} was the dependent variable, x_{it} was the matrix of independent variables, $W_{\ ij}$ was a contiguity spatial weighting matrix (N*N matrix), ρ was the coefficient for the spatial dependence of the dependent variable, θ was the spillover effect of the independent variables, ϕ was spatial dependence of the error term, μ_i was the individual district effect, and δ_t represented the time-fixed effect.

The spatial weighting matrix is a crucial element in spatial regression analysis, as it measures the spillover effects of different variables. The spatial weighting matrix caters for the differences in effects for different areas; thus, areas close to each other are allocated more weight, compared to those that are far apart. This follows Tobler's (1979) first law, which states that things close to each other are more related than those far from each other. The spatial weighting matrix, therefore, shows interrelationships across neighbouring districts. I used the contiguity rook weighting matrix for the analysis to represent spillover effects. The contiguity weighting matrix focuses on districts that share borders (Bose, 2015); thus, the value of the matrix was *1* for districts sharing a border, and *0* otherwise. The values in the main diagonal of the matrix were equal to zero to avoid districts being identified as their neighbours. The spatial weighting matrix was constant over time, and was calculated using one year, given that the borders did not change over time. Data should be balanced, since spatial analysis is challenging to conduct when using unbalanced panels (Elhorst, 2010). Therefore, Bubi district was omitted from the analysis, due to missing stockout information for 2012.

The analysis first determined whether the non-spatial panel data models were preferred over spatial panel data models. The Lagrange multiplier or likelihood ratio test was used to determine the appropriate model between non-spatial models and spatial models (Bose, 2015). The null hypothesis was rejected, as spatial models were appropriate.

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Thereafter, the likelihood ratio test was used to determine the appropriate model between the SDM, SDEM, SEM or SAR model (Astuti *et al.*, 2020; Bose, 2015). The first comparison was between the SAR model and the SDM. The null hypothesis stated that the SAR model was nested in the SDM, and the alternative hypothesis was that the SAR model was appropriate. Rejecting the null hypothesis when the probability value was less than a 5% significance level indicated that the SAR model was appropriate. Rejecting the null hypothesis when comparing the SEM and SDM indicated that the SEM was the appropriate model. Furthermore, accepting both null hypotheses implied that the SDM was appropriate for the analysis. Accepting the alternative hypothesis while comparing the SEM and SDEM implied that the SDEM was appropriate.

Using likelihood ratio tests, the null hypothesis — that the SAR model was nested in the SDM — was rejected (*p*-value is less than 5% significance level), and the SAR model was chosen as the appropriate model. After that, the SAR model and the SDEM model were compared, and the SAR model was found to be the appropriate model. The SDM was the appropriate model when comparing the SDM and the SEM, while the SDEM was found to be appropriate when comparing the SEM and the SDEM. Then SDEM was appropriate when comparing the SDM and the SDEM. Overall, the SAR model was selected as the appropriate model to ensure unbiased and consistent estimates in this analysis (as shown in Appendix J).

The SAR model was expressed as follows:

$$stockout_{it} = \alpha + \beta_0 poverty_{it} + x_{it}\beta + \rho W stockout_{jt} + \delta_t + \varepsilon_{it} \ldots\ldots\ldots\ldots\ldots\ldots \quad (3.5)$$

where *stockout* was the dependent variable, *poverty* was the core independent variable, x was the matrix of other independent variables (*Malaria-endemic*, log of *Population per facility*, and log of *Distance to nearest warehouse*), *i* was the focal district, *j* was the adjacent districts, and *t* represented the years.

A further analysis was conducted to outline the effects of the independent variables on the focal district's stockouts, as well as its neighbours' stockouts. The analysis distinguished between direct, indirect, and total effects. Direct effects show the effect of the independent variables on own district's drug stockouts (Rüttenauer, 2019). The indirect effect focuses on the effect of the independent variables on the neighbour's drug stockouts (spillover effects) (Rüttenauer, 2019; Steenbeek and Ruiter, 2021). The total effect was the summation of the direct and indirect effects (see Bose, 2015; LeSage, 2008). The total effect measures the cumulative effect of the independent variable in one district on stockouts of all other districts (Steenbeek and

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Ruiter, 2021). The results were interpreted as a unit change in the independent variable causing changes to the whole system through the direct effect of the independent variables on focal district stockouts and the indirect effect of these stockouts on the stockouts of its neighbours (Steenbeek and Ruiter, 2021).

After estimating the SAR model, spatial autocorrelation analysis was carried out using the Getis-ORD Gi* statistic. Spatial autocorrelation assesses the spatial concentration of stockouts by evaluating an area against its neighbours (Kondo, 2016). Positive spatial autocorrelation shows the clustering of districts with similar values, with clustering of high and low values defined respectively as hot and cold spots (Pednekar and Peterson, 2018).

A positive z-score and low probability depict hot spots, while a negative z-score and low probability value shows cold spots (Kondo, 2016; Pednekar and Peterson, 2018). The probability value of 1% and 5% were used as benchmarks for the statistical significance of the results. Districts with neither a low nor high significant z-score were deemed statistically insignificant and neutral, compared to their neighbours. The concentration of dissimilar values is referred to as 'negative spatial autocorrelation' (Pednekar and Peterson, 2018).

3.5 Estimated results

Table 3.3 presents descriptive statistics, showing that more than three-fifths of Zimbabwean households were classified as poor.

Table 3.3: Descriptive statistics

	2012		2017			
Variables	mean	std dev	mean	std dev	differences	t-statistics
Poverty prevalence	0.649	0.190	0.620	0.227	-0.029	(-0.931)
Malaria endemic districts	0.462	0.501	0.484	0.502	0.022	(0.295)
Population per facility	7115.620	4662.662	7543.965	3722.407	428.345	(0.685)
Stockouts	0.077	0.063	0.156	0.124	0.079***	(4.424)
Per dosage						
0.5 <= age < 3 years	0.030	0.031	0.131	0.131	0.100***	(5.835)
3 <= age < 8 years	0.038	0.035	0.088	0.085	0.050***	(4.232)
8 <= age < 14 years	0.063	0.064	0.092	0.069	0.029***	(2.371)
age >= 14 years	0.039	0.040	0.077	0.066	0.037***	(3.737)
Observations [a]	91		91		91	

Note: [a] is the number of districts considered in the analysis using ZIMSTAT (2018) data.

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Poverty prevalence was higher in 2012 than in 2017, but the change was not significant. There was no statistical difference in the share of malaria-endemic districts or population per facility between 2012 and 2017. The average proportion of days of district-level stockouts for Artemether in 2017 was double that of 2012, and the difference was significant.

3.5.1 The geographical concentration of facilities and warehouses in Zimbabwe

Figure 3.1 illustrates the geographical concentration of facilities, district-level population per facility, and the location of six NatPharm warehouses. District-level population per facility averages were calculated by combining 2012 and 2017 census data.

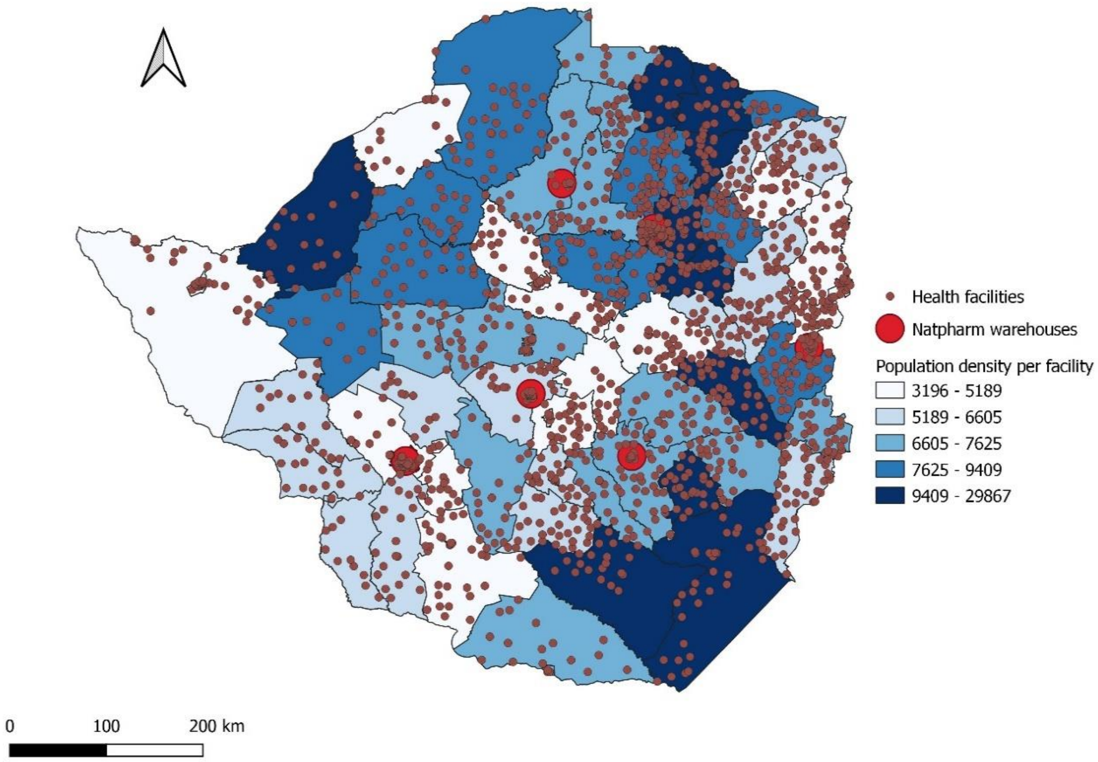

Figure 3.1: Geographical concentration of facilities and warehouses by district

In Figure 3.1, the health facilities are indicated by the small brown dots and the warehouses by the large red dots. The district-level population per facility is indicated by the different shades of blue for districts, with darker shades indicating a higher population per facility.

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There was a higher population per facility for the districts in the northwest, northeast, and southern parts of the country, and a lower population per facility for the districts in the central, western, and eastern parts.

The six warehouses are located in Bulawayo, Chinhoyi, Gweru, Harare, Masvingo, and Mutare. The warehouses were found to be located mostly in districts with a low population per facility, showing a spatial mismatch (see Figure N.1 in Appendix N for the names of the districts shown on the map).

3.5.2 Drug stockouts and district poverty in Zimbabwe

Figure 3.2 shows the proportion of days per year antimalarial drugs were stocked out in each district in 2012 and 2017.

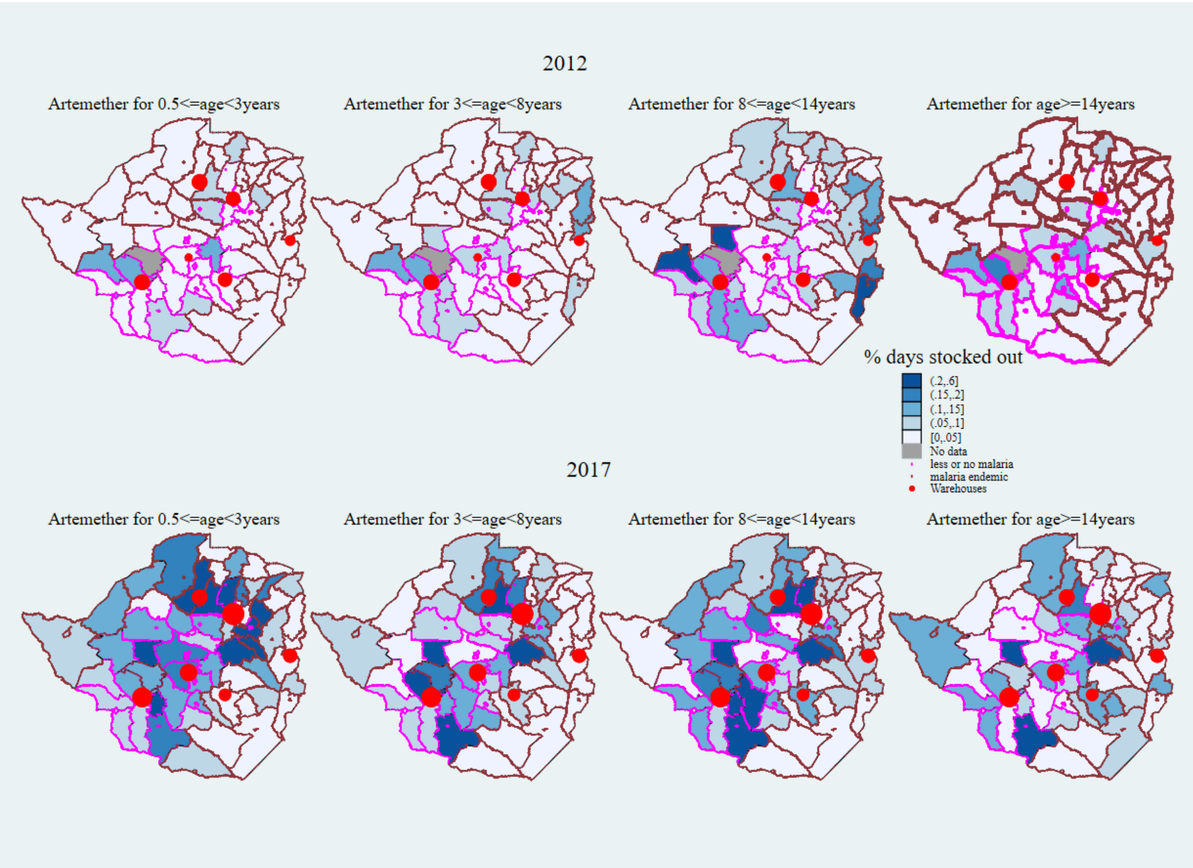

Figure 3.2: Proportion of days with antimalarial stockouts by year

The antimalarial drug stockouts are denoted by different shades; the darker the shade of a district, the more prevalent the drug stockouts were in that district. The districts are grouped

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according to malaria endemicity; malaria-endemic districts are indicated by maroon boundaries, while less-endemic or malaria-free districts are indicated by pink boundaries.

The detailed maps echo what the aggregate analysis in Table 3.3 showed: districts had fewer days of antimalarial stockouts in 2012 than in 2017. Districts in the southeast and eastern parts of the country experienced low drug stockouts in both 2012 and 2017.

The disaggregated maps show that stockouts were lower in 2012 for all Artemether dosages, except for the age group 8–14 years, which had a relatively large proportion of days stocked out. Nkayi, Tsholotsho, Chipinge urban, and Chipinge rural had more days stocked out of Artemether for the age group 8–14 years in 2012. In 2017, Artemether for children aged 0.5–3 years was more stocked out than other dosages. Districts with high Artemether stockouts for the age group 0.5–3 years were Nkayi, Umzingwane, Zvimba, Mazowe, Bindura urban, Bindura rural, Murehwa, Marondera urban, Marondera rural, Hwedza, and Chikomba.

Both malaria-endemic and less malaria-endemic districts experienced high antimalarial drug stockouts for all age groups in 2017. The distance to the warehouse did not influence drug stockouts.

Figure 3.3 illustrates the distribution of district poverty in Zimbabwe for 2012 and 2017. Poverty prevalence in Zimbabwe was high, with the majority of the districts showing poverty greater than 60%. Districts in the northeast, northern, and northwest had relatively high poverty compared to districts in the central, western, southern, southeast and southwest districts.

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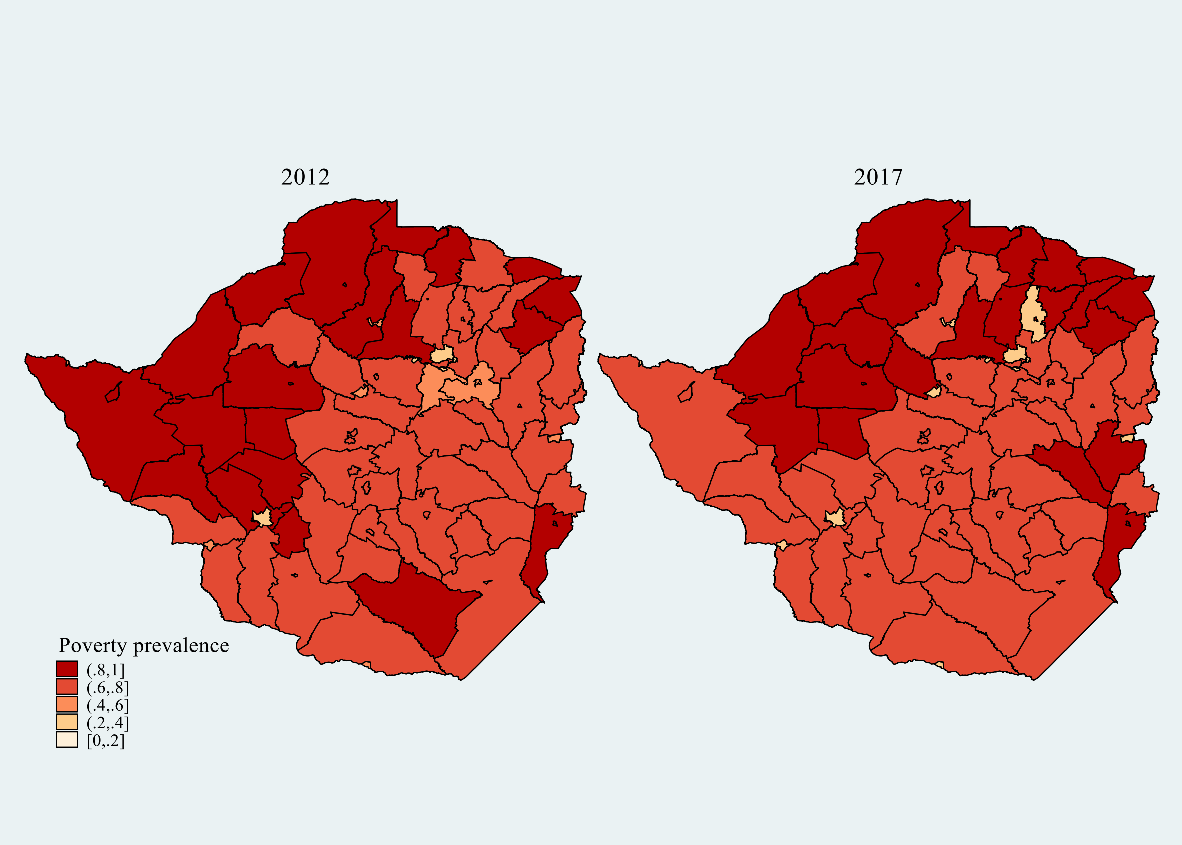

Figure 3.3: Poverty prevalence in 2012 and 2017

There were 16 districts with poverty levels higher than 80% in both 2012 and 2017: Hurungwe, Karoi, Binga, Kariba, Muzarabani, Gokwe South, Gokwe Centre, Nkayi, Lupane, Chipinge urban, Chipinge rural, Mutoko, Mudzi, Muzarabani, Zvimba, and Rushinga. Seven districts had low poverty prevalence in both 2012 and 2017: Harare, Chinhoyi, Norton, Kadoma, Mutare urban, Plumtree, and Bulawayo. There was not a significant difference in the distributions of the prevalence of poverty and extreme poverty in 2017 (see Figure I.1 in Appendix I).

3.5.3 Relationship between drug stockouts and district poverty in Zimbabwe

Bivariate maps were used to show the relationship between drug stockouts and district poverty. These maps have different scales that can be generated automatically or manually. Automatically generated cut-off points show the scales created using an algorithm from data in a specific period, while manually generated cut-off points show data intervals adjusted to suit the data for 2012 and 2017. The automated scales only allow for within-year analysis of the relationship between drug stockouts and district poverty, and do not allow between-year comparisons. On the other hand, manually adjusted scales enable between-year comparisons

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of the relationship. The scales were adjusted to consider drug stockouts and poverty values in both 2012 and 2017. The preference for a specific scale, therefore, depends on the question at hand. Appendix G shows the maps with automatically generated scales, and Figure 3.4 shows the manually generated scales.

Figure 3.4 contains the bivariate thematic maps showing the relationship between drug stockouts and district poverty in 2012 and 2017. The relationship between poverty prevalence and drug stockouts is denoted by different shades: dark purple indicates districts where high stockouts were coupled with high poverty prevalence, and light grey indicates districts where low stockouts coincided with low poverty prevalence. The lavender shade indicates moderate stockouts and poverty prevalence, but it should be noted that, in the case of Zimbabwe, even these moderate levels are quite high. The remaining shades show either low stockouts and high poverty, or high poverty and low stockouts.

Figure 3.4 shows 2012 and 2017 bivariate maps for antimalarial stockouts and poverty prevalence using a common scale in both years, which was used to track change in the relationship between these two variables.

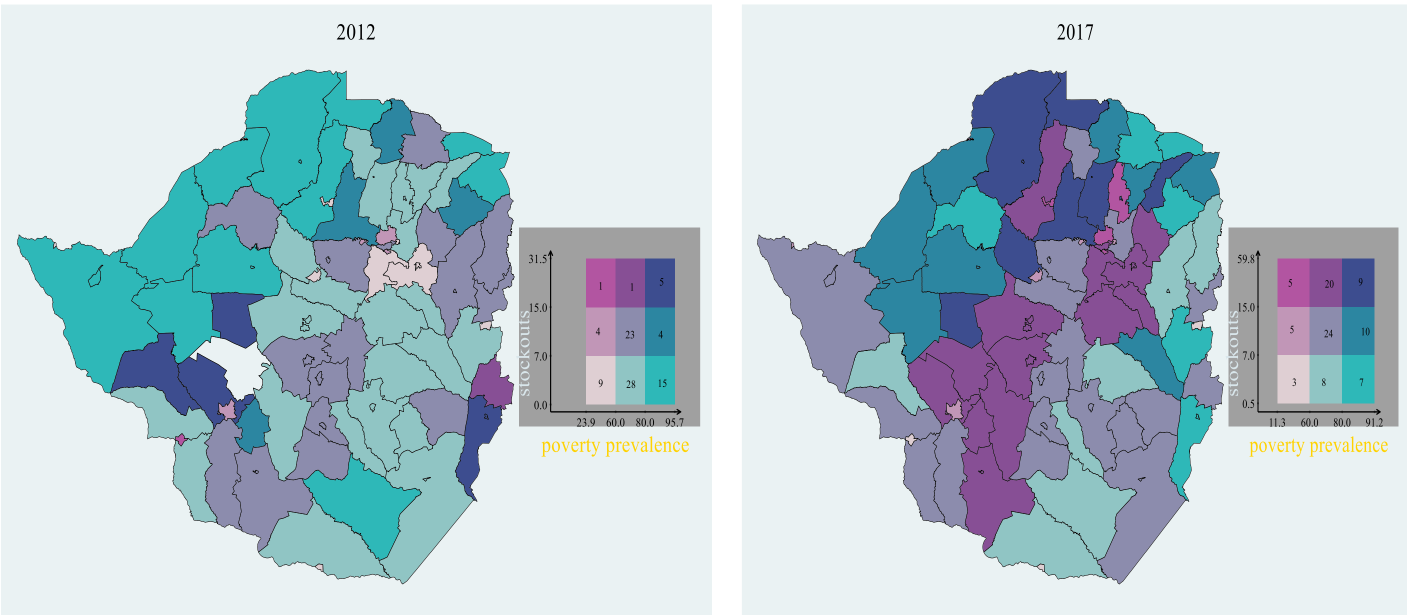

Figure 3.4: 2012 and 2017 Antimalarial stockout and poverty prevalence

A strong positive relationship is indicated by the diagonal colours from the bottom left to the top right of the legend, while the colours corresponding to the bottom right and top left of the legend show a strong negative relationship between stockouts and poverty. Other colours show

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a weak negative relationship between drug stockouts and poverty prevalence. For example, the colour green in the (1,3) matrix indicates high poverty prevalence and low drug stockouts, while the colour pink in the (3,1) matrix indicates low poverty prevalence and high drug stockouts (refer to Table F.1 in Appendix F for the districts in each matrix).

The relationship between district-level drug stockouts and poverty prevalence changed substantially between 2012 and 2017. Considering all districts that had high levels of poverty and antimalarial stockouts (dark purple) in either 2012 or 2017, only Nkayi district was classified as such in both years. More districts experienced high antimalarial stockouts and relatively low poverty prevalence in 2017, whilst more districts experienced high poverty prevalence and relatively low antimalarial stockouts in 2012.

Some patterns stayed the same. Several districts experienced moderate but relatively high drug stockouts and poverty prevalence in 2012 and 2017: Mberengwa, Matobo, Zvishavane urban, Zvishavane rural, Shurugwi urban, Shurugwi rural, Chirumhanzu, Chegutu urban, Chegutu rural, Bikita, and Mutasa. Beitbridge urban and Mutare urban experienced low poverty prevalence and antimalarial stockouts in both 2012 and 2017. Overall, considering that the number of districts showing a weak negative relationship outweighed the ones with a strong relationship, I concluded that there was a weak negative relationship between poverty prevalence and antimalarial drug stockouts in 2012 and 2017. Spatial regression models validated the findings from these thematic maps and descriptive analysis.

3.5.4 Spatial regression models

Table 3.4 shows the RE, SAR model, SEM, SDM, and SDEM. The models included the spatial lags, showing spillover effects to neighbouring districts.

Districts with a high malaria burden had a significant and negative association with drug stockouts, regardless of the model specification used. Poverty prevalence was found to be negatively but insignificantly related to stockouts. Population per facility and distance to the nearest warehouse were insignificantly related to drug stockouts. The coefficient of the spatial interdependence for antimalarial drug stockouts (ρ) was significantly positive, while the coefficient for the weighted poverty prevalence (θ) was significantly negative using the SDM. However, the spatial interdependence for the dependent and independent variables was insignificant after controlling for spatial error. The spatial interdependence for the error term (ϕ) was positive and significant.

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Table 3.4: Spatial regression models

Variables	(1) RE	(2) SAR	(3) SEM	(4) SDM	(5) SDEM
Poverty prevalence	-0.001	-0.053	-0.012	0.001	-0.000
	(0.037)	(0.038)	(0.038)	(0.045)	(0.046)
Malaria endemic districts	-0.034**	-0.027**	-0.025***	-0.028**	-0.027**
	(0.014)	(0.013)	(0.014)	(0.013)	(0.014)
Log of population per facility	-0.002	-0.003	-0.006	-0.002	-0.004
	(0.017)	(0.016)	(0.015)	(0.016)	(0.016)
Log of distance to warehouse	-0.000	-0.000	0.000	0.000	-0.000
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Year					
2017	0.079***	0.055***	0.065***	0.048***	0.058***
	(0.014)	(0.015)	(0.020)	(0.015)	(0.019)
Constant	0.113	0.128	0.150	0.124	0.136
	(0.154)	(0.145)	(0.136)	(0.142)	(0.139)
Weighted variables					
Stockout (ρ)		0. 345***		0.475***	0.276
		(0.091)		(0.107)	(0.192)
Poverty prevalence (θ)				-0.078**	-0.054
				(0.037)	(0.044)
Error (ϕ)			0.551***		0.356*
			(0.113)		(0.314)
Observations	180	180	180	180	180
Number of districts	90	90	90	90	90

RE: random effects model
Standard errors in parentheses
*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

Table K.1 of Appendix K shows the spatial regression model results with the logarithm of poverty prevalence, while Tables I.1 and I.2 of Appendix I show the spatial regression results using poverty prevalence and extreme poverty. These results do not differ substantively from the results shown in Table 3.4.

Table 3.5 reports the direct, indirect and total effects of the independent variables on the antimalarial drug stockouts. The results provide no evidence that poverty prevalence, population per facility, and distance to the warehouse are significantly affecting stockouts.

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Table 3.5: SAR model for stockouts

Variables	Direct effect	Indirect effect	Total effect
Poverty prevalence	-0.054	-0.019	-0.073
	(0.039)	(0.017)	(0.055)
Malaria endemic district	-0.028**	-0.010*	-0.038**
	(0.014)	(0.006)	(0.018)
Log of population per facility	-0.003	-0.001	-0.004
	(0.016)	(0.006)	(0.022)
Log of distance to the warehouse	-0.000	-0.000	-0.001
	(0.002)	(0.001)	(0.003)

Standard errors in parentheses
*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

The direct, indirect, and total effects of high malaria-endemic districts on antimalarial drug stockouts were negative and significant. High malaria-endemic districts had 0.028 less stockouts than low malaria-endemic districts. The spillover effect from the change in malaria endemic on stockouts of neighbouring districts was 0.010. This negative spillover effect was smaller than the negative direct effect, showing a beneficial reduction in stockouts for neighbouring districts with high malaria endemic. The total effect shows that districts with high malaria endemic had low stockouts (0.038) in the focal district and its neighbouring districts. Thus, the total effect indicated a negative relationship between malaria-endemic districts and drug stockouts, showing that districts with high malaria levels had lower drug stockouts than those with low malaria levels.

Figure 3.5 shows the spatial autocorrelation of drug stockouts in terms of hot and cold spots of stockouts (compared to neighbours). Hot spots were clustered districts with a high prevalence of drug stockouts, while cold spots were clustered districts with a low prevalence of drug stockouts. The figure shows drug stockout hot spots for both 2012 and 2017; there were no cold spots in either year.

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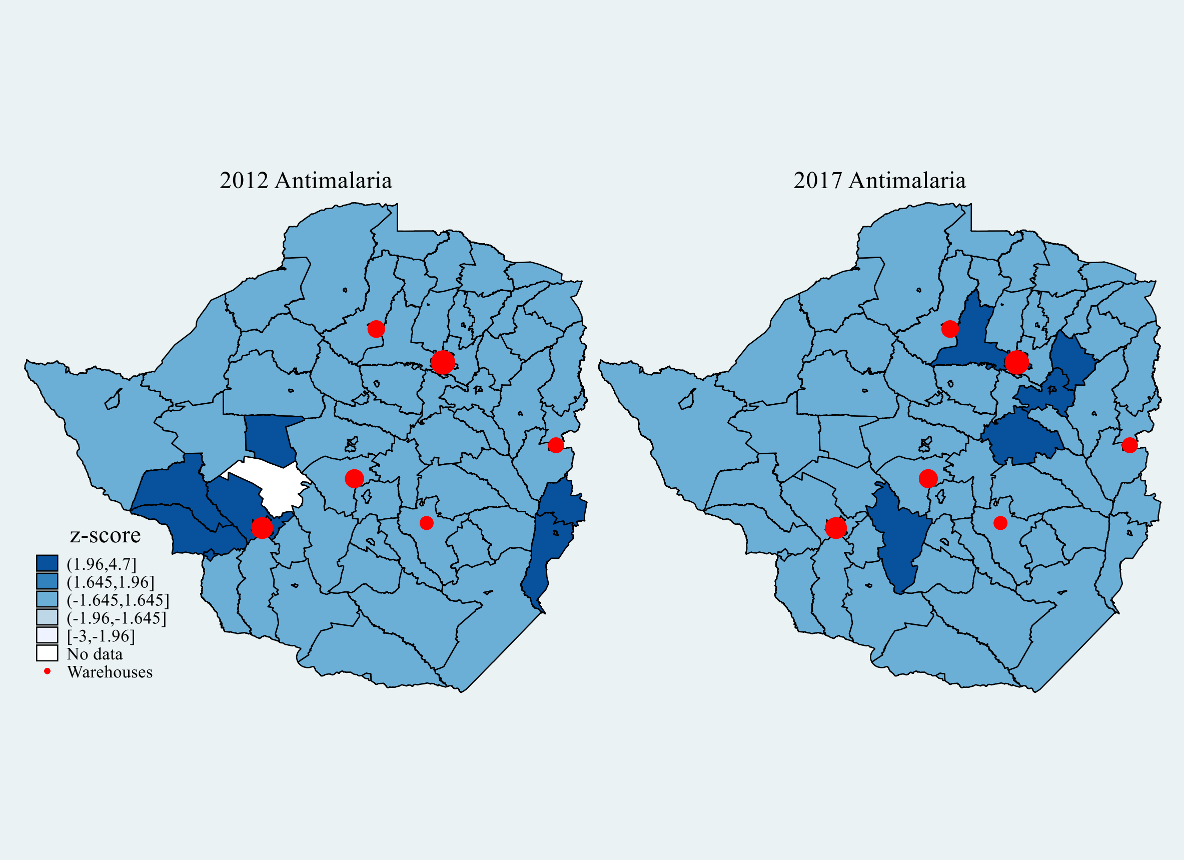

Figure 3.5: Drug stockout hot spot analysis by year

There were more antimalarial stockout hot spots in 2017 than in 2012 (see Appendix L). Furthermore, districts with high clustering values for drug stockouts were not the same for 2012 and 2017. Bulilima, Chipinge urban, Chipinge rural, Chimanimani, Plumtree, Nkayi, Tsholotsho, and Umguza districts were antimalarial stockout hotpots in 2012, while Zvimba, Murehwa, Marondera urban, Marondera rural, Insiza, Chinhoyi, Ruwa, Chikomba, and Norton districts were hot spots in 2017. This provides evidence of geographical clustering for districts with a prevalence of high drug stockouts.

Table 3.6: **Correlation between hot spots and distance to closest warehouse**

	Distance to closest warehouse
2012 z-score	-0.168
	(90)
2017 z-score	-0.357*
	(91)

Number observations in parentheses
*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

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As indicated in Table 3.6, there was a negative correlation between z-scores and distance to the nearest warehouse. Hot spots were negatively and significantly correlated with distance to the nearest warehouse in 2017, but insignificantly correlated with distance to the warehouse in 2012.

3.6 Discussion of results

The results show that high antimalarial drug stockouts are a substantial problem in Zimbabwe, despite the effectiveness and importance of these drugs. Drugs are important to improve health outcomes, hence the need for a steady supply at the facility level. Unfortunately, drug stockouts are common, and affect the reliability of access and adherence to recommended dosages. Aside from drug stockouts, people are likely to face additional constraints in accessing healthcare services, such as high service- and transport costs, unavailability of health workers and facilities, poor-quality services, and long waiting times at the facilities (Gilson and McIntyre, 2007; Mangundu *et al.*, 2020; Ndejjo *et al.*, 2021; Ng *et al.*, 2021).

On average, 7.7% of the days showed drug stockouts in 2012, increasing to 15.6% in 2017. Artemether stockouts were high for children aged 8–14 years in 2012, whilst Artemether stockouts for children aged 0.5–3 years were high in 2017. The results are consistent with previous studies on low- and middle-income countries on this topic, including that of Sintayehu *et al.* (2022), who reported anti-tuberculosis drug stockouts in Ethiopia, and Hwang *et al.* (2019), who found a high prevalence of antiretroviral and anti-tuberculosis drug stockouts in South Africa.

Stockouts may arise due to a variety of problems, including poor supply chain management, incompetent health staff, inaccurate forecasting, and poor storage at the facility level (MoHCC, 2011b; The Global Fund, 2020). In Zimbabwe, stockouts are also linked to economic challenges, such as acute shortages of foreign currency, power, and fuel shortages (US President's Malaria Initiative, 2020; ZIMSTAT and World Bank, 2020), which have contributed to shortages of skilled health workers, reduced health budgets, and a lack of essential drugs (MoHCC, 2020a; World Bank Group *et al.*, 2017). The poorer economic performance and worse service provision in 2017 compared to 2012 contributed to weaker supply chain management, as well as the distribution of resources (MoHCC, 2020a; World Bank Group *et al.*, 2017). Economic challenges resulted in frequent fuel shortages, which, in turn, compromised logistics and the distribution of drugs from warehouses to respective health facilities, worsening drug stockouts at the point of care (ZEPARU, 2014).

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Frequent drug stockouts result in a mismatch of health needs and health resources for the individuals who need the resources to improve their health outcomes. Districts in the eastern and southeast regions experienced low drug stockouts in both 2012 and 2017. The relatively low levels of stockouts may be attributable to the very high malaria levels in these districts, which make these districts a useful example in devising new strategies to reduce malaria transmission and improve the availability of anti-malaria products (Rosen *et al.,* 2015). For example, ZAPS was first piloted in the eastern region between 2014 and 2015, before being implemented nationwide (Rosen *et al.*, 2015).

High malaria control coverage in some of these districts may assist in curbing the demand for antimalarial drugs (Mharakurwa *et al.*, 2013). This interpretation aligns with the results of the SAR model showing that districts with a high malaria endemic had a negative direct, indirect, and total effect on stockouts, thus indicating that antimalarial drug stockouts were lower in malaria-endemic areas than in districts with a low prevalence of malaria. The analysis showed that drug stockouts were low in the high malaria-endemic districts and the districts with which they share a border. Again, this may have been due to better distribution of preventive and treatment products (including ITNs and indoor residual spraying) in malaria-endemic areas, which could be expected to reduce infections and the demand for anti-malaria treatment (MoHCC, 2020a; Sande *et al.*, 2017).

Overall, the maps and regression analysis showed a weak relationship between poverty prevalence and drug stockouts. This may be attributable to compromised access to healthcare services in poor and marginalised areas (supported by the results in Appendix M), resulting in unused drugs at these facilities, thereby reducing drug stockouts. The poor are less likely than the affluent to seek treatment when ill (ZEPARU, 2014). In rural areas, households often reside far from health facilities (Osika *et al.*, 2010, ZEPARU, 2014), and the weak transport system in Zimbabwe further hampers their access to healthcare services (Dube *et al.*, 2019; MoHCC, 2020a). The poor are also more likely than the affluent to seek treatment from traditional and faith healers in Zimbabwe, which may further decrease the demand for public healthcare in poor areas (ZIMSTAT, 2019). Therefore, clustering in drug stockouts exists, but district-level poverty is not an explicit cause of stockouts in the regions where stockouts are clustered. Given that poverty is prevalent and high in most districts, poverty may be correlated with a high baseline of stockouts countrywide in a more systemic way. The analysis showed considerable district-level heterogeneity in this relationship, which is consistent with the findings of Amstislavski *et al.* (2012), Pednekar and Peterson (2018), and Wigley *et al.* (2020).

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The results showed that facilities, at the time of study, were more concentrated in the northeast, eastern, and central parts of the country, with a low population per facility, except in the northeast. In addition, facilities were concentrated in the urban and better-resourced areas, leaving the rural and under-resourced areas at a disadvantage, with this population having to walk long distances to reach the nearest facility (ZSARA, 2015). This shows that few resources or little backup, together with the time and the cost associated with travelling to the nearest facility when there are stockouts, hamper these areas' access to antimalarial drugs (Buzuzi *et al.*, 2016). The results showed a spatial mismatch between the population per facility and the location of warehouses, with warehouses located in areas with a low population per facility. The results reported in this chapter are consistent with those of Tandi *et al.* (2015) for Cameroon, Ward *et al.* (2014) for South Africa, Zamfir *et al.* (2015) for Romania, and Wigley *et al.* (2020) for SSA, who found inequalities with regard to healthcare facilities and workers. This is attributable to differences in development between regions worsening the inequality in health service delivery, with urban regions having more and better health resources, compared to rural regions. Moreover, disparities in disease prevalence across geographical regions also contribute to a spatial mismatch in health services provision.

Concerning weighted variables' coefficients, stockouts spillover was positive and significant amongst the districts. This shows that positive spatial interdependence exists for drug stockouts in Zimbabwe. Changes in drug stockouts in the focal district are thus affect drug stockouts in the neighbouring districts in Zimbabwe. The results showed that districts with a high prevalence of drug stockouts were clustered with neighbouring districts with a high prevalence of drug stockouts (hot spots). This shows that drug stockouts occur at a higher level than the district level. Drug stockouts are widespread as a result of regional-level bottlenecks, as the facilities in a district are serviced by the same warehouse. In the same vein, the service networks and supply chain management for antimalarial drugs are integrated across districts in Zimbabwe (Rosen *et al.*, 2015). Given that districts are interrelated, correlated disruptions arise in facilities in districts that are affected by similar supply chain management challenges. These regional disruptions in the supply chain of drugs affect a network of districts that depend on the same services. This shows that there is a broader drug stockouts challenge at the district level, which requires an investigation of the regional network of drug provision in Zimbabwe.

Ultimately, the impact of drug stockouts on health outcomes depends on the coping mechanisms patients and health workers use to reduce the negative effects of drug stockouts. Therefore, no discussion or assessment of drug stockouts can be comprehensive without

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considering the role of coping mechanisms in determining how drug stockouts impact health outcomes. Faced with a drug stockout at their local facility, individuals may seek treatment from other nearby facilities. Others may try to borrow money or drugs from their neighbours, friends, or relatives, but then have to repay the debt, which could drive them into a debt trap (Ndejjo *et al.*, 2021; Ng *et al.*, 2021). There is also the risk that, due to desperation, individuals use incorrect drugs in times of need (Gilson and McIntyre, 2007).

When their local public facility has a drug stockout, people are often forced to buy drugs from the private sector, which may be expensive. Although the Artemether drug is provided free in the public sector, the private sector might take advantage of stockouts in the public sector by charging a relatively high fee for the drug. Given that the majority of people rely on OOP health payments, purchasing drugs from the private sector may be financially catastrophic. Buzuzi *et al.* (2016) notes that Zimbabweans often sacrifice essentials such as clothing, food, and school fees to pay for healthcare services. Selling assets is thus another coping mechanism, and may ultimately lead to a complete depletion of assets (Buzuzi *et al.*, 2016; Gilson and McIntyre, 2007; Ng *et al.*, 2021).

Previous studies in Kenya and Uganda suggest that individuals tend to use their social networks to access cheap drugs from the informal sector when faced with drug stockouts (Ndejjo *et al.*, 2021; Ng *et al.*, 2021). Buying drugs from the growing informal sector in Zimbabwe is not recommended because these drugs are not regulated by the medicine control authorities, and may be of poor quality, thus posing a risk to health outcomes (Gwatidzo *et al.*, 2017). Specifically, it may result in Artemisinin resistance or antimicrobial resistance, and, in some instances, death. Poor-quality antimalarial drugs in the informal market pose global health challenges by increasing hospitalisation and the cost of treatment in developing countries (Jackson *et al.*, 2020; Ozawa *et al.*, 2019).

People also use traditional and herbal medicines in times of drug stockouts. Gilson and McIntyre (2007) note that, in South Africa, many people seek healthcare services from traditional or faith healers. The use of traditional medicines increased during the COVID-19 pandemic, in Zimbabwe and globally (Chali *et al.*, 2021; Mangombe *et al.*, 2021; MoHCC, 2020b), due to the absence of drugs to treat COVID-19 infections. Again, these treatments come with risks, because traditional medicines are not regulated.

Lastly, one should also consider that drug stockouts can cause people to lose trust in the health system, and they may then forgo health services even when they are seriously ill

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(Kuwawenaruwa *et al.*, 2020). Faced with drug stockouts, poor individuals either choose an alternative treatment or no treatment at all (Kamvura *et al.*, 2022). The likelihood of forgoing treatment is increased by the high drug prices that individuals face in times of drug stockouts. A qualitative study by Kamvura *et al.* (2022) found that individuals in Zimbabwe opt out of the formal health sector due to the frequent unavailability of medicine to treat non-communicable diseases. This is supported by ZIMSTAT and the World Bank (2020) showing that the proportion of people who access healthcare services decreased over time in Zimbabwe.

3.7 Conclusion

The availability of healthcare resources is an important element in the provision of healthcare services, and is vital to creating a sustainable and effective health system. Despite the government's efforts to improve antimalarial drug availability at the point of care, antimalarial drug stockouts remain a public health challenge in Zimbabwe. Spatial inequality in stockouts exists in the country. There is also evidence of spatial interdependence in drug stockouts, where stockouts in the focal districts influence stockouts in neighbouring districts. In addition, although districts have different relationships between drug stockouts and district poverty, overall, the nexus between drug stockouts and district poverty is weak, as poverty is prevalent in Zimbabwe, and is correlated with a high baseline of stockouts. Therefore, there is a need for further research on other factors affecting drug stockouts in order to reduce spatial inequalities and interdependences in Zimbabwe.

In the event of drug stockouts, individuals use traditional medicines, forgo treatment, sell assets, borrow money and drugs, and purchase drugs from the private or informal sector to maintain or smooth their drug supply. However, some of these coping mechanisms have negative effects, including the risk of death. This underlines the severe risk and health impact of drug stockouts and the urgent need to ensure reliable availability of drugs at health facilities. Improving the availability of antimalarial drugs at public health facilities, particularly in underserved districts, may contribute significantly to the MoHCC achieving its mandate to ensure equitable access to health services and improve health outcomes.

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Chapter 4

Malaria prophylaxis stockouts and birth- and maternal outcomes in Zimbabwe

4.1 Introduction

Despite rapid advances in medicine over the past few decades, mothers and their neonates in developing countries continue to die from diseases that are easy and affordable to prevent and treat, such as malaria (Bhattacharya *et al.*, 2020; Boateng *et al.*, 2018). Pregnant women, neonates, and children under the age of five years are more vulnerable to malaria. For example, unlike other adults, women lose immunity against malaria during pregnancy, and the existence of a new body organ (placenta) makes women easily infected by the parasites (Centers for Disease Control and Prevention, 2018). Hence, improved malaria prevention and treatment will promote the attainment of SDG 3[20] by reducing neonatal and maternal mortality. SDG 3 aims to achieve improved health outcomes through reliable access to health services (United Nations, 2022).

As indicated by the WHO (2020), 12 million (35%) pregnant women in SSA were exposed to malaria infections in 2018. Malaria infections amongst pregnant women are more prevalent in Africa, where around four in every 10 women tend to be anaemic (WHO, 2019c). According to the WHO (2023), approximately 300 000 women died in 2020 during pregnancy and birth, with around 95% of these women residing in developing countries. Furthermore, almost one million (822 000) children had a low birth weight, and 272 000 (67%) children died as a result of malaria in 2018 in SSA (WHO, 2020). This is evidence of malfunctioning health systems, specifically inadequate access and use of healthcare services in times of need (Hill *et al.*, 2013; Rao *et al.*, 2013).

Zimbabwe also faces a high burden of malaria, which falls heavily on pregnant women and their neonates. This burden contributed to a high maternal mortality rate of 651 deaths per 100 000 live births, a 10% prevalence of low birth weight, and a 27% prevalence of maternal anaemia in 2015, reported by ZIMSTAT and ICF International (2016). These compromised

[20] These targets include SDG 3.1, 3.2, and 3.8. SDG 3.1: "By 2030, reduce the global maternal mortality ratio to less than 70 per 100 000 live births." Target 3.2: "By 2030, end preventable deaths of newborns and children under 5 years of age, with all countries aiming to reduce neonatal mortality to at least as low as 12 per 1 000 live births and under-5 mortality to at least as low as 25 per 1 000 live births." Target 3.8: "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" (United Nations, 2022).

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health outcomes affect vulnerable and marginalised groups of people, such as the poor who live in rural areas (Nkonki *et al.*, 2011).

In 2013, the WHO recommended pregnant women to receive IPTp for protection against malaria (WHO, 2019c). Sulfadoxine/pyrimethamine (SP), sold under the brand name Fansidar, is used in Zimbabwe as the IPTp during ANC visits, and the first dose is administered at 13 weeks into women's pregnancy, regardless of malaria status. The women receive additional doses a month apart, and the prophylaxis is administered for free. Administering the SP from the 13th week is beneficial, as the placenta is forming, and malaria parasite density is highest during this period. SP uptake reduces the carriage of the malaria parasite and the probability of negative health outcomes for pregnant women and neonates (Kalilani-Phiri *et al.*, 2013; Mikomangwa *et al.*, 2020). According to the WHO (2020), around half a million low birth weights are pushed towards healthy birth weight using IPTp, and low birth weight could be addressed if pregnant women in countries with a high malaria burden receive the recommended SP doses.

At least three doses of SP are recommended until delivery, with the expectation that women attend the recommended ANC visits (Bakken and Iversen, 2021). Despite an increased number of ANC visits over the years, most pregnant women still receive less than three SP doses (Bausell and Katherine, 2014; WHO, 2019c) Regardless of IPTp's effectiveness in malaria management, receipt of at least three SP doses is a challenge (Rao *et al.*, 2013). Drug stockouts, an inexperienced workforce, poor infrastructure, gaps in knowledge of the IPTp guidelines, and asymmetric information are the major reasons for the low uptake of SP despite increasing ANC visits (Bausell and Katherine, 2014; Hill *et al.*, 2013; Ndyomugyenyi and Katamanywa, 2010). Médecins Sans Frontières (2015) defines drug stockouts as the complete unavailability of drugs at a facility for at least one day.

Drug stockouts are the major reason why women do not receive adequate IPTp (Thakataka *et al.*, 2021; WHO, 2019d), with 10% of missed opportunities attributed to SP stockouts (US President's Malaria Initiative, 2018a). Drug stockouts are a public health challenge in most developing countries, compromising access to essential healthcare services. According to Zimbabwean MoHCC stockouts data, one in every three facilities faced malaria prophylaxis stockouts in 2020. This reduces access to essential healthcare services during pregnancy. Not receiving the SP doses as recommended increases the probability of malaria infections, resulting in placental malaria and, eventually, a low birth weight for neonates, and even death

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(Khaja and Sequeira, 2021; Mikomangwa *et al.*, 2020). Pitts (2013) noted that malaria prophylaxis stockouts have caused the death of 219 million people worldwide. This shows missed opportunities to improve maternal and neonatal health outcomes.

Several studies have examined the determinants of the uptake of IPTp (for example, Bausell and Katherine, 2014; Chikwasha *et al*., 2014; Ndyomugyenyi and Katamanywa, 2010; Rao *et al.*, 2013). Drug stockouts are one of the reasons why pregnant women receive fewer doses of SP than recommended. Despite the existing literature on drug stockouts, there remains a lack of empirical analysis of the health implications of malaria prophylaxis stockouts on pregnant women and their neonates. Prior studies have examined the effects of antiretroviral and tuberculosis drug stockouts on health outcomes (Atif *et al.*, 2021; Brennan *et al.*, 2017; Gils *et al.*, 2018; Koomen *et al.*, 2019; Pasquet *et al.*, 2010; Poku, *et al.*, 2017; Qiu and Dungca, 2015; Seunanden and Day, 2014), but less is known about malaria prophylaxis stockouts. These studies reported mixed results regarding the implications of drug stockouts: some found that drug stockouts worsen health outcomes (Atif *et al.*, 2021; Koomen *et al.*, 2019; Mclaughlin *et al.*, 2013; Seunanden and Day, 2014), while others reported that drug stockouts do not affect health outcomes (Brennan *et al.*, 2017; Gils *et al.*, 2018). Some studies also focused on the effects of disruption of the health system through unavailability of health workers as a measure of the quality of healthcare for maternal and child healthcare in developing countries (for example, Friedman *et al*., 2022; Goldstein *et al.*, 2013). These studies note that disruption of healthcare services worsens maternal and child health outcomes.

Although high levels of stockouts of malaria prophylaxis in developing countries are well-documented, there seem to be no studies on the association between these stockouts and health outcomes. This is despite pregnant women and neonates being vulnerable to malaria and malaria being one of the major causes of inpatient and outpatient admissions (MoHCC, 2014). Against the backdrop of scant literature on malaria prophylaxis stockouts, the current chapter sheds light on the association between malaria prophylaxis stockouts and birth- and maternal outcomes in Zimbabwe.

Following the above aim, it was hypothesised that women who do not receive malaria prophylaxis due to stockouts during pregnancy are at risk of malaria infections, and maternal anaemia, and their neonates have a low birth weight. The results of this chapter could assist policymakers in making informed decisions regarding efforts to reduce negative health consequences of malaria for pregnant women and their neonates. This chapter, therefore,

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contributes to the existing body of academic literature on drug stockouts. Given that Zimbabwe is among countries with high maternal and child mortality, the empirical evidence from this study may make a significant contribution to improving healthcare service provision for vulnerable groups and accelerate the achievement of SDG 3.

The chapter outline is as follows. In Section 2, I discuss SP administration in Zimbabwe. Section 3 explores the literature on malaria during pregnancy and drug stockouts, and provides a conceptual framework for birth health outcomes. In Section 4, I discuss the sources from which the data used in this chapter were obtained. This is followed by a comprehensive discussion of the data analysis methods and variables. Section 5 presents the results of malaria prophylaxis stockouts with regard to health outcomes in Zimbabwe, followed by a discussion of the results and the conclusion.

4.2 SP administration in Zimbabwe

It is important to first shed light on how SP is administrated in Zimbabwe. According to Zimbabwe's MoHCC (2020), only high malaria-endemic districts are recommended to administer SP. These districts are situated in the eastern, northern, southern, southeast, northeast, and northwest parts of the country.[21] Other districts in the country are not recommended to administer SP, given that they have low malaria transmission rates. However, the authorities in these low malaria transmission areas still administer SP doses, citing the need to improve the health outcomes of their people (US President's Malaria Initiative, 2017). The other reason authorities administer SP doses in low malaria transmission areas is to cater for pregnant women who reside in high malaria-endemic areas, but whose closest facility is in low malaria-endemic areas. This takes into consideration the fact that accessing health facilities is not dependent on district or province, but on convenience in terms of distance, as well as related costs. Furthermore, malaria infections still exist in low malaria transmission areas, and negatively affecting pregnant women and their neonates, and SP uptake is effective in reducing malaria infections in these areas. The WHO (2014) notes that discontinuing SP in areas with no or a low malaria burden should be done cautiously, as malaria incidence changes from time to time.

[21] The districts recommended to administer SP include 30 districts in Manicaland, Mashonaland Central, Mashonaland East, Mashonaland West, Matabeleland North, Midlands, and Masvingo.

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Additionally, pregnant women are encouraged to receive IPTp via direct observation therapy (US President's Malaria Initiative, 2018). Direct observation therapy administered by health workers is to ensure that a full preventive dose is taken (Khaja and Sequeira, 2021; WHO, 2014). Health workers provide SP doses to pregnant women upon attending their routine ANC, and women who attend the recommended ANC visits are expected to receive the recommended number of doses of SP. Village health workers are employed by the MoHCC to encourage pregnant women to attend ANC early and take up IPTp by outlining the benefits of taking SP during pregnancy.

An SP dose consists of three tablets, each tablet containing 500/25mg SP, a total of 1 500mg/75mg per SP dose (Khaja and Sequeira, 2021; WHO, 2014). There are no maximum doses that women should receive during pregnancy. SP doses are safe to administer between the second trimester and delivery, with a month between doses (WHO, 2014). SP is not recommended during the first trimester, because it is unclear whether it is safe to use in this period. For the first trimester, it is advised that women protect themselves by using ITNs and other malaria prevention methods. ITNs are supposed to be provided in the first weeks of pregnancy, during ANC visits (Chua *et al.*, 2021). Furthermore, SP is effective as an IPTp in improving maternal and neonatal health outcomes, regardless of drug resistance in areas with plasmodium falciparum mutations (WHO, 2014).

Despite high malaria-induced morbidity and mortality, according to the 2016 Malaria Indicator Survey, only 20% of pregnant women in Zimbabwe received three or more doses of SP, and, according to the ZDHS for 2010–2011, 8% received at least two doses (US President's Malaria Initiative, 2020). Notwithstanding approximately 80% of pregnant women attending at least four ANC visits, few receive at least three doses of SP. This signifies a crippled health sector that fails to provide essential services to those in need, with dire effects on their health outcomes (Friedman *et al.*, 2022; Goldstein *et al.*, 2013). As a complementary initiative, pregnant women also receive an ITN, to reduce malaria infections. Despite adequate access to ITNs, only 15% of women reported using them in the 2015 ZDHS (ZIMSTAT and ICF International, 2016).

Research in Tanzania found that public facilities are more likely than private facilities to dispense SP doses (Bajaria *et al.*, 2019). In Zimbabwe, private facilities also have limited implementation of IPTp as part of ANC services (Chikwasha *et al.*, 2014; US President's Malaria Initiative, 2018). Due to low levels of adherence to this policy, combined with a lack

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of data on malaria prophylaxis availability in private health facilities, this chapter focused on malaria prophylaxis stockouts in public health facilities.

4.3 Literature review

4.3.1 Malaria in pregnancy and drug stockouts

Malaria infections from plasmodium falciparum have negative effects on mothers and their neonates (Khaja and Sequeira, 2021; Menendez *et al*., 2000). Pregnant women are at high risk of placental malaria, maternal anaemia, and mortality as a result of malaria infections (Ekvall, 2003; Menendez *et al*., 2000). Placental malaria tends to infiltrate and infect red blood cells, thickening the placental membrane, which makes it difficult to exchange nutrients and waste between mother and foetus (Bakken and Iversen, 2021; Khaja and Sequeira, 2021). The disruption of the exchange mechanism results in the foetus receiving fewer nutrients than required, which restricts foetal growth (Chua *et al*., 2021). Placental malaria, therefore, results in adverse maternal and neonatal health outcomes (Chua *et al*., 2021). Furthermore, malaria infections tend to destroy the red blood cells and disrupt the production of red blood cells, thereby reducing haemoglobin levels, which results in maternal anaemia (Menendez *et al*., 2000). Thus, malaria infections are the major determinant of maternal anaemia in pregnancy in malaria-endemic countries (Khaja and Sequeira, 2021; Menendez *et al*., 2000).

Birth weight is a major determinant of neonatal and infant mortality (Bakken and Iversen, 2021; Menendez *et al*., 2000). Malaria infections either affect neonatal birth weight through malaria-induced maternal anaemia or placental malaria (Menendez *et al*., 2000; Uneke, 2007), which can be reduced or prevented through the correct dose of malaria prophylaxis (Bakken and Iversen, 2021; Mikomangwa *et al*., 2020; Kalilani-Phiri *et al*., 2013). Malaria prophylaxis blocks plasmodium falciparum's movement into the placenta and clears parasites from the body (Chua *et al*., 2021; Khaja and Sequeira, 2021).

In areas where transmission is low and mothers' acquired immunity is therefore also low, malaria infection tends to result in stillbirth, preterm delivery, maternal mortality, and small gestational age[22] (Bakken and Iversen, 2021; Khaja and Sequeira, 2021). In high-infection areas, where mothers have developed a high level of immunity, malaria infection results in

[22] Small gestational age refers to weight below 10th percentile for gestational age (Adanikin *et al*., 2022; Chua *et al*., 2021)

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maternal anaemia and low birth weight (Centers for Disease Control and Prevention, 2018). Early prevention and management of malaria infections among pregnant women is crucial in reducing the incidence of low birth weight and maternal anaemia, which are the major causes of infant- and maternal mortality (Feresu *et al*., 2015; Ticconi *et al*., 2003).

From the above, it is clear that mortality and morbidity due to malaria in pregnancy are preventable through access to the necessary healthcare services. Despite the effectiveness of malaria prophylaxis, they cannot work if they are not taken, and they cannot be taken if they are not available. Drug stockouts thus compromise the effectiveness of initiatives to prevent malaria in pregnancy. Stockouts are caused by poor supply chain management, bureaucracy, theft, expiry, unexpected increases in demand, lack of funding, and unskilled health workers manning facilities (Koomen *et al*., 2019; Wagenaar *et al*., 2014). The Parliament of Zimbabwe (2019) notes that some of the drugs available at healthcare facilities have a short shelf life of, at most, three months, which complicates stock management. Overstocking of drugs without proper storage (for example, a cool and dry place) is also a challenge for many facilities in Zimbabwe (Rosen *et al*., 2015).

Given the storage and supply chain management challenges, drug stockouts are a prominent public health challenge in developing countries (Sintayehu *et al*., 2022; Thakataka *et al*., 2021). According to a study by the WHO, developing countries' health sectors, on average, have only 50% drug availability (Cameron *et al*., 2011).[23] Zimbabwe also faces frequent drug stockouts, with the availability of drugs varying between 55% to 72% in 2019 (Parliament of Zimbabwe, 2019). An assessment using drug stockouts data from the MoHCC showed that, on average, 39% of the facilities surveyed experienced SP stockouts from 2011 to 2015. Stockouts affect vulnerable populations disproportionately. Vulnerable populations reside in deprived areas, which are associated with a rudimentary infrastructure, affecting the logistics and delivery of drugs (Koomen *et al*., 2019). The facilities in these poor areas are often staffed by unskilled workers, which further increases the occurrence of stockouts.

Stockouts constrain individuals from accessing essential healthcare services when needed (Médecins Sans Frontières, 2015). Therefore, stockouts lead to reduced retention of patients in

[23] Availability of drugs was measured using the WHO/Health Action International standard methodology. The information used to measure availability of drugs was collected from health facilities (public facilities, private facilities, dispensaries, pharmacies, and any facilities that provide drugs) in 43 countries, for approximately 15 drugs. Trained data collectors conducted the data collection, which were recorded in Microsoft Excel. The data also included information on medicine prices. Availability was calculated as the number of facilities with stock on the day of data collection (Cameron *et al*., 2011).

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care, treatment resistance, and poor health status, which may lead to their death (Bhattacharya *et al.*, 2020; Gils *et al.*, 2018; Koomen *et al.*, 2019; Qiu and Dungca, 2015). Drug stockouts also lead to interruptions in treatment, increased direct and indirect costs, reduced trust in the health system, morbidity, and mortality (Mori and Owenya, 2014; Pasquet *et al.,* 2010). According to Brennan *et al.* (2017), patients are usually referred to other facilities during stockouts, and they then incur extra travelling costs and high OOP expenditure.

4.3.2 Conceptual framework

The framework for the current chapter was adapted from Chera *et al*. (2015). Supply-side factors include the policy environment and human and financial resources which influence the training and performance of health workers, supply chain management, behaviour change communication, and research (Aberese-Ako *et al*., 2020; Bajaria *et al*., 2019; Bausell and Katherine, 2014; Chera *et al*., 2015; Koblinsky *et al*., 1995). The demand-side factors comprise individual and household factors: SES, HIV status, parity, birth interval, and distance to the nearest health facility (Bausell and Katherine, 2014; Boateng *et al*., 2018; Chera *et al*., 2015; Khan *et al*., 2020; Rahman *et al*., 2021; Sunguya *et al*., 2021; Tamirat *et al*., 2021). Figure 4.1 shows the conceptual framework of how demand and supply factors affect birth outcomes. The framework shows that health outcomes such as low birth weight and preterm delivery are affected by demand and supply factors, both directly or indirectly. Therefore, appropriate policies to improve health outcomes should address these demand and supply factors holistically, for instance, work status, education and supply chain management.

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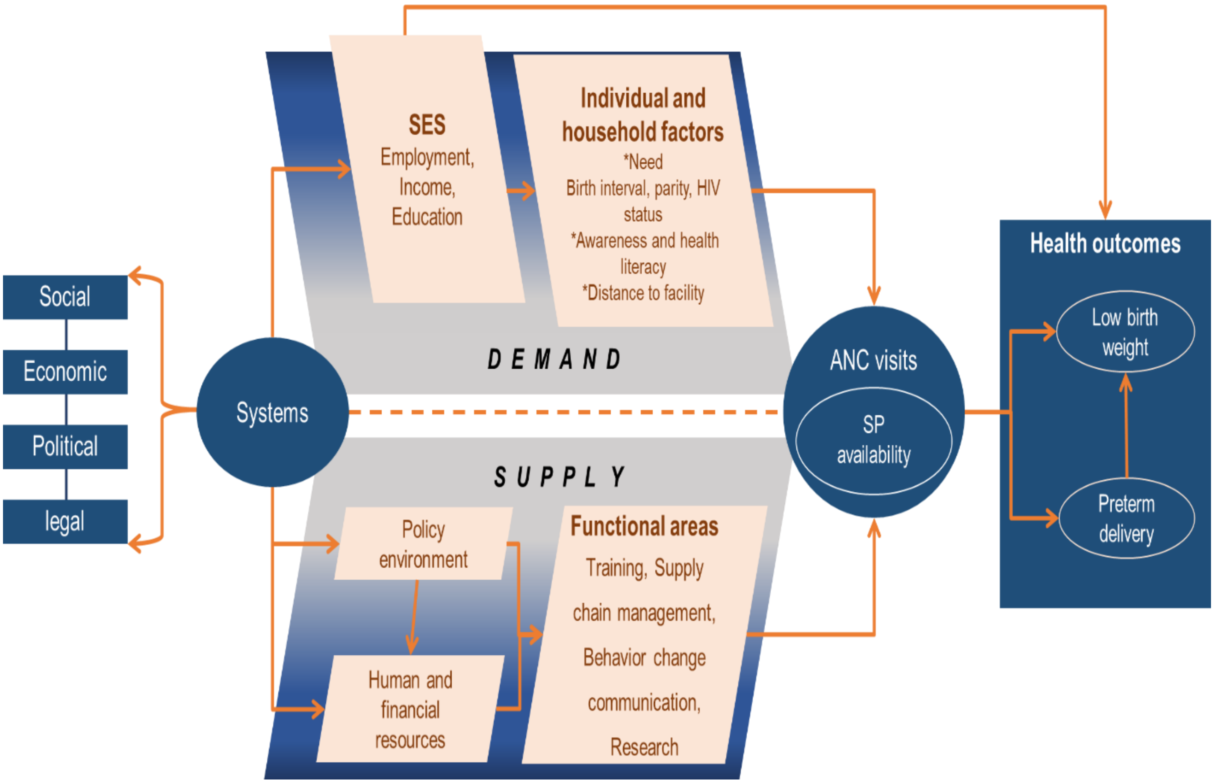

Figure 4.1: Conceptual framework for birth outcomes

Source: Adapted from Chera et al. (2015)

The framework shows that SES in the form of education, wealth and education influences need factors and also health awareness and is expected to be correlated to distance to the facility. In turn, these factors affect ANC visits during which SP doses are administered. Wealth, education and employment affect health outcomes directly.Education enhances women's health knowledge, which, in turn, increases their uptake of antenatal care and birth outcomes (Koblinsky *et al.*, 1995; Ndugga *et al.*, 2020; Sunguya *et al.*, 2021; Tamirat *et al.*, 2021).

Healthcare service utilisation and outcome are also influenced by employment status and household wealth. Affluent and employed women tend to use healthcare services more than poor and unemployed women, given their enhanced capacity to afford the services and the services being in closer proximity (Ndugga *et al*., 2020), which improves their health outcomes (Hill *et al*., 2013). Being employed provides women with the financial capacity to use better-quality services and make important health decisions without first seeking their husband's permission (Ndugga *et al.*, 2020). Employed women from wealthy households are directly associated with improved health outcomes through adequate maternal nutrition and knowledge

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of possible health effects of late utilisation of appropriate health services (Chikwasha *et al*., 2014; Ndugga *et al*., 2020; Tamirat *et al*., 2021).

Distance to the nearest health facility also influences access to healthcare services. Women far from healthcare facilities are less likely to visit such facilities during pregnancy. This weak access to healthcare services compromises their health outcomes (Chera *et al*., 2015; Ndugga *et al*., 2020). Due to the underdeveloped infrastructure and transport systems in rural areas, weak access to services as a result of long travel distances remains a challenge in most developing countries (Isbell and Krönke, 2018; ZEPARU, 2014).

Other factors influencing the utilisation of healthcare services in times of need are birth interval and parity. Parity and birth interval are influenced by SES; women in higher socioeconomic groups tend to have fewer children and longer birth intervals than those in lower socioeconomic groups. Furthermore, women with more children are likely to be constrained in accessing healthcare services, due to increased financial demands and responsibilities (Ndugga *et al.*, 2020). As supported by Sunguya *et al*. (2021), women with prior birth experiences tend to have a high prevalence of anaemia and low birth weight, compared to women in their first pregnancy. However, multiparous women tend to have increased knowledge of the benefits of ANC visits and maternal nutrition, based on their previous experiences (Chikwasha *et al.*, 2014; Hill *et al.*, 2013). Previous experience therefore improves the uptake of antenatal care and, ultimately, birth weight. On the other hand, a shorter birth interval is associated with low uptake of healthcare services, due to late recognition of pregnancy, as well as more responsibilities due to other children (Tamirat *et al.*, 2021; WHO, 2007).

Supply-side factors also influence the utilisation of maternal healthcare services. Training, supply chain management, behaviour communication change, and research are important in enhancing the availability of healthcare services at the point of care. Specifically, poor supply chain management increases the likelihood of SP stockouts at a facility which compromises birth outcomes.

4.3.3 Empirical literature review

This literature review explores the existing literature on the disruption of healthcare services and related health outcomes. Several studies investigated the health implications of drug stockouts and the unavailability of health workers in developing countries (Atif *et al.*, 2021; Friedman *et al.*, 2022; Gils *et al.*, 2018; Seunanden and Day, 2014). However, there is a dearth

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of literature on the association between malaria prophylaxis stockouts and maternal and neonatal health outcomes, despite malaria being one of the major causes of mortality and morbidity in developing countries.

Several studies have been conducted on the health implications of drug stockouts. Koomen *et al.* (2019) and Seunanden and Day (2014) examined the health implications of anti-tuberculosis stockouts in South Africa, and Mori and Owenya (2014), Poku *et al.* (2017), and Pasquet *et al.* (2010) (using the Cox regression model) focused on antiretroviral drug stockouts in Tanzania, Ghana, and Cote d'Ivoire, respectively. Using descriptive analysis, Atif *et al.* (2021), Mclaughlin *et al.* (2013), and Qiu and Dungca (2015) investigated the effects of drug stockouts on health outcomes in Pakistan, the US, and Kenya, respectively. Brennan *et al.* (2017) used linear regression and Gils *et al.* (2018) used descriptive analysis to analyse HIV treatment stockouts and health outcomes in South Africa and the Democratic Republic of Congo, respectively. These studies yielded mixed results on the effects of drug stockouts on health outcomes. Atif *et al.* (2021), Koomen *et al.* (2019), Mclaughlin *et al.* (2013), Pasquet *et al.* (2010), Qiu and Dungca (2015), Seunanden and Day (2014), Mori and Owenya (2014), and Poku *et al.* (2017) found that drug stockouts at the health facility worsen individuals' health outcomes, while Brennan *et al.* (2017) and Gils *et al.* (2018) found that drug stockouts have no effects on health outcomes. Brennan *et al.* (2017) and Gils *et al.* (2018) noted that patients are usually provided with alternative drugs or referred to a nearby facility with stock during stockouts at the focal facility. Thus, these solutions counteract the negative health effects associated with drug stockouts.

Koomen *et al.* (2019) and Seunanden and Day (2014) used the proportion of facilities stocked out to depict drug stockouts in their analysis, rather than the proportion of days with stockouts. Atif *et al.* (2021), Brennan *et al.* (2017), Gils *et al.* (2018), Pasquet *et al.* (2010), and Poku *et al.* (2017) used drug stockouts collected from a health facility on a specific day to illustrate stockouts in the analysis. This is not a true representation of stockouts at the facility, and overstates stockouts, given that a day without drugs at the facility is less harmful than a week or month of stockouts. The current chapter used the proportion of days stocked out within two quarters at each facility when women were supposed to receive the drug as a measure of drug stockouts.

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4.4 Measures and methods

4.4.1 Data sources

The 2015 ZDHS and drug stockouts data were used to explore the relationship between malaria prophylaxis stockouts and health outcomes in Zimbabwe. These two datasets are described below.

Drug stockouts data were obtained from Zimbabwe's MoHCC, whose Pharmacy Services Department is responsible for collecting the data. Facility authorities submit their stock information every quarter to the MoHCC, and the Ministry collates the dataset into a single database. The data contain information on SP availability at each facility in all the districts. The information is collected to monitor drug availability at the health facilities, which includes stock in hand, drugs used, and stockouts. The information enables improved drug procurement and delivery at the facility- and regional levels. The data used in the current chapter were collected quarterly, per facility and district, from 2011 to 2015. The data specify the province, district, facility name, the date the information was recorded, name of the drug, the quantity of drugs in hand, and the number of days the drug was stocked out. This information was used to assess the prevalence of malaria prophylaxis stockouts in Zimbabwe.

The DHS dataset is collected from developing countries every five years, and has been conducted in Zimbabwe since 1988. Six ZDHSs have been conducted so far — in 1988, 1994, 1999, 2005/2006, 2010/2011, and 2015. All six surveys asked the same questions and collected the same health information, with a few amendments to the variables. The ZDHS is conducted by the ZIMSTAT in partnership with the MoHCC and other NGOs. The dataset contains information on demographic and socioeconomic variables, healthcare services utilisation, maternal and child health outcomes, and maternal and child mortality. The survey contains questionnaires for households, women, men, and children. The women's questionnaire captures information on background characteristics, birth history, antenatal and postnatal care, malaria prevention and treatment, as well as child- and maternal mortality. The data also include information on HIV status and cluster GPS coordinates (ZIMSTAT and ICF International, 2016). Like other surveys, DHS data are prone to recall, non-response, and response bias, which might result in measurement errors. Although the data are prone to these biases, they are widely used in health research, given their reliability and accuracy. The current chapter used the 2015 ZDHS data, as this is the only publicly available survey to collect health outcomes information during the same period overlapping with stockout data.

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The 2015 ZDHS dataset was designed to be representative of each of the country's provinces and census districts. Two-stage sampling method was used, whereby enumeration areas were selected first, using proportional probability to size. Thereafter, households were allocated to their respective enumeration areas. A total of 400 enumeration areas were selected — 166 in urban areas and 234 in rural areas, with an average of 24 households in each enumeration area. Enumeration areas are also referred to as 'clusters' or 'primary sampling units'. The data were stratified by separating each province into urban or rural areas. The survey included women aged 15 to 49, men aged 15 to 59, and children aged younger than one year to 14 years. I used the women's questionnaire, as it contains information on child- and maternal health outcomes, which were essential for this analysis. The survey was conducted from July 2015 to December 2015 with a sample of 11 196 households, selected from the 2012 population census data (ZIMSTAT and ICF International, 2016).

A total of 10 534 households were interviewed, yielding a response rate of 98.8%. A total of 9 955 women were interviewed, yielding a 96.2% response rate. However, I only included information on women who gave birth between 2011 and 2015, for which stockout data were available. Data on 2010 health outcomes were not included, as there were no data on stockouts for the same year. After excluding individuals with missing observations, the data analysis was based on 3 432 observations.

In addition, the 2015 DHS data does not include information on the number of SP doses received by a pregnant woman during ANC visits. The question on the number of SP doses received during ANC was included in the 2015 DHS; however, individuals did not respond to the question. The information on IPTp is important in determining whether the women received drugs after a stockout. The number of SP doses would have been used in the analysis to check if women receive drugs during pregnancy.

I used 2015 ZDHS, which was, at the time of this study, the most recent survey that contained data on maternal and neonatal health outcomes that were suitable for this analysis. Maternal mortality, low birth weight, and maternal anaemia have decreased over time; however, these remain a problem, evident in maternal mortality in Zimbabwe being amongst the highest in the SSA region (ZIMSTAT and ICF International, 2016; ZSARA, 2015). This compromises the country's efforts to achieve international and national healthcare goals. The level of malaria prophylaxis stockouts is also high in Zimbabwe, with an average of 27% of facilities

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experiencing drug stockouts in 2020. This shows that drug stockouts are still a challenge, and affect the health outcomes of, especially, vulnerable populations.

4.4.2 Linking facility and DHS data

Linking facility and household survey data is often done to measure the quality of health services women receive during pregnancy (Mallick *et al.*, 2017). However, linking facility and household survey data presents challenges, as the location of households is anonymised and pregnant women sometimes do not use the nearest facilities (Mallick *et al.*, 2017).

I first added facility GPS coordinates to the stockout data by merging master facility data, which contained information on facility location and stockout data, given that stockout data does not contain information on facility coordinates. To combine the drug stockouts data and the ZDHS data, I then used the facility and cluster GPS coordinates. The ZDHS cluster coordinates and the facility coordinates were merged, based on the assumption that people in the same cluster use the same facility. Therefore, if a cluster was serviced by more than one facility, only the closest facility to the cluster coordinates was considered in the analysis. The ZDHS cluster coordinates were displaced from their original position to protect households' information. The coordinates were displaced 2 km in urban areas and 5 km to 10 km in rural areas. The displacement of coordinates was done carefully, to ensure that clusters did not overlap with other administrative areas (see Mayala *et al.*, 2018). The comprehensive information on data extraction is found in the DHS geospatial covariates dataset manual (Mayala *et al.*, 2018). To correct the impact of displacement of coordinates, I used a 10 km buffer zone by considering only the facilities within a 10 km radius. The facility was omitted if its name was absent from the stockouts database or is more than 10 km away from the cluster, and the next closest facility was used.

I combined the 2015 ZDHS and drug stockout data in the analysis. I used 2015 cross-sectional data, where the year of birth was used to pool the data within the same cross-sectional survey, given that drug stockout data are collected yearly. For example, if the child was born in the third quarter of 2012, the stockout information for the respective quarter in 2012 was merged with the relevant information in the ZDHS.

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4.4.3 Description of variables

Based on the conceptual framework for health outcomes and prior literature, the following independent variables were used to investigate the association between malaria prophylaxis stockouts and the health outcomes of mothers and their neonates in Zimbabwe. These variables were: *Birth interval*, *Parity*, *Stockout index*, *Education*, *Wealth index*, *Work status*, *HIV status*,[24] *BMI* (body mass index), *Current pregnancy*, and *Preterm delivery*.

Work status was a dummy variable, denoted by *Working* (for women with a paying job or a business) and *Not working*. Working women were expected to have better health outcomes than non-working women. *Education* represented the total number of years in which a woman attained her educational qualifications, and *HIV status* was a dummy variable, representing HIV-positive and HIV-negative women. Educated and HIV-negative individuals experience improved health outcomes (Sunguya *et al.*, 2021; Tamirat *et al.*, 2021). *Wealth index* is another variable measured in the ZDHS, using principal component analysis on the household's assets. This variable is standardised by subtracting the mean wealth index from the household's wealth index, and then dividing it by the standard deviation, as suggested in literature (Rustein and Johnson, 2004). Women and neonates from affluent households are expected to have better health outcomes than women and neonates from poor households.

The variable *Parity* represented the number of children that the woman had given birth to, including both stillborn and live births. The women could be either primiparous (one birth) or multiparous (multiple births). According to Chikwasha *et al.* (2014) and Hill *et al.* (2013), based on prior pregnancy experience, multiparous women have enhanced knowledge of the benefits of ANC visits and maternal nutrition, which improves their babies' birth weight. They are also more likely to face increased financial demands and responsibilities, which constrain access, and hence compromise birth weight (Ndugga *et al.*, 2020; Sunguya *et al.*, 2021).

Birth interval also influences health outcomes. It shows the spacing between pregnancies which affects the health of the children and represents the number of births by a woman within a year in this chapter. The shorter the birth interval is, the more compromised the health outcomes of mothers and their neonates are (Tamirat *et al.*, 2021). *Preterm delivery* was a dummy variable. Preterm delivery also influences health outcomes. The variable was coded *1* if the child was

[24] HIV-positive women were included in the study, although they are not expected to use SP during pregnancy. This is because it is not known whether they were positive and receiving antiretrovirals drugs when they were pregnant, as the tests were conducted after they had given birth in 2015.

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born before 37 weeks of pregnancy, and *0* otherwise. Preterm neonates are more likely to be lighter than non-preterm neonates.

BMI was included as a variable, as it is known to influence health outcomes (Rahman *et al.*, 2021). *Current pregnancy* was a dummy variable, coded *1* if a woman is pregnant, and *0* if not.

ANC visits represented the number of times women had consulted health workers. Women were recommended to attend at least four ANC visits, to enhance neonatal and maternal health outcomes during the data collection period (ZIMSTAT and ICF International, 2016). Less than four ANC visits were represented by *0*, whilst at least four ANC visits are denoted by *1*. Administering of IPTp in different districts was also included as a variable, with districts recommended by MoHCC to administer IPTp denoted by *1*, and *0* otherwise.

Birth weight and *Maternal anaemia* were the dependent variables, and represented neonates' and maternal health outcomes, respectively. These two variables were discussed in greater detail below.

4.4.3.1 Maternal anaemia

While there are many causes of anaemia in pregnant women, including iron deficiency and genetic factors, malaria is considered one of the major causes (WHO, 2019c). The WHO (2005) defines anaemia as a condition where the number of red blood cells is below the recommended level. Haemoglobin level is used as a measure of maternal anaemia. I used women who had given birth or were currently pregnant (in 2015) to represent the stockout association amongst women who were vulnerable to maternal anaemia due to malaria infections.

4.4.3.2 Birth weight

Birth weight was used to measure the association of neonatal health outcomes with malaria prophylaxis stockouts. According to the WHO (2019c), babies with a weight of more than 0.5 kg and less than 2.5 kg are considered to have a low birth weight, which is not desirable for a child’s growth. Children born to mothers with malaria are more likely to have a low birth weight than those born to mothers who are not infected (WHO, 2019c). Given that birth weight can either be affected directly, via placental malaria, or indirectly, via maternal anaemia, I assumed direct effects of malaria on birth weight, as maternal anaemia is measured when the mother is not pregnant in the ZDHS. Although children with a low birth weight face a high risk of stunted growth, poor cognitive development, and infant mortality, it has been established

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that children at the lower end of normal birth weight (2.5 kg to 3.0 kg) may also face developmental disabilities (Adanikin *et al*., 2022; Boulet *et al*., 2011; Madigan *et al*., 2014).

4.4.3.3 Stockout index

Prior studies measured drug stockout as the drug unavailability on a particular day at a facility (e.g., Atif *et al*., 2021; Mclaughlin *et al*., 2013; Pasquet *et al*., 2010; Qiu and Dungca, 2015). However, this does not fully portray the magnitude and extent of the prevalence of drug stockouts at a facility. An individual can always come back and obtain the drugs without permanent health effects when drugs are only stocked out for one day. Thus, using one day without drugs as a measure will lead to overstating of the stockout prevalence at facilities.

I created the stockout index by calculating the proportion of stockouts per quarter per facility, and then averaged the proportion of days drugs are stocked out at a facility for two quarters with available information in the stockout data. The index ensured that the proportion of days with stockouts at a facility matches the time when the women were expected to receive SP doses. Furthermore, over a quarter of the facilities had stockouts information for only one quarter, whilst the rest had information for the two quarters necessary for the analysis. The stockout information for two quarters respectively was merged with the health outcomes information. In the event of missing data for a quarter, only the information for one quarter was used. A stockout index of *0* represented the absence of stockouts at a facility, and values greater than zero indicated the presence and extent of stockouts. Drug stockouts increase the likelihood of receiving no or fewer SP doses than recommended, hence increasing the probability of malaria infections (Feresu *et al.*, 2015; Mikomangwa *et al.*, 2020). Therefore, SP stockouts were expected to be negatively associated with birth weight and maternal haemoglobin levels.

4.4.4 Model specification and estimation technique

4.4.4.1 OLS model

A variety of methods have been employed in prior studies to examine the health implications of drug stockouts, including qualitative and descriptive analysis (e.g., Atif *et al.*, 2021; Gils *et al.*, 2018; Mclaughlin *et al.*, 2013; Qiu and Dungca, 2015). Pasquet *et al.* (2010) used a Cox regression model, and Koomen *et al.* (2019) used a fixed effect regression model. I used the OLS model to examine the relationship between malaria prophylaxis stockouts and birth- and maternal outcomes in Zimbabwe. I also included regional and birth year fixed effects in the

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analysis, to capture regional and birth-year variations. Clustered standard errors are used to account for common variations inside survey clusters. Therefore, I measured associations, and not causal relationships.

I formulated Equation 4.1 to show the association between stockouts and birth weight for neonates and maternal anaemia. Given that haemoglobin levels are only monitored during data collection and not during the pregnancy, when women are more vulnerable to malaria, the chapter focused on mothers who had given birth or were pregnant in 2015. This is because these women were more likely to be affected by malaria infections than women who were not pregnant at the time of the survey. However, one major weakness of this analysis is that haemoglobin levels might have adapted to post-birth experiences in potentially biased ways. The results on the association between malaria prophylaxis stockouts and maternal anaemia are reported in Tables O.1 and O.2 of Appendix O, and are presented as explanatory rather than definitive. The model for malaria prophylaxis stockouts' relationship with health outcomes was specified as follows:

$$y_{ict} = \alpha_1 stockout_{ct} + \alpha_2 X_{ict} + \theta_i + \phi_t + \varepsilon_{ict} \qquad (4.1)$$

where y_{ict} was the birth weight or haemoglobin level of individual *i* in cluster *c* at time *t*, $stockout_{ct}$ was the SP stockout at cluster *c* (where the cluster was equal to the facility) in period *t*. X_{ict} was the matrix of other control variables in the model, which were education, parity, preterm delivery, wealth index, BMI, currently pregnant, work status, birth interval, and HIV status, α_2 was the vector of parameters, ε_{ict} represented the error term, θ_i represented regional fixed effects, and ϕ_t represented birth year fixed effects.

The coefficients (α_1) were expected to be negative, and were interpreted as a change in health outcomes associated with changes in the independent variables. In this regard, a negative α_1 was interpreted as an increase in the proportion of days drug was stocked out at a facility, was associated with a decrease in neonatal birth weight. After this analysis, I used the RIF unconditional quantile regression model to estimate the association between malaria prophylaxis stockouts and health outcomes along different quantiles.

4.4.4.2 RIF unconditional quantile regression analysis

The unconditional quantile regression model shows the marginal effects of explanatory variables on the unconditional quantile of the dependent variable (Firpo *et al.*, 2009; Rios-Avila and De New, 2022). According to Wirba *et al*. (2021), RIF regresses the unconditional

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quantile of the dependent variable (in this chapter, birth weight) on a set of independent variables. RIFs of the unconditional quantile provide a robust analysis of every unconditional quantile, even after data changes (Rios-Avila and De New, 2022). The model provides distributional changes that are useful for policy implementation (Alejo *et al.*, 2021). The model assumes that the error term is not correlated with the independent variables, and can be used even when the error term is correlated with independent variables (Firpo *et al.*, 2009). According to Firpo *et al.* (2009), the model is simple and easy, and can be used for other distributional statistics like the Gini coefficient and conditional quantile. Moreover, the analysis allows estimation of the association between the distribution of independent and unconditional quantiles of the dependent variables (Rios-Avila and De New, 2022). The unconditional quantile regression model is interpreted using unconditional partial effects, as the marginal change in the unconditional quantile of changes in the independent variables, holding other variables constant (Firpo *et al.*, 2009; Rios-Avila and De New, 2022).

According to Firpo *et al.* (2009), unconditional quantile regression model focuses on unconditional quantiles when independent regressors are present, which is different from conditional quantile used in the presence of endogenous regressors. In this regard, conditional quantile regression shows heterogeneity in parameters used to characterise the relationship between conditional quantiles of dependent variables and independent variables (Alejo *et al.*, 2021). The effects of independent variables in unconditional quantile regression are a weighted average of conditional quantile regression. This provides a clear lower and upper bound of the unconditional quantile regression, and helps to detect any misspecification (Alejo *et al.*, 2021). The RIF unconditional quantile regression was specified as follows:

$RIF\left(y, v, F_y\right) = v\left(F_y\right) + IF\left(y, v, F_y\right)$………………………………… (4.2).

Assuming that $E_y\left[IF\left(y, v, F_y\right)\right] = 0$, Equation 4.3 was represented as follows

$v\left(F_y\right) = E_y[RIF\left(y, v, F_y\right)$…………………………………………….. (4.3).

For p-quantiles, $v\left(F_y\right) = q_y(p) = F_y^{-1}(p)$, unconditional quantile regression model was denoted as follows:

$RIF\left(y_i, q_y(p)\right) = q_y(p) + \frac{p+1\left(y \le q_y(p)\right)}{f_y\left(q_y(p)\right)}$…………………………….. (4.4), and

$RIF\left(y_i, q_y(p)\right) = \alpha + \beta_j X_i + \varepsilon_i$……………………………………… (4.5),

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where y was the dependent variable (birth weight), α represented the constant, and β_j represented the unconditional quantile partial effect of changes in X in the model. X_i showed the independent variables (SP stockouts, education, parity, preterm delivery, wealth index, work status, birth interval and HIV status) used in the chapter, p showed the quantiles, and ε_i represented a normally distributed error term.

4.5 Estimated results

Table 4.1 summarises the descriptive statistics of the variables used in the analysis.

Table 4.1: Descriptive statistics

	N	Mean	Std. Dev.	Min	Max
Maternal age	3432	28.054	6.600	15	49
Birth weight of the child (kgs)	3432	3.126	0.583	0.500	5.900
Maternal haemoglobin level	3429	12.965	1.692	3.9	18.6
ANC visits	2948	0.813	0.390	0	1
IPTp district	3432	0.511	0.500	0	1
SP stockout	3432	0.062	0.133	0	0.994
Currently pregnant	3432	0.048	0.215	0	1
BMI of the mother	3427	24.315	4.571	14.76	57.74
Preterm delivery	3432	0.028	0.164	0	1
Birth interval	3432	0.352	0.503	0	2
Parity	3432	2.790	1.623	1	11
HIV status of the mother	3432	.0161	0.367	0	1
Maternal education (years)	3432	9.25	2.82	0	21
Household wealth index	3432	-0.361	0.998	-1.957	2.4
Working (ref: not working)	3432	0.383	0.486	0	1

Notes: ANC represents antenatal care, BMI represents body mass index and IPTp districts represent districts recommended to administer SP (*1*) and non-recommended districts (*0*).

Mean maternal age, birth weight, and haemoglobin level were 28.05 years, 3.13 kg, and 12.97 g/dl, respectively. On average, women reported having some secondary education, with an average of nine years of education. A total of 16.1% of the women were HIV-positive, and women were less likely to give birth to one child per year on average; therefore, they had long birth intervals. Concerning SP stockout, facilities experienced malaria prophylaxis stockouts for 6.2% of the days, on average. More than three-quarters of the women had more than one child, and were thus regarded as multiparous. Most pregnant women had attended at least four ANC visits, as recommended by the WHO during the data collection period. On average, 4.8% of the women were pregnant during data collection. Furthermore, approximately two in every five women reported that they were working, and 2.8% of the neonates were born prematurely. On average, over half of the districts were recommended to administer malaria prophylaxis.

Figure 4.2 shows the proportion of days SP drugs were stocked out in Zimbabwe for different districts from 2011 to 2015.

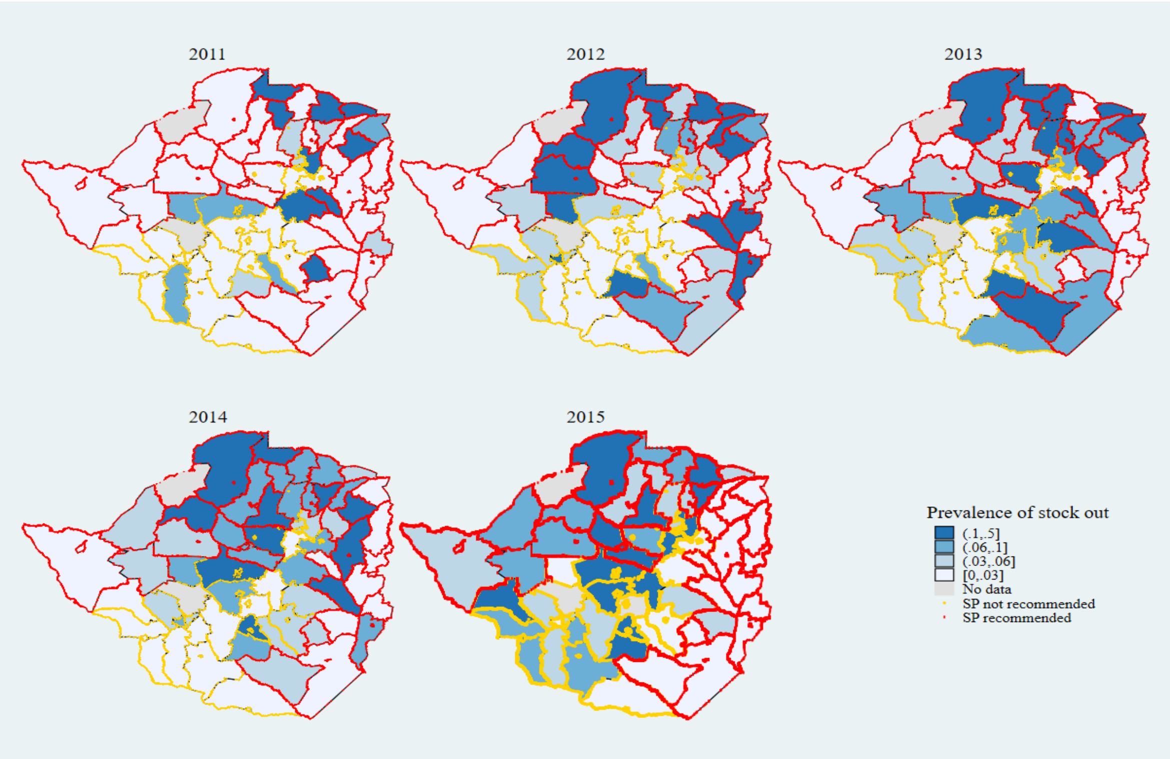

Figure 4.2: Proportion of days stocked out by year in Zimbabwe

The districts are bounded by red colour for the SP/IPTp-recommended districts, and in yellow for SP/IPTp non-recommended districts. The prevalence of drug stockouts is represented by the blue shading of the districts. The darker the shade of the district, the higher the prevalence of drug stockouts are in that district.

The results demonstrate that several districts were affected by malaria prophylaxis stockouts with evidence of spatial inequality. The MoHCC recommends that districts in the northwest, northern, northeast, eastern, southeast, and southern parts of the country administer SP. Using the average proportion of drug stockouts (6.2%), a high proportion of days of SP stockouts

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were experienced in both IPTp-recommended districts and non-recommended districts. The proportion of days when SP was stocked out increased from 2011 to 2015, indicating the prevalence of malaria prophylaxis stockouts in Zimbabwe. Districts in the northern, northeast, and central parts of the country experienced a higher prevalence of stockouts than other regions. A total of 19 districts had a high prevalence of stockouts in Zimbabwe: Hurungwe, Karoi, Gokwe North, Kwekwe urban, Kwekwe rural, Redcliff, Guruve, Muzarabani, Mount Darwin, Rushinga, Shamva, Uzumba Maramba Pfungwe, Zvimba, Chegutu urban, Chegutu rural, Gweru urban, Gweru rural, Mberengwa, and Umzingwane. Eastern and southeast regions had a lower prevalence of stockouts.

Malaria prophylaxis stockouts were less prevalent in 2011 when compared to 2012–2015. This is because the collection of drug stockouts data only started around 2011, which might have affected the data gathered for 2011. Some facilities might not have been familiar with the data-capturing method in 2011 and may thus not have submitted their stockout reports during that time.

Figure 4.3 shows the proportion of neonates born with low birth weight, as well as the proportion of women with maternal anaemia by district over time.

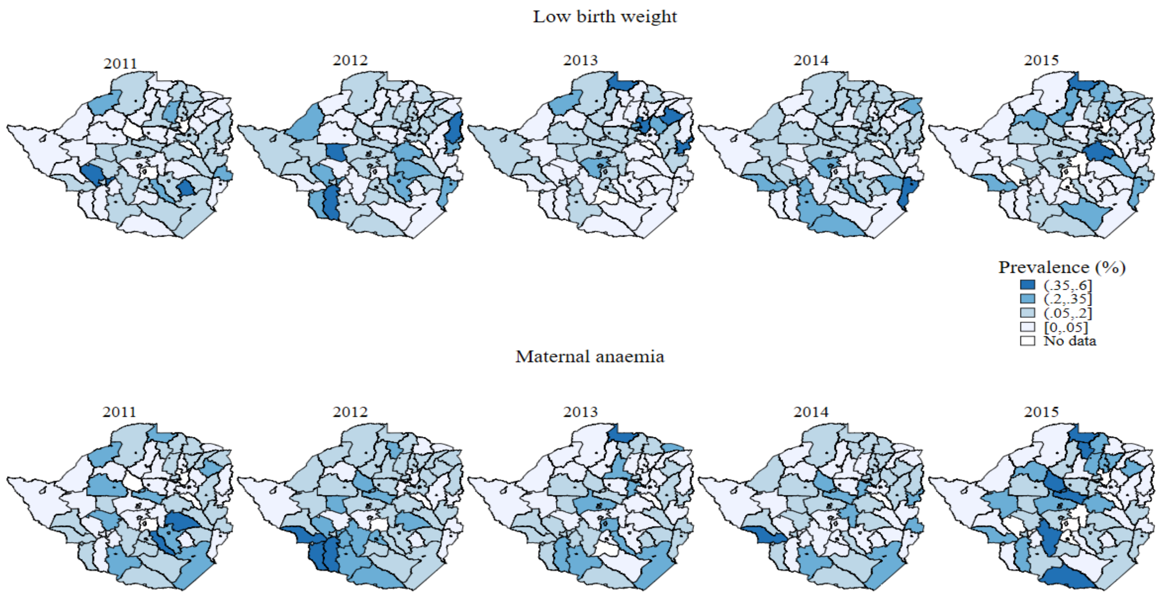

Figure 4.3: Low birth weight and maternal anaemia

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The districts facing a high prevalence of low birth weight and maternal anaemia were not consistent over time. Few districts had a high prevalence of low birth weight during the period 2011–2015. Mudzi district had a high prevalence of low birth weight compared to other districts over time. Districts with a high proportion of women with maternal anaemia in 2015 compared to other years showed that women who were close to pregnancy or had just given birth had high maternal anaemia than those who had not given birth in at least one year. Bulilima and Mudzi had a high prevalence of maternal anaemia over time.

Figure 4.4 depicts the prevalence of SP stockouts, low birth weight, and maternal anaemia in urban and rural Zimbabwe from 2011 to 2015.

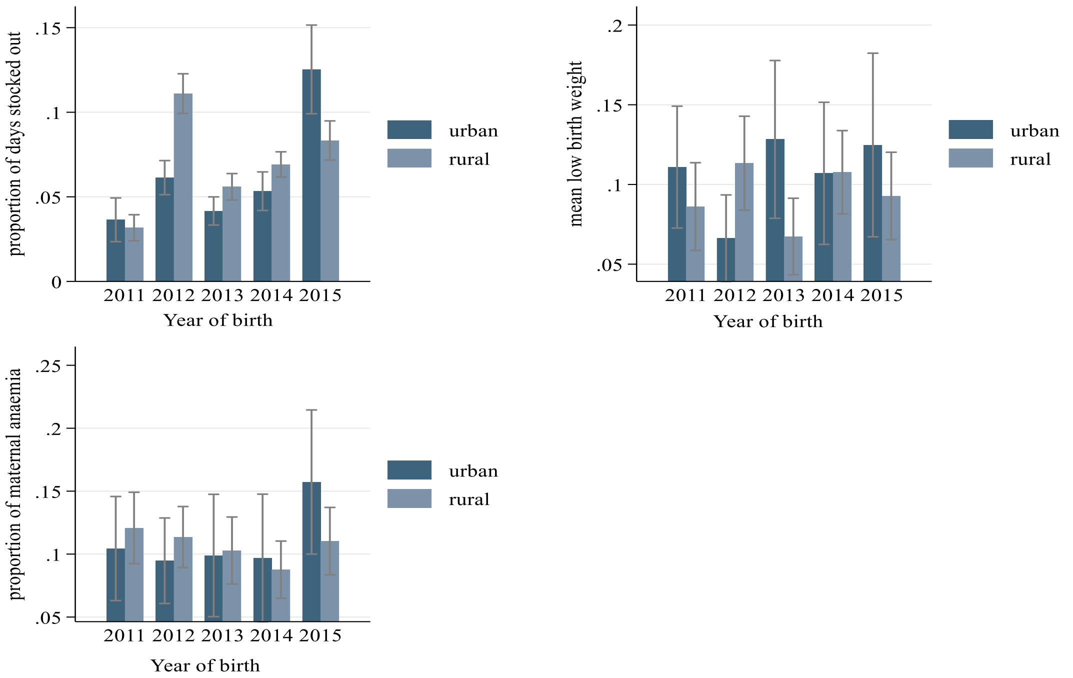

Figure 4.4: Prevalence of SP stockout, low birth weight, and anaemia in Zimbabwe

The prevalence of SP stockouts, low birth weight, and maternal anaemia were subdivided into rural and urban locations. SP stockouts were low in 2011, with less than 5% of the days showing stockouts at the facilities. However, the proportion of days stocked out at facilities increased over time, from approximately 3% in 2011 to around 9.5% in 2015, on average. The results showed that facilities had high stockouts in 2012 and 2015, as illustrated in Figure 4.4. Rural facilities faced more SP stockouts in 2012, 2013, and 2014, while urban facilities

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experienced higher levels of stockouts in 2015, though the regional differences were only statistically significant in 2012 and 2015

Low birth weight increased over the years, with a decrease in 2012 for urban areas, though the time differences are not statistically significant. At least 6% of neonates had a low birth weight. Neonates in urban areas had lower birth weights than their rural counterparts. A higher proportion of rural neonates had lower birth weight compared to urban neonates was recorded in 2012. In 2012, urban areas had the lowest proportion of neonates with a low birth weight, while rural areas had the lowest proportion in 2013. More rural women were anaemic compared to their urban counterparts. Maternal anaemia did not change significantly from 2011 to 2014, and increased from around 25% in 2014 to around 30% in 2015.

Table 4.2 reports the OLS results for the association of malaria prophylaxis stockouts and birth weight. Standard errors were clustered per enumeration area to correct for heteroscedasticity.

Table 4.2: OLS results for *Birth weight*

Variables	(1)	(2)	(3)	(4)
SP stockout	-0.142*	-0.104	-0.129	-0.053
	(0.074)	(0.080)	(0.131)	(0.119)
ANC >= 4			0.044	
			(0.033)	
IPTp district				0.021
				(0.028)
SP stockout* ANC >= 4			0.039	
			(0.154)	
SP stockout* IPTp district				-0.161
				(0.150)
Preterm delivery	-0.989***	-1.020***	-1.013***	-0.989***
	(0.128)	(0.132)	(0.133)	(0.128)
Birth interval	-0.046	0.022	0.021	-0.046
	(0.039)	(0.062)	(0.062)	(0.039)
Parity	0.028***	0.035**	0.035***	0.028***
	(0.009)	(0.008)	(0.008)	(0.009)
HIV status	-0.006	-0.017	-0.019	-0.005
	(0.031)	(0.031)	(0.031)	(0.031)
Education	-0.003	-0.001	-0.001	-0.003
	(0.005)	(0.005)	(0.005)	(0.005)
Wealth index	0.025	0.013	0.011	0.025
	(0.016)	(0.015)	(0.015)	(0.016)
Work status	0.049**	0.057**	0.057**	0.049**
	(0.024)	(0.024)	(0.024)	(0.024)
Constant	3,091***	3.132***	3.093***	3.075***
	(0.078)	(0.075)	(0.080)	(0.079)

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Observations	3,432	2,948	2,948	3,432
R-squared	0.087	0.082	0.083	0.088
Time FE	Yes	Yes	Yes	Yes
Regional FE	Yes	Yes	Yes	Yes

Robust standard errors in parentheses
*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

Note: Column 1 shows the OLS results for the independent variables without interacted variables. Column 2 introduces SP stockouts and ANC visits interacted variable in the analysis, and Column 3 incorporates SP stockouts and IPTp districts interacted variable.

The results showed that *SP stockouts* are related to significantly lower *Birth weight*; this was before including *ANC visits* and *IPTp district* variables. Model 2 included the same specification as model 1 but focused only on observations where *ANC visits* are not missing. The SP stockout results in model 1 became insignificant when focusing on model 2 due to the missingness in *ANC visits* and not the association between ANC visits and SP stockouts. After that ANC visits were interacted with SP stockouts to check if the SP stockouts results are still significant in the presence of ANC visits missingness. Interacting *SP stockouts* with *ANC visits* insignificantly reduced *Birth weight*. This was due to the quality of services offered at some facilities, which compromised pregnant women's use of healthcare services. This means that, neonates born from women using these facilities were affected by drug stockouts. Introducing the *IPTp district* variable insignificantly reduced *Birth weight*, which could be attributable to women in malaria-endemic districts receiving other preventive services during ANC visits, and were thus protected from malaria despite SP stockouts. *Preterm delivery*, *Parity*, and *Work status* were significantly associated with *Birth weight*. *Parity* was significant and positively associated with *Birth weight*. *Preterm delivery* significantly reduced *Birth weight*, while women working significantly improved the birth weight of neonates. However, HIV-positive women, short birth interval, low education, and low wealth index were insignificantly related to neonatal birth weight.

Table 4.3: RIF unconditional quantile results for *Birth weight* (50th percentile)

Variables	(1)	(2)	(3)	(4)
SP stockout	-0.271**	-0.160	-0.223	-0.048
	(0.121)	(0.111)	(0.229)	(0.176)
ANC>=4			0.055	
			(0.040)	
IPTp district				-

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SP stockout *ANC>=4			0.088	
			(0.242)	
SP stockout *IPTp district				-0.395*
				(0.228)
Preterm delivery	-0.617***	-0.557***	-0.545***	-0.617***
	(0.076)	(0.088)	(0.077)	(0.079)
Birth interval	-0.057**	-0.033	-0.030	-0.058**
	(0.027)	(0.032)	(0.031)	(0.027)
Parity	0.037***	0.057***	0.057***	0.037***
	(0.011)	(0.011)	(0.011)	(0.010)
HIV status	-0.042	-0.059	-0.063	-0.042
	(0.038)	(0.039)	(0.045)	(0.039)
Education	-0.002	0.006	0.006	-0.002
	(0.006)	(0.007)	(0.007)	(0.006)
Wealth index	0.048	0.044	0.039	0.047
	(0.030)	(0.034)	(0.032)	(0.031)
Work status	0.046	0.060**	0.060**	0.046
	(0.031)	(0.029)	(0.030)	(0.030)
Constant	3.141***	2.975***	2.932***	3.142***
	(0.091)	(0.086)	(0.095)	(0.078)
Observations	3,432	2,948	2,948	3,432
R-squared	0.033	0.032	0.037	0.034

Bootstrapped standard errors (200 replications) in parentheses
*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

Note: Column 1 shows the 50th percentile results for the independent variables without interacted variables. Column 2 introduces SP stockouts and ANC visits interacted variable in the analysis while Column 3 incorporates SP stockouts and IPTp districts interacted variable.

Table 4.3 reports the results from the RIF unconditional quantile regression for *Birth weight*, with an emphasis on the 50th percentile.

Consistent with the OLS results, stockouts were significantly and negatively associated with neonatal birth weight, whilst the ANC-stockouts interacted model was insignificantly associated with birth outcomes. *SP stockouts* in IPTp-recommended districts were negatively and significantly associated with *Birth weight*. The results also indicated that *Preterm delivery* and *Birth interval* were significantly and negatively associated with *Birth weight*, while *Parity* and *Work status* showed a significant and positive association with *Birth weight*. However, *HIV status*, *Education*, and *Wealth index* showed an insignificant association with *Birth weight*.

Tables O.1 and O.2 show OLS and RIF unconditional quantile regression results on maternal haemoglobin levels. Results on haemoglobin levels portray the transmission mechanism of malaria infections on low birth weight through maternal anaemia. Given that haemoglobin levels were only collected during the survey in 2015, the analysis using maternal anaemia does not portray a robust link between maternal anaemia and low birth weight. Therefore, a direct

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link was assumed between malaria infections (placental malaria) and low birth weight in the analysis of malaria prophylaxis stockouts and birth weight.

The survey data were prone to missing observations, due to recall and non-response bias. Robustness checks were performed to examine whether the missing observations in the analysis resulted in biased estimates. The mean coefficients for the models with missing observations were not significantly different from the mean coefficients for the models without missing observations. These results showed that missingness in observations was random, and does not lead to biased coefficients. The analysis thus produced reliable estimates. The robustness checks for OLS and RIF unconditional quantile regression are included in Appendices P.

4.6 Discussion of results

SP is administered during ANC visits to reduce malaria infections and the consequences of malaria on maternal and neonatal health outcomes (Feng *et al.*, 2010; Kalilani-Phiri *et al.*, 2013; WHO, 2020). However, at most, one-fifth of the women who had attended the recommended number of ANC visits received at least three doses of SP during pregnancy, despite its demonstrated effectiveness in reducing malaria infections and improving health outcomes (ZIMSTAT and ICF International, 2016). Previous studies pointed to drug stockouts as a major reason for the low use of malaria prophylaxis in Malawi, Uganda, and Zimbabwe (Bausell and Katherine, 2014; Ndyomugyenyi and Katamanywa, 2010; Thakataka *et al.*, 2021). This chapter, therefore, focused on the association of malaria prophylaxis stockouts with birth- and maternal outcomes in Zimbabwe.

The results showed that SP stockouts increased from 2011 to 2015, indicating the health system's failure to provide basic health services. Many facilities experienced a high proportion of days of stockouts in the northern, northeast, and central parts of Zimbabwe. SP stockouts were found in both SP-recommended and SP non-recommended districts, compromising the uptake of the drugs where it was needed most. Malaria prophylaxis is still administered in low malaria-burdened districts, but the results showed that these areas faced frequent stockouts. A concerning result is the high level of SP stockouts in some areas with a high prevalence of malaria: the northern, central and northeast parts, Hurungwe, Karoi, Gokwe North, Guruve, Kwekwe urban, Kwekwe rural, Redcliff, Muzarabani, Mount Darwin, Rushinga, Shamva, Uzumba Maramba Pfungwe, Zvimba, Chegutu urban and Chegutu rural. The non-administering districts also had high levels of SP stockouts, for example, Gweru urban, Gweru

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rural, Mberengwa, and Umzingwane. However, this result is not surprising, given the mismatch in demand and supply of malaria prophylaxis. Malaria transmission is not stable, and changes in malaria transmissions might increase infections in the previously low-burden districts, which then affects availability of drugs at the facilities in these districts.

Eastern and southeast parts of the country showed a low prevalence of malaria prophylaxis stockouts over time. The eastern and southeast regions were among malaria-endemic regions, and most policies on reducing malaria transmission and improving availability of malaria products are first implemented in these regions before they are implemented nationwide, as indicated by Rosen *et al.* (2015). This might have led to the low prevalence of stockouts in these regions.

The results also showed that regional disparities in low birth weight and maternal anaemia exist in Zimbabwe. Prevalence of low birth weight and maternal anaemia varies over space and time, meaning different districts face different levels of prevalence over time. The results showed that Mudzi district experienced a high prevalence of low birth weight in 2012 and 2014, while Bulilima and Mudzi showed a high prevalence of maternal anaemia over time. Mudzi simultaneously experienced a high prevalence of low birth weight and maternal anaemia. Focusing on different provinces, ZIMSTAT and ICF International (2016) noted regional inequality in low birth weight and maternal anaemia in Zimbabwe.

Using RIF unconditional quantile regression, birth interval was found to be significantly and negatively associated with birth weight. Giving birth to a child every year significantly reduces neonatal birth weight. The results are aligned with the literature, which states that short birth intervals compromise neonatal health outcomes (Tamirat *et al.*, 2021). Shorter birth intervals delay access to ANC, as the parent has to take care of other infants, and, in some instances, the pregnancy is discovered late (Khan *et al*., 2020; Rahman *et al.*, 2021; Tamirat *et al.*, 2021). A period of at least two years between pregnancies is recommended to allow a woman's body to recover, enhancing health outcomes for both the mother and foetus in the succeeding pregnancy (Tamirat *et al.*, 2021; WHO, 2007).

It is worth noting that birth weight was found to be negatively associated with preterm delivery using both OLS and RIF unconditional quantile regression. On average, children born preterm are approximately 1 kg lighter than those who are not preterm. The results corroborate those of Feresu *et al.* (2015), who notes that children born prematurely have a low birth weight compared to children not born prematurely. Giving birth before the appropriate time leads to a

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low birth weight because the neonate has not yet received enough of the nutrients necessary for growth and development.

The mother working was found to be significantly and positively associated with birth weight, by 0.05 kg — babies of working women have healthier birth weights than those of non-working women. This result is consistent with the results of Mahumud *et al.*'s (2017) analysis of developing countries, including Zimbabwe. Working women are empowered and have the financial capacity to access essential healthcare services during ANC visits on their own (Ndugga *et al.*, 2020; Thakataka *et al.*, 2021). Moreover, these women have improved knowledge of maternal nutrition and the health implications of late ANC visits (Chikwasha *et al.*, 2014; Tamirat *et al.*, 2021).

With regard to parity, the results showed that multiparous women gave birth to neonates with 0.03 kg healthier birth weight than those born of primiparous women. Both OLS and RIF unconditional quantile results presented significant evidence supporting this result, which is also aligned with results of Tamirat *et al.*'s (2021) study of SSA. In support of the findings, ZIMSTAT and ICF International (2016) note that multiparous women are more likely than primiparous women to have healthy babies. Multiparous women have more knowledge of the benefits of ANC visits, based on their previous experiences. The effect thereof is increased access to healthcare services and ANC visits, which improves their health outcomes (Chikwasha *et al.*, 2014; Hill *et al.*, 2013; Tamirat *et al.*, 2021). Primiparous women are also affected by malaria infections more than multiparous women, which compromises their babies' birth weight, as noted by Chua *et al.* (2021) and Bakken and Iversen (2021).

The proportion of days stocked out showed a negative and significant association with birth weight. An increase in the proportion of days without SP at facilities reduced birth weight by 0.14 kg when using OLS, and 0.27 kg when using RIF unconditional quantile regression. SP stockouts showed a strong negative and significant relationship with birth weight. Pregnant women are recommended by the WHO to receive at least three SP doses during ANC visits, but they sometimes do not receive these, due to stockouts (Bajaria *et al.*, 2019; Bausell and Katherine, 2014; WHO, 2019d). Given that SP prevents malaria infections, not receiving the drug increases malaria infection during pregnancy, which leads to placental malaria (Khaja and Sequeira, 2021; Menendez *et al.*, 2000; Uneke, 2007). Placental malaria thickens the placenta and disrupts the nutrients and waste exchange between mother and foetus. The disruption of this process results in the foetus receiving few nutrients, which restricts foetal growth, hence

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compromising birth weight (Chua *et al.*, 2021). Prior studies have noted that receiving the recommended number of SP doses is associated with the clearance of placental malaria and prevention of malaria infections, which improve birth outcomes (e.g., Bakken and Iversen, 2021; Feresu *et al.*, 2015; Mikomangwa *et al.*, 2020). These results indicate the need to improve and prioritise preventive services related to malaria in pregnancy.

The association of malaria prophylaxis stockouts and birth weight is in line with the results of Atif *et al.* (2021) in Pakistan, Koomen *et al.* (2019) and Seunanden and Day (2014) in South Africa, and Pasquet *et al.* (2010) in Cote d'Ivoire. It is also in line with the results of Friedman *et al.* (2022) and Goldstein *et al.* (2013), who note that disruptions in health services through health worker strikes and absenteeism worsen child health outcomes in Kenya. However, these results contradict the findings of Brennan *et al.* (2017) and Gils *et al*. (2018) that drug stockouts do not affect health outcomes in South Africa and the Democratic Republic of Congo, respectively.

Surprisingly, the results showed that SP stockouts did not affect neonates with a low birth weight, but affected children with an average birth weight (shown in Table P.1 of Appendix P). This shows that there are other factors besides SP stockouts that constrain birth weight, which were not established in this study. Improving drug availability improves birth weight for neonates with a higher birth weight; thus, structural constraints in the health system should be addressed to ensure healthier birth weight for neonates.

While drug stockouts may not push neonates with above normal birth weight towards low birth weight (less than 2.5 kg), these stockouts disadvantage neonates with healthy birth weights and push them towards the lower end of normal birth weight (2.5 kg–3.0 kg). Although a low birth weight is associated mainly with developmental challenges, neonates with a healthier birth weight could also suffer from developmental disabilities (Adanikin *et al.*, 2022; Boulet *et al.*, 2011; Madigan *et al.*, 2014). The neonates on the lower end of the normal birth weight are more likely to suffer from mental retardation, learning impairment, poor language development, and cerebral palsy than neonates on the middle and upper end of birth weight, which compromises their cognitive development and subsequent academic performance (Boulet *et al.*, 2011; Madigan *et al.*, 2014). Children with developmental disabilities are also more likely to have lifelong disabilities if appropriate interventions are not implemented. Neonates pushed towards the lower end of normal birth weight by SP stockouts are more likely to experience these developmental disabilities. Given that two in every five primary school

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students and one in every three secondary school students in Zimbabwe suffer from an intellectual disability (UNESCO, 2022), it is important to ensure that SP doses are available during ANC visits to improve birth weight and enhance lifetime health outcomes.

On the other hand, the results in Appendices O show that malaria prophylaxis stockouts were negative and insignificantly associated with haemoglobin levels. This is because women receive other haemoglobin-boosting drugs like iron tablets during ANC visits. Thus, malaria prophylaxis drug stockouts insignificantly reduce haemoglobin levels. This result is consistent with the findings of Brennan *et al.* (2017) and Gils *et al*. (2018) on the health implications of drug stockouts. The authors note that negative health implications from drug stockouts are counteracted by providing individuals with alternative treatments or referring them to the closest facilities with drugs in stock. However, administering other alternative drugs during pregnancy is not effective in improving maternal haemoglobin levels in malaria-endemic districts. The results showed that malaria prophylaxis stockouts were significantly and negatively associated with maternal haemoglobin levels in these districts.

4.7 Conclusion

Zimbabwe is a malaria-endemic country, and ensuring the availability of SP is important in reducing the negative effects of malaria on neonates. Drug stockouts are evidence of a health system's failure to provide safe and affordable services to people in times of need, and such disruptions in the health sector affect neonatal health outcomes. Frequent malaria prophylaxis stockouts at healthcare facilities are prevalent in Zimbabwe, which significantly compromise the birth weight of neonates with average birth weight. However, malaria prophylaxis stockouts do not influence low birth weight, which indicates that structural constraints in the health system should be interrogated to establish the factors associated with low birth weights.

There is a need to ensure the availability of SP drugs at the facility level and to encourage pregnant women to have the recommended ANC visits, to improve SP uptake. In addition, policymakers should invest in pharmaceutical information systems and stock-ordering systems to prioritise the prevention of malaria as proposed in the SDGs. It is, therefore, crucial to ensure the provision of safe, affordable, and high-quality malaria control services in Zimbabwe.

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Chapter 5

Summary and conclusion

5.1 Introduction

Individuals' access to healthcare services is crucial in reducing morbidity and mortality, and is also vital in meeting international and national health goals like Vision 2030 and UHC. However, despite its importance, access to healthcare services remains a public health challenge that affects mainly the poor in rural and marginalised areas (Burger and Christian, 2018; Harris *et al.*, 2011; Zeng *et al.*, 2018). Unaffordability and unavailability of services compromise individuals' access to healthcare. Approximately half of the global population has weak access to healthcare services (WHO, 2019b), and more people are expected to suffer if no policies are put in place to improve the provision and utilisation of healthcare services.

5.2 Summary of the results

Against the backdrop of weak access to healthcare services globally, Zimbabwe is burdened by a high proportion of people who do not consult health workers when ill. This is due to long distances to facilities and expensive healthcare services. Failure to access the necessary healthcare services in times of need increases inequality in health, reduces productivity, increases cost of treatment if treatment is sought at a later stage, and sometimes results in death (Buzuzi *et al.*, 2016; ZEPARU, 2014). Despite the government's efforts to achieve health mandates and improve access to healthcare services through user-fee exemption, increased support for HIV, malaria, and TB patients, and results-based financing, access remains a public health challenge and threatens the realisation of health goals. This hampers the MoHCC's mandate to promote equity in health and enhance the quality of life by targeting resources towards the most vulnerable and needy Zimbabweans (MoHCC, 2017). Failure to ensure proper, affordable, and accessible services to everyone also obstructs Zimbabwe's vision to be an upper middle-income country by 2030 by alleviating poverty and child- and maternal mortality, and by enhancing everyone's health outcomes (Government of Zimbabwe, 2018).

The thesis achieved the following three main objectives in three different chapters:

- The first objective was to investigate fiscal incidence and inequality in access to healthcare services, as well as the factors contributing to inequality in access, in Zimbabwe.

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- The second objective was to examine the spatial inequality in drug stockouts, as well as the relationship between district-level drug stockouts and poverty, in Zimbabwe.
- The third objective was to examine the association between malaria prophylaxis stockouts and birth- and maternal health outcomes in Zimbabwe.

These three objectives were achieved using different datasets and estimation methods.

The first paper (reported in Chapter 2) focused on fiscal incidence and inequality in access to healthcare services, as well as the factors contributing to inequality. The chapter investigated whether government health expenditure and access to healthcare services are socioeconomically and/or geographically skewed towards the affluent or the poor, rural or urban populations. In this chapter, I used a combination of the 2017 PICES dataset and government health expenditure data. I also used the standard CI to examine fiscal incidence, and the Erreygers CI to examine inequality in access to healthcare services. RIFs were used to explore the contributing factors to inequality in access to healthcare services in Zimbabwe.

The results showed that, overall, two in every five people did not visit health facilities in the period under study, due to long distances to the health facilities, high healthcare costs, religious reasons, treatment being unnecessary, and home treatment. A high proportion of the affluent significantly used high-level facilities whilst a considerable proportion of the poor used low-level facilities in both urban and rural areas. When disaggregating public facilities as public clinics and public hospitals, the distribution of government health expenditure was pro-poor in public clinics and pro-rich in public hospitals. Thus, government health expenditure was skewed towards the poor in low-level facilities, at the expense of the affluent, while skewed towards the affluent in high-level facilities at the expense of the poor. This is because the affluent frequently use high-level facilities, which receive a considerable portion of government health expenditure, while the poor use low-level facilities with low government health expenditure. Although fiscal incidence in public hospitals was found to be pro-rich, the cross-location inequities in public hospitals were not significant. In addition to that, fiscal incidence for low-level facilities was significantly more pro-poor in urban areas than in rural areas. Therefore, there is a need to improve resource allocation and ensure that the government resources in public hospitals and clinics reach the rural and poor populations.

Inequality in access to healthcare services was also investigated, using affordability and availability dimensions. The aim was to determine whether the poor are burdened with weak access to healthcare services, compared to their affluent counterparts. With regard to

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affordability, inequality in affordability exists in both rural and urban Zimbabwe, and was found to be pro-rich. This shows that healthcare services were more affordable for the affluent than the poor, in both urban and rural areas. However, pro-rich affordability was more pronounced in urban areas than in rural areas. On the other hand, the average availability was significantly skewed towards the affluent. The poor continue to struggle with unavailability of healthcare services, mainly due to long the distance they have to travel to health facilities. Thus, regardless of pro-poor distribution of government health expenditure in low-level facilities, the poor struggle to access the necessary services in Zimbabwe.

Regarding inequality-contributing factors, urban–rural differences contributed significantly to pro-rich inequality in access to healthcare services. An increase in the share of rural population was more pro-rich for inequality in affordability. This was due to a lower availability of private facilities in rural areas and individuals using public facilities. Facilities in rural areas charge almost the same prices than urban facilities that have a considerable price differential for health services. The insignificant price differentials in rural areas are pro-rich with regard to affordability, compared to urban areas. Moreover, an increase in the proportion of rural populations made availability inequality more pro-rich. This was due to different geographical setups, with households being widely dispersed and far from the facilities in rural areas, unlike in urban areas, where households are close to facilities. The factors included in the analysis did not entirely explain the differences in inequality between rural and urban areas, showing that there are other factors that also contribute to differences in inequality in access to healthcare services between rural and urban areas in Zimbabwe.

Further, there is evidence of inequalities in the incidence of fiscal expenditure and access to healthcare services in Zimbabwe between different groups of people. Although the government put in place several reforms to improve healthcare service delivery, a considerable share of individuals still struggles to access decent healthcare services at an affordable cost. Therefore, policymakers should make decisions aimed at reducing the inequality in healthcare delivery and access to healthcare services.

In the second paper (discussed in Chapter 3), I examined spatial inequality and the relationship between drug stockouts and district poverty in Zimbabwe. The chapter detailed spatial inequalities in drug stockouts and poverty at the district level, which could inform improved resource allocation to vulnerable populations. I used the drug stockouts data combined with the PICES data for 2012 and 2017 at the district level. The results showed that antimalarial drug

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stockouts were high for all the antimalarial drug types in Zimbabwe, in both malaria-endemic and less malaria-endemic districts. Using thematic maps, there was evidence of spatial inequality in drug stockouts and district poverty in Zimbabwe. Given that spatial inequality in district-level drug stockouts and poverty exists, it is important to focus on underserved districts to alleviate these inequalities.

The SAR model showed that there are fewer antimalarial stockouts in high malaria-endemic districts and their neighbours. This is consistent with behaviour whereby individuals use preventive measures to reduce malaria infections, which reduces demand for antimalarial treatment, as these individuals are protected against malaria. Therefore, the supply of anti-malaria drugs is sufficient in malaria-endemic areas.

Thematic maps showed that the relationship between drug stockouts and district poverty was different for various districts; some districts showed a strong relationship, whilst others showed a weak relationship. Nkayi consistently experienced high antimalarial stockouts and high poverty in both 2012 and 2017. Mberengwa, Zvishavane urban, Zvishavane rural, Shurugwi urban, Shurugwi rural, Chirumhanzu, Chegutu urban, Chegutu rural, Bikita, and Mutasa had intermediate but high poverty prevalence and antimalarial stockouts in 2012 and 2017. In 2012 and 2017, Beitbridge urban and Mutare urban had low antimalarial stockouts and low district poverty. Overall, the relationship between drug stockouts and district poverty was negative and insignificant. This shows that district poverty is only a baseline variable, and that changes in stockouts are not entirely associated with poverty. Therefore, there are other factors determining the changes in drug stockouts.

The results also showed the presence of positive spatial interdependence in drug stockouts (hot spots). The changes in drug stockouts in one district positively affected drug stockouts in the neighbouring districts. The positive spatial interdependence means that drug stockouts occur at a level higher than the district level in Zimbabwe. This is evidence that supply chain management and service provisions are interconnected across districts. Therefore, drug stockouts at warehouses are likely to affect facilities in more than one district.

In addition, a spatial mismatch between population per facility and warehouses exists, where the warehouses are situated in districts with a low population per facility. This shows that health resources are situated in areas with less need, leaving those in need of the services with few resources and alternatives. Individuals, therefore, tend to borrow drugs or money from friends or relatives, purchase drugs from the informal or private sector, sell assets, use previously

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unused drugs, forgo treatment, and use traditional medicines during drug stockouts. Some of these strategies are not recommended by health authorities, as they may result in adverse health outcomes, drug resistance, high OOP payments, asset depletion, and debt traps.

The last objective was addressed in the third paper (in Chapter 4). I examined the association between the unavailability of healthcare services and health outcomes in Zimbabwe. In examining the relationship between malaria prophylaxis stockouts and birth- and maternal health outcomes, I combined the 2015 ZDHS data and drug stockout administrative data from the MoHCC. Malaria prophylaxis stockouts were high and increased over time. Regional disparities in stockouts were evident in both IPTp-recommended and non-recommended districts. The result on spatial inequality in malaria prophylaxis stockouts was consistent with the descriptive results reported in Chapter 3, which indicated spatial inequality in antimalarial stockouts in both high- and low malaria-burden districts. Despite antimalarial drugs being donor-funded, inequalities and inefficiencies in their distribution exist, which further compromise the health outcomes of vulnerable populations.

Using OLS and RIF unconditional quantile regressions, malaria prophylaxis stockouts were found to be significantly associated with the birth weight of neonates. Given that SP doses are effective in improving birth weight, not receiving or receiving fewer SP doses during pregnancy increases the probability of malaria infections and, thus, placental malaria, which compromises neonatal birth weight. Although SP stockouts were not associated with neonates with low birth weight, the push foetus with average weight towards the lower end of normal birth weight. These neonates are more likely to experience developmental disabilities. It is therefore important to improve drug availability to prevent malaria infections and ensure that foetal with an average weight are not pushed towards the lower end of the normal birth weight. There is a need to ensure drug availability at the point of care. ANC visits do not influence the significance of the SP stockout variable, however, the missingness in ANC visits results in an insignificant association between SP stockout and birth weight using both OLS and RIF unconditional quantile regressions.

Spatial inequality in health resources exists in Zimbabwe, regardless of the healthcare service provider. Both government and donor-funded services are prone to inequalities, which affect the service provision and access to healthcare services of the majority of citizens. Therefore, the health authorities need to make informed decisions to ensure that vulnerable populations have access to essential healthcare services.

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5.3 Limitations of the thesis

Although the thesis contributes to the body of knowledge on access to healthcare services in resource-constrained environments in terms of inequity, spatial inequality, and the health implications associated with drug stockouts, several limitations are worth mentioning.

Existing literature notes that general household data do not provide comprehensive information on access to healthcare services, and these limitations should be acknowledged (Alaba and McIntyre, 2012; McIntyre and Ataguba, 2011). The surveys collect information only for a single healthcare visit to one facility, although individuals might have made several visits to different facilities, or several visits to the same facility, for an episode of illness. The data also only incorporate access to curative treatment, and not preventive and palliative treatment, thereby underreporting the utilisation of healthcare services and health needs, which might result in underestimation of inequality in healthcare delivery in Zimbabwe. Thus, the results from this analysis should be interpreted with caution.

The displacement of the cluster GPS coordinates in the ZDHS data is another limitation in linking the clusters to facilities' coordinates (in Chapter 4). The displacement of cluster coordinates might have distorted the location, which may have resulted in errors when linking the ZDHS and drug stockout data. This means that there is a possibility that a cluster was matched with a different facility than was used during ANC visits. However, the DHS report noted that cluster coordinates displacement was done cautiously to ensure that cluster coordinates did not overlap in different districts (Mayala *et al.*, 2018). To reduce the distortion and correct the displacement effect, I also used a 10 km buffer zone. On the other hand, the two datasets in Chapter 4 were linked under the assumption that the women within a cluster were using the same facility during pregnancy. This eliminates the possibility of pregnant women receiving ANC from at least one facility hence this assumption might affect the results.

The drug stockouts information was only available from 2011 up to 2020, and was merged with birth outcomes data recalled during the 2015 ZDHS. Therefore, it was only possible to merge the stockout dataset for the period 2011 to 2015 cross-sectional ZDHS using birth year, hence limiting the time that could be considered for the analysis. Furthermore, the ZDHS captures information for the entire year, which includes the time when malaria was at its peak and off-peak, which might result in underreporting of malaria's effects on the health outcomes of vulnerable groups in Zimbabwe.

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The use of aggregated stockouts data over space and time (rather than individual experiences of stockouts) is also a limitation, as this might have resulted in information loss, thereby affecting the accuracy of the results.

Although survey data have high representativeness and are convenient and cost-effective, which increases the probability of precise results, such data pose several challenges. The use of survey data is another limitation, as these data are prone to sampling, recall, non-response, and response bias. Thus, survey data are prone to measurement errors, which might result in biased estimates.

5.4 Strengthening health systems to improve equity

Despite the limitations outlined above, the results of this thesis provide a better understanding of inequality and access to healthcare services in resource-constrained environments. The results also shed more light on issues in access to healthcare services, providing empirical insights for relevant stakeholders. These results may prove useful in reviewing policies and devising interventions. Access to healthcare services and inequity are major goals of the government and other international organisations, and improving access to healthcare services is necessary for the achievement of the UN's and the country's Vision 2030. Therefore, the following actions are recommended to complement the existing policies, to ensure an equitable health system.

It is impossible to have a well-functioning healthcare system in the absence of effective administrative structures and a committed government and health workers (Deaton, 2013). Strong government commitment to health systems is an important step towards attaining UHC. Given that inequity and access issues are normally used to advance political agendas, the government needs to consider its citizens' needs and prioritise them, and not use them for political gain. The government should remain committed to reducing inequities and inequalities that exist in the health sector. Therefore, to achieve an equitable society, policymakers should address these inequities and inequalities in access to healthcare services, as well as the social determinants of health that are detrimental to individual health outcomes (McIntyre and Ataguba, 2015).

Pockets of inequalities in incidence to fiscal expenditure and access to healthcare services exist between the urban and rural populations in Zimbabwe. The poor and rural populations benefit less from the resources channelled by the government to public facilities. Therefore, there is a

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need to improve the management and distribution of resources in rural areas. Currently, resources are mainly allocated towards settings with an increasing population, as well as to high-level facilities. These resources are channelled towards the urban areas, where most high-level facilities are located, and the affluent residing in urban areas benefit from these well-resourced facilities. However, given that over three-fifths of the Zimbabwean population resides in rural areas, it is important to ensure that the rural facilities and populations are not underserved. Health services in rural areas should be well-financed, so that the poor in rural areas receive better quality services, thereby reducing the inequality that exists in access to healthcare services. Individuals should, therefore, benefit fairly from government health resources.

According to Chakraborty *et al*. (2013), increasing funding is important, but what matters more is how the resources are used to attain equity in health systems. There is a need for efficient resource allocation at the regional level to ensure efficient use of healthcare resources. Efficient use of resources will go a long way in improving the living standards of the population by reducing inequality and improving access to healthcare services. Thus, there is a need to channel more resources to regions and populations that are in need and underserved, and also to increase local capacity and human resource development to enable the use of resources and benefit individuals who need them the most.

Given that healthcare challenges are intertwined, the health authorities need to collaborate with other stakeholders, such as government departments, NGOs and the private sector, through public–private partnerships, to improve the health system's performance. There is also a need for joint intersectoral activities amongst different government departments in Zimbabwe, for example, the MoHCC and the Ministry of Local Government for infrastructure development, which has implications for the supply chain management of healthcare services. This multi-stakeholder and intersectoral collaboration could address the factors affecting access to healthcare services and health outcomes that are beyond the MoHCC's mandate. These factors include, but are not limited to, water and sanitation, climate change, natural hazards, poor infrastructure development, and macroeconomic challenges. Governments face financial constraints in providing better healthcare services, and partnering with NGOs and the private sector could ensure improved financial flow towards health facilities, resulting in the availability of better-quality equipment and enhanced supply chain management of resources, especially drugs.

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Regional disparities exist in the provision of healthcare services in Zimbabwe, with more drugs available in certain areas than in others. This shows an unequal distribution of healthcare services, which affects the provision of services at the point of care. This intensifies inequality in access to healthcare services at the regional level. I, therefore, recommend improved resource allocation using a needs-based approach. Thus, more resources should be made available to populations with a greater need for the services than to those with less need for the resources. This will improve the general availability of healthcare services.

Drug stockouts are a prominent challenge in Zimbabwe, affecting both health systems and individuals. A high proportion of drug stockouts exist at facility level, where the services are most needed. Therefore, policymakers need to ensure adequate drug availability at the point of care to improve access to these essential services. There is a need to improve the storage at the facility level, given that, according to The Global Fund (2020), proper storage is a challenge at the facility level, compared to the warehouse level in Zimbabwe. Moreover, health facilities are recommended to keep 'buffer stock' at all times, to prevent frequent drug stockouts. There is also a need for an improved drug management system that uses improved information systems. Policymakers should consider a shift from paper-based data capturing to computer systems or short message services, which have proven to be efficient in reducing drug stockouts in other developing countries (Rao *et al.*, 2013).

There is also a need to strengthen the decentralisation approach to resource forecasting and allocation. Although the approach exists in data capturing and resource distribution in Zimbabwe, it is important to strengthen the process to ensure that adequate healthcare services reach the 'last mile', where they are needed. Facility authorities should be responsible for forecasting and reporting their healthcare needs to the MoHCC, and the MoHCC should make the necessary services available to avoid frequent drug stockouts at the point of care.

Zimbabwe's health authorities could also invest in pharmaceutical management and stock-ordering systems to ensure adequate availability of drugs at the facility to match individual needs. Moreover, pregnant women should be incentivised to frequently visit health facilities to increase the probability of receiving at least three SP doses before delivery. ANC visits are important to improve health outcomes, and it is equally important that malaria prophylaxis is available during these visits, so that women continue to use these services.

A lack of data presents challenges in evidence-based decision-making, which is required if the government is to attain UHC and achieve the SDGs in 2030. Therefore, the government need

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to provide easy access to routine data to ensure robust research and reliable results for purposes of policymaking. In addition, there is a need for transparency regarding data collection, so that research will yield reliable results that can be properly interpreted by researchers.

Access to healthcare services in terms of availability and affordability, especially drugs, should be prioritised to improve the health system's performance and drive the country towards achieving its health aspirations.

5.5 Suggestions for future research

The lack of reliable and sufficient data constrains research on Zimbabwe. In that regard, the first paper (Chapter 2) discussed only availability and affordability in measuring access to healthcare services. The PICES does not capture data on the dimension of acceptability. Therefore, future research could include acceptability in examining inequality in access to healthcare services, to provide a comprehensive view of access to these services in Zimbabwe. PICES also provides information on only one visit to a facility. I averaged the number of visits to the health facility to calculate fiscal incidence. Further research could use recent household data (which were not available when this research was conducted), which provides comprehensive health utilisation information. This will enable the comparison of changes in health service utilisation and fiscal incidence in Zimbabwe using different datasets.

The data used for analysing the malaria prophylaxis stockouts and maternal health outcomes (Chapter 4) were collected during the 2015 survey, when some women were not pregnant. Future researchers could collect data from the facilities or individuals during pregnancy, which will resolve the mismatch in timing and improve the reliability of the results, given that the ZDHS data might understate the effects of drug stockouts on maternal health outcomes. Further studies could also analyse the effects of malaria prophylaxis stockouts on other long-term health outcomes, for example, to determine if stockouts compromise the health outcomes of children as they grow older. Furthermore, I did not include SP doses in the analysis of the association between malaria prophylaxis stockouts and birth and maternal health outcomes, because the 2015 ZDHS did not contain this information. Future research could therefore estimate the effects of SP uptake on birth- and maternal health outcomes using more recent household datasets.

The antimalarial drugs used in the analysis were donor-funded, with stockouts mainly due to poor supply chain management, rather than financial constraints. The availability of

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government-procured drugs is hampered by both supply chain management and financial challenges, and these drugs are more likely to be stocked out than donor-funded drugs. Drugs procured by the government include those used to treat diabetes, cardiovascular diseases, and chronic respiratory infections. Future studies could, therefore, explore inequalities in access to government-procured drugs and the effects of unavailability of these drugs on individual health outcomes.

Given the weak relationship between drug stockouts and district poverty, there is a need for further research to examine other factors influencing drug stockouts in Zimbabwe. Future research could also explore other structural factors influencing low birth weight in Zimbabwe.

5.6 Summary and conclusion

Despite efforts by the government of Zimbabwe to improve access to healthcare services for everyone, the inclusiveness of these services is still compromised. Contrary to prior studies that found a pro-rich distribution of government health expenditures, the current study found a pro-poor distribution of government health expenditures, channelled towards low-level facilities, and a pro-rich distribution for high-level facilities. In line with existing literature, affordability and availability remain access challenges in developing countries, with the poor and rural populations suffering the most in Zimbabwe. The disparities in access to healthcare services are evident — the affluent benefit from affordable and available services. The urban–rural difference also plays an important role in inequality in the availability and affordability of healthcare services. It is evident that inequities are still prevalent in healthcare service delivery.

Existing literature highlights that spatial inequalities exist in healthcare service provision. Consistent with existing literature, there is a spatial mismatch in health facilities and warehouses in Zimbabwe, where resources are concentrated in areas with less need, at the expense of those with greater need. Using thematic maps and spatial regression models, this study found spatial inequality in drug stockouts. Spatial interdependence in drug stockouts also exists due to drug stockouts in one district causing drug stockouts in neighbouring districts. This shows a more intense clustering of districts with a high prevalence of drug stockouts, referred to as hot spots. Clustering of districts is evidence that drug stockouts are a regional challenge, not a district challenge, in Zimbabwe. This study is, therefore, amongst the few to have explored spatial inequality and interdependence in drug stockouts, especially in developing countries.

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Literature is silent on the spatial relationship between drug stockouts and district poverty in developing countries, and this thesis filled this gap. When focusing on the relationship between drug stockouts and district poverty in Zimbabwe, a negative and insignificant relationship between these two variables is evident. In light of this relationship, district poverty provides a baseline for drug stockouts, as drug stockouts are influenced by other factors other than poverty prevalence. In addition, individuals tend to come up with coping mechanisms to smooth access to healthcare services during drug stockouts.

The analysis of the association between malaria prophylaxis stockouts and health outcomes is a unique contribution. Prior studies focused on the implications of stockouts of antiretroviral and anti-tuberculosis drugs in developing countries. The implications of malaria drug stockouts have received no research attention, despite the fact that malaria is one of the major contributors to morbidity and mortality in developing countries. In that regard, the current thesis found prevalent malaria prophylaxis stockouts in Zimbabwe, and that these stockouts are significantly associated with neonatal birth weight, especially average birth weight.

Everyone deserves access to high-quality, affordable healthcare services. Proper access is important in promoting healthy lives and productive nations, which are key to achieving Vision 2030. There is undoubtedly much room for improvement in healthcare services provision and delivery to reduce the existing health disparities in developing countries. It is hoped that the results of this study will be useful in formulating appropriate policies and interventions to improve access to healthcare services for everyone in resource-constrained environments, particularly in Zimbabwe.

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Appendices

Appendix A: Comparing descriptive statistics for non-missing and missing observations

Table A.1: Descriptive statistics

	Non-missing		Missing			
	mean	std dev	mean	std. dev.	difference	t-statistic
Age	30.808	22.517	25.471	-22.517	-7.648***	(-18.739)
Gender	0.407	0.491	0.398	0.490	0.010***	(1.211)
Marital status						
Never married	0.267	0.442	0.199	0.399	0.068***	(4.516)
Married or cohabiting	0.546	0.498	0.463	0.499	0.083***	(4.988)
Divorced or widowed	0.187	0.390	0.337	0.473	-0.150***	(-9.442)
Household size	5.223	2.215	4.939	2.136	0.10***	(8.214)
Education						
Primary	0.661	0.473	0.442	0.497	0.219***	(14.300)
Secondary	0.324	0.467	0.489	0.500	-0.165***	(-10.767
Tertiary	0.015	0.122	0.069	0.254	-0.054***	(-5.266)
SES						
1	0.259	0.438	0.195	0.396	0.064***	(5.710)
2	0.248	0.432	0.188	0.391	0.060***	(5.389)
3	0.216	0.412	0.187	0.389	0.029***	(2.635)
4	0.174	0.379	0.199	0.399	-0.025***	(2.293)
5	0.102	0.303	0.231	0.421	-0.129***	(12.104)
Affordability	0.642	0.479	0.612	0.487	0.028*	(3.069)
Availability	0.281	0.449	0.397	0.489	-0.120***	(-14.115)
Per capita household expenditure	25.011	29.000	42.567	55.506	-16.656***	(-19.337)
Observations		12 521		5 122		14 320

*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

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Appendix B: Health care utilisation in Zimbabwe

Table B.1: Share of healthcare utilisation

	Public sector			Private sector			Other alternatives[a]		
SES	Total	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural
1	0.965	0.955	0.965	0.019	0.045	0.019	0.016	-	0.016
	(0.005)	(0.045)	(0.005)	(0.004)	(0.045)	(0.004)	(0.003)	-	(0.003)
2	0.941	0.876	0.946	0.038	0.110	0.033	0.021	0.014	0.022
	(0.007)	(0.063)	(0.006)	(0.006)	(0.062)	(0.005)	(0.003)	(0.014)	(0.004)
3	0.920	0.854	0.935	0.064	0.128	0.050	0.015	0.018	0.014
	(0.010)	(0.045)	(0.007)	(0.010)	(0.045)	(0.006)	(0.003)	(0.010)	(0.003)
4	0.877	0.827	0.908	0.111	0.164	0.080	0.012	0.010	0.013
	(0.011)	(0.024)	(0.010)	(0.010)	(0.023)	(0.009)	(0.004)	(0.007)	(0.004)
5	0.675	0.610	0.799	0.312	0.380	0.182	0.013	0.010	0.019
	(0.020)	(0.028)	(0.018)	(0.020)	(0.028)	(0.018)	(0.005)	(0.007)	(0.007)
Total	0.879	0.727	0.930	0.106	0.262	0.053	0.015	0.011	0.017
	(0.005)	(0.018)	(0.003)	(0.005)	(0.018)	(0.003)	(0.002)	(0.002)	(0.002)

Note: *Other alternative* refers to services acquired from traditional healers, spiritual healers and outside the country.

Table B.2: Chi-square test of association

		Urban	Rural	Total	Pearson chi2	P-value
Affordability						
Individuals with proportion of health and per capita non-consumption expenditure < 40%		723	4 010	4 733	54.863	0.000
		(0.057)	(0.314)			
Individuals with proportion of health and per capita non-consumption expenditure >= 40%		870	7 188	8 058		
		(0.068)	(0.562)			
Availability						
Individuals travelling distance	< 5 km	725	8 766	9 491	608.798	0.000
		(0.052)	(0.63)			
Individuals travelling distance	>= 5 km	989	3 422	4 411		
		(0.071)	(0.246)			

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Appendix C: CI using equivalence scales

Table C.1: CI for fiscal incidence using equivalence scales

	OECD-modified scale		OECD equivalence scale		Square root scale	
	Public clinics	Public hospitals	Public clinics	Public hospitals	Public clinic	Public hospital
Urban	-0.287***	-0.075	-0.287***	-0.099	-0.323***	-0.021
	(0.083)	(0.099)	(0.083)	(0.073)	(0.084)	(0.102)
Rural	-0.121***	0.046	-0.121***	-0.186	-0.117***	0.148
	(0.010)	(0.081)	(0.010)	(0.225)	(0.010)	(0.108)
Total	-0.201***	0.296*	-0.201***	0.169*	-0.198***	0.315***
	(0.012)	(0.109)	(0.012)	(0.098)	(0.012)	(0.117)

Robust standard errors in parentheses
*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

Table C.2: CI for access to health care services using equivalence scales

	OECD-modified scale		OECD equivalence scale		Square root scale	
	Affordability	Availability	Affordability	Availability	Affordability	Availability
Urban	0.195***	-0.086	0.195***	-0.086	0.180***	-0.091
	(0.064)	(0.055)	(0.064)	(0.055)	(0.063)	(0.055)
Rural	0.145***	-0.032	0.145***	-0.032	0.127***	-0.037
	(0.022)	(0.023)	(0.024)	(0.023)	(0.024)	(0.023)
Total	0.095***	0.078***	0.095***	0.078***	0.082***	0.073**
	(0.028)	(0.029)	(0.029)	(0.029)	(0.028)	(0.029)

Robust standard errors in parentheses
*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

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Appendix D: Concentration curves

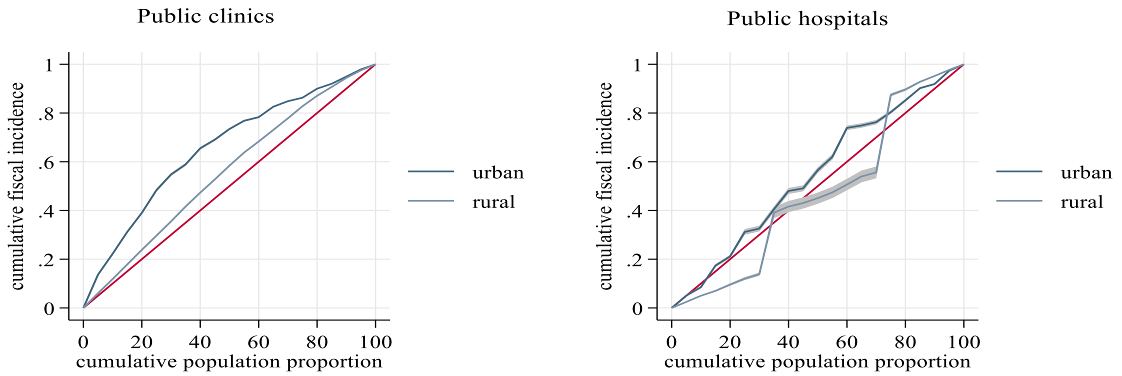

Figure D.1: Concentration curves for fiscal incidence in Zimbabwe

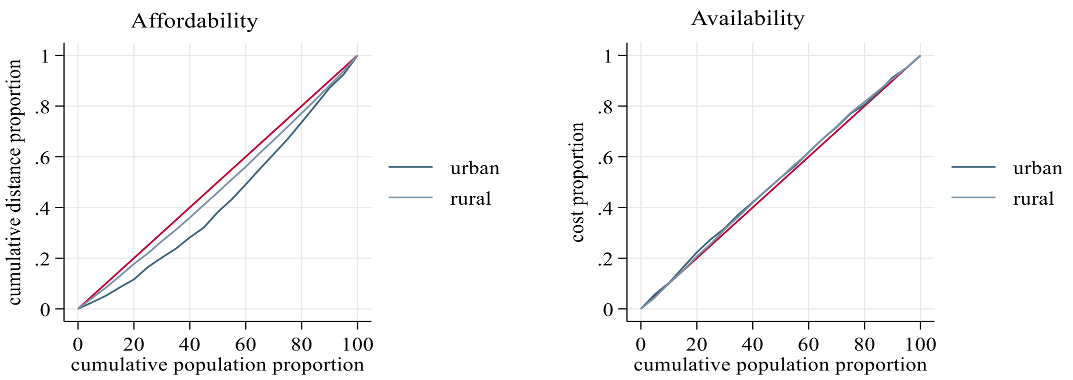

Figure D.2: Concentration curves for availability and affordability of health care services in Zimbabwe

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Appendix E: RIF robustness check

Table E.1: RIF of covariates on inequality in affordability

Variables	(1) Full sample	(2) Full sample	(3) Urban	(4) Urban	(5) Rural	(6) Rural
Age		0.000		0.001		-0.002*
		(0.001)		(0.005)		(0.001)
Gender (Male = 1; Female = 0)		0.050		-0.015		0.074**
		(0.038)		(0.112)		(0.034)
Location (Rural = 1; Urban = 0)	-0.059	0.135**				
	(0.043)	(0.057)				
Education (ref: Primary)						
Secondary		-0.012		-0.140		-0.004
		(0.037)		(0.115)		(0.034)
Tertiary		0.341***		-0.036		0.447***
		(0.127)		(0.168)		(0.113)
Health insurance (Yes = 1; No = 0)	0.262*	-0.040	0.385**	0.557***	0.010	-0.213
	(0.138)	(0.202)	(0.173)	(0.176)	(0.208)	(0.219)
Transport (Yes = 1; No = 0)		1.047***		1.255***		0.861***
		(0.220)		(0.169)		(0.216)
Household size	-0.008	-0.032***	-0.003	-0.021	-0.010	-0.016**
	(0.007)	(0.009)	(0.023)	(0.024)	(0.006)	(0.008)
Marital status (ref: Never married)						
Married or cohabitating		0.009		-0.038		0.044
		(0.057)		(0.169)		(0.052)
Divorced or widowed		-0.004		-0.315		0.126*
		(0.082)		(0.238)		(0.071)
Constant	0.265***	0.141*	0.238**	0.518***	0.217***	0.253***
	(0.052)	(0.081)	(0.111)	(0.176)	(0.034)	(0.059)
Observations	12,790	8,150	1,593	987	11,197	7,163
R-squared	0.002	0.012	0.003	0.023	0.000	0.007

Robust standard errors in parentheses
*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

Note: Columns (1), (3) and (5) present regression results using samples without missing observations; columns (2), (4) and (6) present regression results using samples with missing observations.

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Table E.2: RIF of covariates on inequality in availability

Variables	(1) Full sample	(2) Full sample	(3) Urban	(4) Urban	(5) Rural	(6) Rural
Age		-0.002**		-0.005**		-0.001
		(0.001)		(0.002)		(0.001)
Gender (Male = 1; Female = 0)		-0.049		-0.167*		-0.010
		(0.030)		(0.092)		(0.027)
Location (Rural = 1; Urban = 0)	0.095**	0.088*				
	(0.041)	(0.049)				
Education (ref: Primary)						
Secondary		0.002		-0.000		0.003
		(0.031)		(0.097)		(0.027)
Tertiary		-0.056		-0.166		0.215
		(0.113)		(0.156)		(0.163)
Health insurance (Yes = 1; No = 0)	0.617***	0.688***	0.607***	0.742***	0.621***	0.643***
	(0.143)	(0.156)	(0.193)	(0.212)	(0.216)	(0.229)
Transport (Yes = 1; No = 0)		0.678		1.590***	0.078	0.053
		(0.428)		(0.213)	(0.235)	(0.282)
Constant	-0.108***	-0.022	-0.108***	0.146	-0.016	0.018
	(0.040)	(0.056)	(0.040)	(0.107)	(0.011)	(0.031)
Observations	13,902	10,470	1,714	1,272	11,991	9,198
R-squared	0.004	0.008	0.007	0.033	0.002	0.003

Robust standard errors in parentheses
*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

Note: Columns (1), (3) and (5) present regression results using samples without missing observations; columns (2), (4) and (6) present regression results using samples with missing observations.

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Appendix F: Matrix for bivariate maps

Table F.1: Relationship between stockouts and poverty by year

2012			2017		
Strong negative Plumtree **(1)**	**Weak negative** Chimanimani **(1)**	**Strong positive** Tsholotsho; Umguza; Nkayi; Chipinge urban and rural **(5)**	**Strong negative** Bindura urban and rural; Harare urban; Chinhoyi; Chitungwiza **(5)**	**Weak negative** Makonde; Murehwa; Hwedza; Chikomba; Kwekwe urban and rural; Redcliff; Umguza; Umzingwane; Insiza; Epworth; Bubi; Gwanda urban and rural; Gweru urban and rural; Harare rural; Marondera urban and rural; Seke **(20)**	**Strong positive** Zvimba; Mvurwi; Mazowe; Nkayi; Uzumba Maramba Pfungwe; Hurungwe; Mbire; Karoi; Sanyati **(9)**
Weak negative Bulawayo; Norton; Harare urban; Epworth **(4)**	**Strong positive/negative** Gokwe North; Matobo; Gwanda urban and rural; Mberengwa; Zvishavane urban and rural; Gweru urban and rural; Chirumhanzu; Bikita; Chegutu urban and rural; Shurugwi urban and rural; Mount Darwin; Murehwa; Makoni; Rusape; Nyanga; Mutasa; Chitungwiza; Harare rural **(23)**	**Weak negative** Umzingwane; Zvimba; Muzarabani; Mutoko **(4)**	**Weak negative** Bulawayo; Kadoma; Norton; Ruwa; Victoria Falls **(5)**	**Strong positive/negative** Hwange urban and rural; Bulilima; Mangwe; Mberengwa; Zvishavane urban and rural; Shurugwi urban and rural; Chirumhanzu; Masvingo urban and rural; Zaka; Chegutu urban and rural; Mutasa; Chiredzi urban and rural; Chimanimani; Guruve; Goromonzi; Mhondoro-Ngezi; Chimanimani; Matobo **(24)**	**Weak negative** Lupane; Binga; Kariba urban and rural; Gokwe Centre and Gokwe South; Buhera; Mudzi; Muzarabani; Shamva **(10)**

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Strong positive Marondera urban and rural; Seke; Beitbridge urban; Victoria Falls; Ruwa; Kadoma; Chinhoyi; Mutare Urban **(9)**	**Weak negative** Beitbridge rural; Bulilima; Mangwe; Chiredzi urban and rural; Chivi; Zaka; Masvingo urban and rural; Insiza; Gutu; Buhera; Mutare rural; Hwedza; Chikomba; Sanyati; Redcliff; Mhondoro-Ngezi; Kwekwe urban and rural; Goromonzi; Shamva; Mazowe; Mvurwi; Guruve; Kwekwe urban and rural; Bindura urban and rural; Uzumba Maramba Pfungwe **(28)**	**Strong negative** Mwenezi; Hwange urban and rural; Binga; Lupane; Gokwe South; Gokwe Centre; Kariba urban and rural; Hurungwe; Karoi; Makonde; Mbire; Mudzi; Rushinga; **(15)**	**Strong positive** Beitbridge urban; Plumtree; Mutare urban **(3)**	**Weak negative** Beitbridge rural; Mwenezi; Chivi; Tsholotsho; Gutu; Makoni; Rusape; Nyanga **(8)**	**Strong negative** Gokwe North; Chipinge urban and rural; Mutare rural; Mutoko; Rushinga; Mount Darwin; **(7)**

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Appendix G: Bivariate maps with automatically generated scales

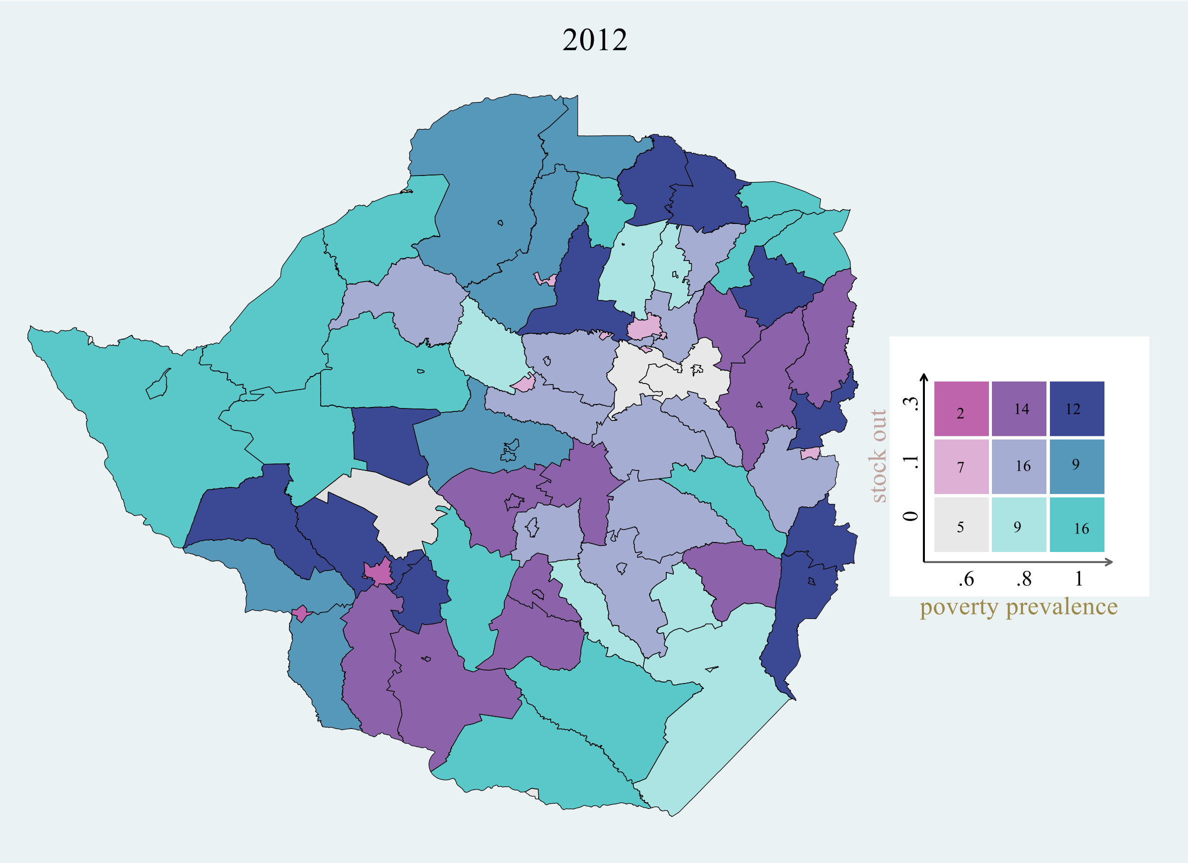

Figure G.1: Antimalarial stockouts and poverty prevalence in 2012

The figure depicts the relationship between antimalarial stockouts and poverty prevalence in 2012. The dark purple parts of the map show a simultaneous high prevalence of poverty and high drug stockouts. Twelve districts in the eastern, northeast and western parts of the country had a high poverty prevalence and high drug stockouts in 2012: Tsholotsho, Umguza, Umzingwane, Nkayi, Zvimba, Muzarabani, Mount Darwin, Mutoko, Mutasa, Chimanimani, Chipinge urban and Chipinge rural districts.

Districts with the least stockouts and poverty prevalence were: Beitbridge urban, Seke, Victoria Falls, Marondera urban and Marondera rural. Gokwe North, Chegutu urban, Chegutu rural, Mhondoro-Ngezi, Shamva, Goromonzi, Hwedza, Harare rural, Epworth, Chikomba, Mutare rural, Gutu, Masvingo urban, Masvingo rural, Shurugwi urban and Shurugwi rural districts showed a decline in the middle category for both stockouts and poverty. Consequently, there was a strong positive relationship between drug stockouts and poverty prevalence in areas shaded in dark purple, light grey, and lavender. Plumtree and Bulawayo had high antimalarial stockouts and low poverty prevalence in 2012. Sixteen districts had the least drug stockouts

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and high poverty prevalence, while the remaining districts had intermediate and high/low drug stockouts and poverty during 2012.

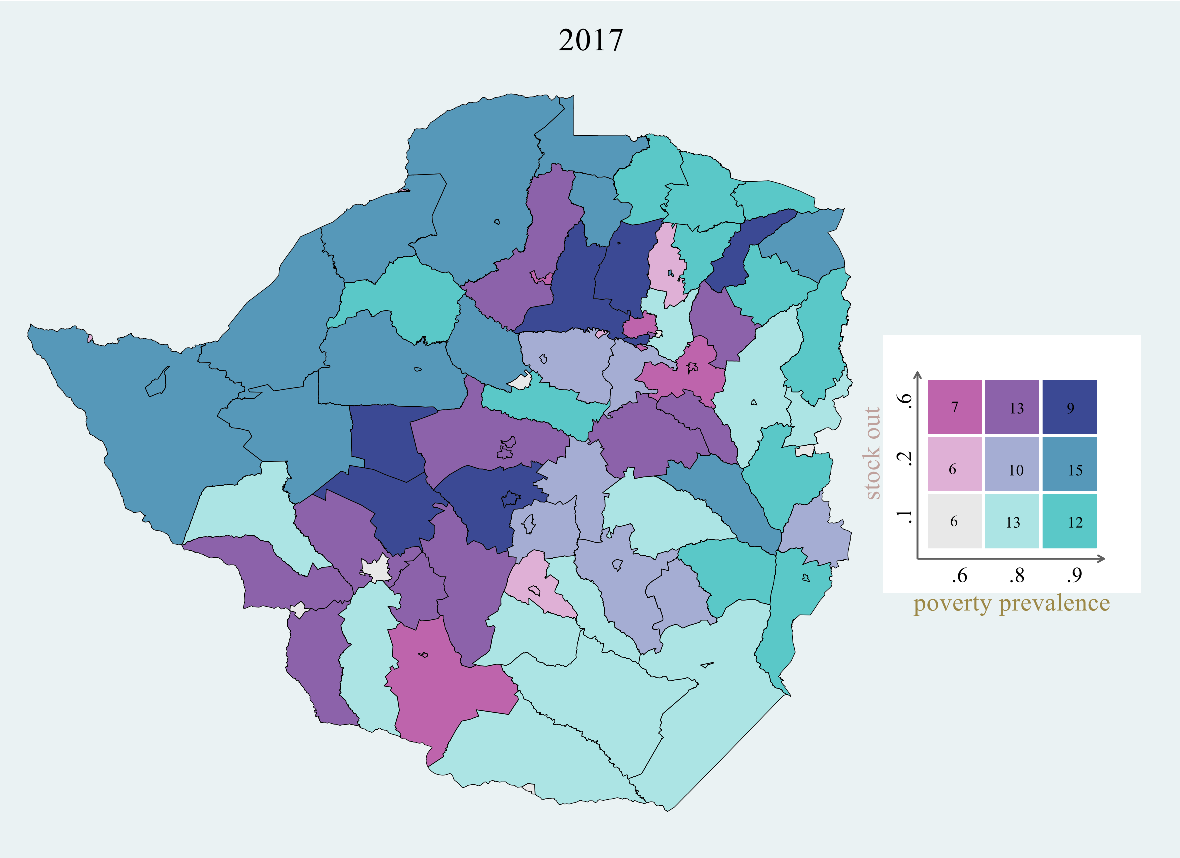

Figure G.2: Antimalarial stockouts and poverty prevalence in 2017

This figure depicts the relationship between antimalarial stockouts and poverty prevalence in 2017. The map shows high antimalarial drug stockouts and poverty prevalence coinciding in the northern and central parts of the country. In 2017, the nine districts with both high drug stockouts and high poverty prevalence were: Bubi, Nkayi, Gweru urban and rural, Zvimba, Mvurwi, Mazowe, Harare rural, and Uzumba Maramba Pfungwe. Six districts with a low prevalence of both stockouts and poverty prevalence were: Beitbridge urban, Mutare urban, Kadoma, Ruwa, Plumtree and Bulawayo. Furthermore, ten districts (shaded in lavender) fell in the middle category for both poverty prevalence and stockouts: Chimanimani, Masvingo urban, Masvingo rural, Zaka, Shurugwi urban, Shurugwi rural, Chirumhanzu, Chegutu urban, Chegutu rural and Seke. Twelve districts had low levels of drug stockouts but high levels of poverty, while seven had high levels of drug stockouts but low levels of poverty. The other shades denote areas with either intermediate stockouts and low/high poverty prevalence, or low/high antimalarial stockouts and intermediate poverty prevalence. These areas were mostly in the northeast, northwest, and central parts of the country.

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Appendix H: Correlation matrix analysis

Table H.1: Correlation matrix

	Poverty prevalence	Location	Malaria endemic	Population density	Distance to the warehouse
Poverty prevalence	1				
Location	0.806	1			
Malaria endemic	0.194	0.184	1		
Population density	-0.156	-0.186	-0.118	1	
Distance to warehouse	0.246	0.125	0.326	-0.319	1

Note: *Location* was a dummy variable representing urban and rural areas.

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Appendix I: Analysis using poverty prevalence and extreme poverty

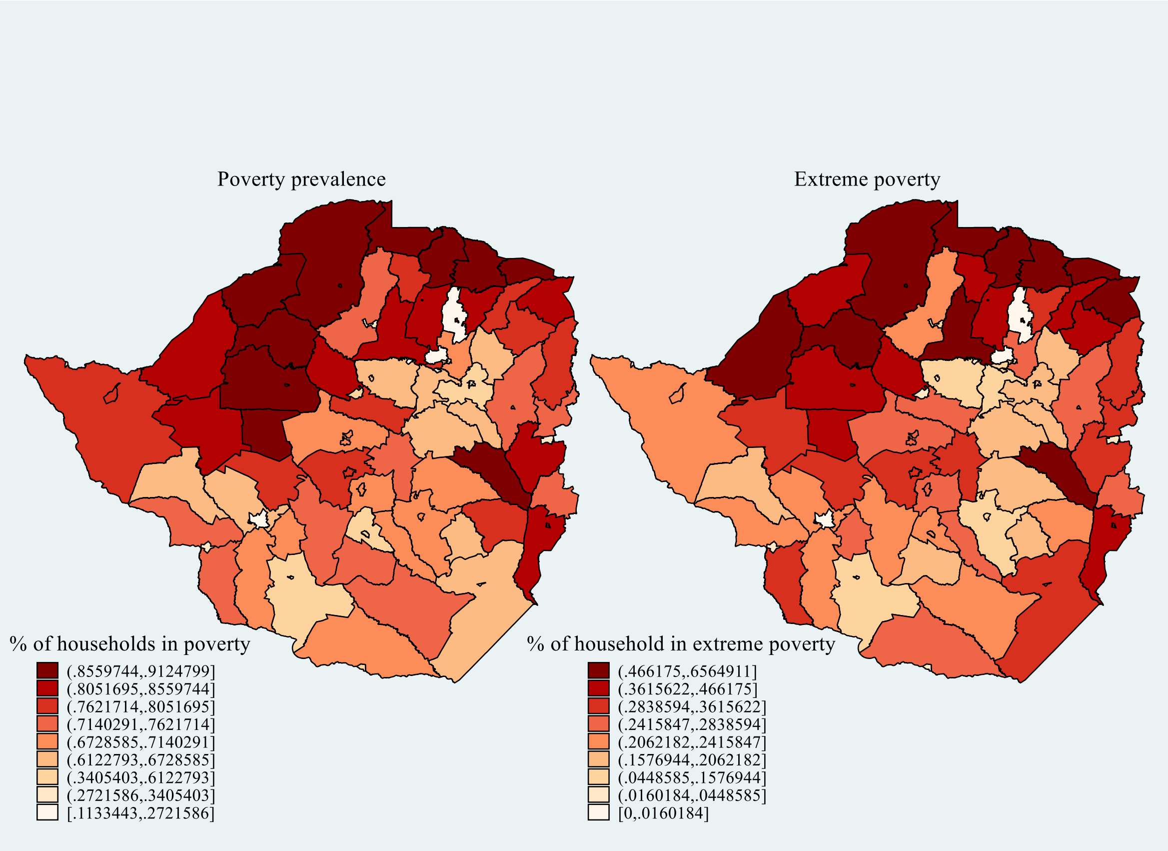

Figure I.1: 2017 poverty prevalence and extreme poverty

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Table I.1: 2017 Spatial regression results using poverty prevalence

Variables	(1) Maximum Likelihood	(2) SAR	(3) SEM	(4) SDM	(5) SDEM
Poverty prevalence	-0.009	-0.088	-0.018	-0.026	0.004
	(0.060)	(0.059)	(0.060)	(0.070)	(0.066)
Malaria endemic (ref: low burden)	-0.053**	-0.038*	-0.042*	-0.039*	-0.044*
	(0.024)	(0.022)	(0.023)	(0.022)	(0.023)
Population density	0.014	0.014	0.019	0.014	0.020
	(0.031)	(0.028)	(0.028)	(0.027)	(0.027)
Distance to warehouse	-0.001	0.001	0.001	0.001	0.001
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Constant	0.062	0.052	0.001	0.047	-0.007
	(0.275)	(0.249)	(0.248)	(0.244)	(0.244)
Weighted variables					
Stockout (ρ)		0.411***		0.510***	
		(0.117)		(0.129)	
Poverty prevalence (θ)				-0.211	-0.129
				(0.139)	(0.167)
Error (ϕ)			0.587***		0.648***
			(0.153)		(0.170)
Observations	91	91	91	91	91

Standard errors in parentheses
*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

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Table I.2: Spatial regression model using extreme poverty

Variables	(1) Maximum Likelihood	(2) SAR	(3) SEM	(4) SDM	(5) SDEM
Poverty prevalence	-0.046	-0.107	-0.021	-0.026	0.008
	(0.078)	(0.073)	(0.079)	(0.089)	(0.084)
Malaria endemic (ref: low burden)	-0.053**	-0.038*	-0.042*	-0.039*	-0.044*
	(0.024)	(0.022)	(0.023)	(0.022)	(0.023)
Population density	0.015	0.015	0.019	0.014	0.020
	(0.031)	(0.028)	(0.028)	(0.027)	(0.027)
Distance to warehouse	0.000	0.000	0.001	0.000	0.001
	(0.004)	(0.004)	(0.004)	(0.003)	(0.003)
Constant	0.058	0.017	-0.006	0.038	-0.005
	(0.274)	(0.249)	(0.247)	(0.244)	(0.244)
Weighted variables					
Stockout (ρ)		0.383***		0.503***	
		(0.112)		(0.131)	
Poverty prevalence (θ)				-0.216	-0.131
				(0.140)	(0.167)
Error (ϕ)			0.580***		0.650***
			(0.153)		(0.169)
Observations	91	91	91	91	91

Standard errors in parentheses
*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

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Appendix J: Likelihood ratio

Table K.1: Likelihood ratio results

	Null hypothesis	LR (*p*-value)	Appropriate model
SAR vs SDM	SAR nested in SDM	4.260 (0.039) **	SAR
SAR vs SDEM	SAR nested in SDEM	6.820 (0.033) **	SAR
SEM vs SDM	SEM nested in SDM	-0.640 (1.000)	SDM
SEM vs SDEM	SEM nested in SDEM	1.930 (0.382)	SDEM
SDM vs SDEM	SDM nested in SDEM	2.56 (0.110)	SDEM

*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

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Appendix K: Robustness check using the logarithm of poverty

Table K.1: Spatial regression results using the logarithm of poverty

Variables	(1) RE	(2) SAR	(3) SEM	(4) SDM	(5) SDEM
Poverty prevalence	0.003	-0.0243	-0.006	0.000	0.001
	(0.018)	(0.019)	(0.019)	(0.045)	(0.022)
Malaria endemic (ref: low burden)	-0.033**	-0.027**	-0.025*	-0.029**	-0.025*
	(0.014)	(0.013)	(0.014)	(0.013)	(0.014)
Population density	-0.003	-0.003	-0.006	-0.002	-0.006
	(0.017)	(0.016)	(0.015)	(0.016)	(0.015)
Distance to warehouse	-0.001	-0.000	0.000	0.000	-0.000
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Year					
2017	0.080***	0.055***	0.064***	0.047***	0.065***
	(0.014)	(0.015)	(0.020)	(0.015)	(0.020)
Constant	0.123	0.083	0.153	0.120	0.154
	(0.153)	(0.147)	(0.137)	(0.145)	(0.136)
Weighted variables					
Stockout (ρ)		0. 345***		0.477***	
		(0.091)		(0.107)	
Poverty prevalence (θ)				-0.078**	-0.018
				(0.037)	(0.039)
Error (ϕ)			0.553***		0.565***
			(0.113)		(0.116)
Observations	180	180	180	180	180
Number of groups	90	90	90	90	90

Standard errors in parentheses
*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

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Appendix L: Spatial autocorrelation in Zimbabwe

Table L.1: Drug stockouts hot spot analysis

	z< = -2.58	-2.58 < z <= 1.96	-1.96 < z < 1.96	1.96 <= z < 2.58	Z >= 2.58
2012					
Stockouts	0	0	82	1	7
2017					
Stockouts	0	0	81	6	3

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Appendix M: Linear probability model

Table M.1: Linear probability model results of service utilisation

Variables	Coefficients
District poverty	-0.646***
	(0.0773)
Constant	0.156***
	(0.059)
Observations	1 898

Robust standard errors in parentheses
*** $p < 0.01$; ** $p < 0.05$; * $p<0.1$

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Appendix N: Map of Zimbabwe

Figure N.1: Map of Zimbabwe with labelled districts

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Appendix O: Haemoglobin level results

Table O.1: OLS results for haemoglobin level

Variables	(1)	(2)	(3)
SP stockout	-0.153	-0.820	0.805
	(0.535)	(0.907)	(0.689)
ANC>=4		0.011	
		(0.209)	
IPTp district			0.056
			(0.173)
SP stockout *ANC>=4		1.044	
		(1.214)	
SP stockout* IPTp district			-1.500*
			(0.897)
Currently pregnant	-0.725**	-0.692**	-0.704*
	(0.366)	(0.337)	(0.380)
BMI	0.045**	0.042**	0.044**
	(0.018)	(0.018)	(0.018)
Birth interval	0.184	0.143	0.223
	(0.515)	(0.543)	(0.514)
Parity	-0.010	-0.009	-0.009
	(0.037)	(0.037)	(0.038)
HIV status	-0.649***	-0.735***	-0.663***
	(0.223)	(0.224)	(0.223)
Education	-0.020	-0.014	-0.021
	(0.031)	(0.030)	(0.031)
Wealth index	-0.087	-0.091	-0.088
	(0.100)	(0.099)	(0.100)
Work status	-0.137	-0.133	-0.134
	(0.152)	(0.152)	(0.151)
Constant	12.213***	12.255***	12.153***
	(0.733)	(0.738)	(0.752)
Observations	674	661	674
R-squared	0.076	0.079	0.080
Regional FE	Yes	Yes	Yes

Robust standard errors in parentheses
*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

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Table O.2: RIF unconditional quantile results for haemoglobin level

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	25%	50%	75%	25%	50%	75%	25%	50%	75%
SP stockout	1.473	1.156	-0.145	3.150	1.637	0.014	2.135	2.332	0.068
	(1.974)	(1.216)	(1.158)	(2.905)	(1.924)	(1.382)	(3.660)	(2.916)	(2.365)
ANC>=4				0.406	0.084	-0.145			
				(0.456)	(0.266)	(0.286)			
IPTp district							-	-	-
SP stockout* ANC>=4				-2.404	-0.676	-0.204			
				(2.841)	(1.843)	(1.435)			
SP stockout* IPTp district							-0.854	-1.518	-0.275
							(4.519)	(3.435)	(2.751)
BMI	0.041	0.087***	0.037	0.041	0.083***	0.040	0.041	0.087**	0.037
	(0.054)	(0.031)	(0.028)	(0.048)	(0.032)	(0.030)	(0.053)	(0.035)	(0.029)
Birth interval	-1.115	-0.002	0.372	-1.075	0.022	0.358	-1.108	0.012	0.374
	(0.718)	(0.536)	(0.613)	(1.066)	(0.718)	(0.793)	(0.759)	(0.522)	(0.617)
Parity	0.031	-0.093	-0.049	0.024	-0.098	-0.060	0.029	-0.095	-0.049
	(0.103)	(0.069)	(0.063)	(0.096)	(0.067)	(0.066)	(0.098)	(0.072)	(0.057)
HIV status	0.057	-0.383	-0.278	-0.035	-0.443	-0.282	0.050	-0.395	-0.280
	(0.518)	(0.333)	(0.260)	(0.464)	(0.358)	(0.286)	(0.481)	(0.307)	(0.272)
Education	-0.005	-0.039	-0.001	-0.001	-0.038	0.004	-0.006	-0.042	-0.001
	(0.093)	(0.056)	(0.048)	(0.089)	(0.055)	(0.051)	(0.083)	(0.056)	(0.043)
Wealth index	0.399	0.114	-0.378	0.392	0.110	-0.385	0.405	0.124	-0.376*
	(0.427)	(0.293)	(0.247)	(0.412)	(0.291)	(0.282)	(0.399)	(0.294)	(0.227)
Work status	0.158	-0.266	-0.156	0.120	-0.243	-0.123	0.157	-0.268	-0.157
	(0.405)	(0.303)	(0.282)	(0.410)	(0.325)	(0.265)	(0.382)	(0.308)	(0.244)
Constant	12.112***	11.638***	12.623***	11.758***	11.640***	12.652***	12.118***	11.648***	12.625***
	(1.760)	(1.118)	(1.120)	(1.946)	(1.367)	(1.227)	(1.762)	(1.158)	(1.036)
Observations	674	674	674	661	661	661	674	674	674
R-squared	0.020	0.041	0.023	0.022	0.043	0.025	0.020	0.042	0.023

Bootstrapped standard errors (200 replications) in parentheses
*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

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Appendix P: Birth weight results

Table P.1: RIF unconditional quantile results for birth weight

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	25%	50%	75%	25%	50%	75%	25%	50%	75%
SP stockout	-0.075	-0.271**	-0.049	0.016	-0.223	0.089	-0.022	-0.048	0.054
	(0.101)	(0.115)	(0.096)	(0.225)	(0.229)	(0.204)	(0.182)	(0.176)	(0.145)
ANC>=4				-0.006	0.055	0.109***			
				(0.047)	(0.040)	(0.039)			
IPTp district							-	-	-
SP stockout* ANC>=4				-0.093	0.088	-0.118			
				(0.248)	(0.242)	(0.221)			
SP stockout* IPTp district							-0.094	-0.395*	-0.181
							(0.239)	(0.211)	(0.203)
Preterm delivery	-0.924***	-0.617***	-0.411***	-0.893***	-0.545***	-0.391***	-0.924***	-0.617***	-0.411***
	(0.113)	(0.072)	(0.049)	(0.126)	(0.077)	(0.058)	(0.115)	(0.079)	(0.054)
Birth interval	-0.079***	-0.057**	-0.087***	-0.047	-0.030	-0.073***	-0.080 **	-0.058**	-0.087***
	(0.029)	(0.028)	(0.027)	(0.034)	(0.031)	(0.026)	(0.032)	(0.027)	(0.022)
Parity	0.028***	0.037***	0.036***	0.035***	0.057***	0.044***	0.028***	0.037***	0.036***
	(0.009)	(0.010)	(0.008)	(0.009)	(0.011)	(0.008)	(0.009)	(0.010)	(0.007)
HIV status	-0.090**	-0.042	-0.015	-0.142***	-0.063	-0.014	-0.090**	-0.042	-0.015
	(0.039)	(0.040)	(0.030)	(0.042)	(0.045)	(0.037)	(0.040)	(0.039)	(0.036)
Education	0.004	-0.002	0.004	0.007	0.006	0.005	0.004	-0.002	0.004
	(0.006)	(0.007)	(0.005)	(0.007)	(0.007)	(0.006)	(0.006)	(0.006)	(0.006)
Wealth index	0.057*	0.048	0.021	0.052	0.039	0.022	0.057*	0.047	0.021
	(0.032)	(0.030)	(0.027)	(0.038)	(0.032)	(0.031)	(0.034)	(0.031)	(0.029)
Work status	0.060**	0.046	0.034	0.075**	0.060**	0.033	0.060**	0.046	0.034
	(0.029)	(0.030)	(0.027)	(0.032)	(0.030)	(0.029)	(0.028)	(0.030)	(0.022)
Constant	2.760***	3.141***	3.473***	2.727***	2.932***	3.347***	2.760***	3.142***	3.473***
	(0.075)	(0.093)	(0.060)	(0.089)	(0.095)	(0.077)	(0.072)	(0.085)	(0.062)
Observations	3,432	3,432	3,432	2,948	2,948	2,948	3,432	3,432	3,432
R-squared	0.052	0.033	0.025	0.048	0.037	0.030	0.053	0.034	0.025

Bootstrapped standard errors (200 replications) in parentheses
*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

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Table P.2: Robustness check for birth weight using OLS

Variables	Full birth weight	Post-2011 (start of stockout data)	Missing stockout quarter	Large sample for stockout only	Small sample with stockout only	Small sample for all variables except ANC & IPTp	Large sample for stockout & ANC	Small sample for stockout & ANC	Small sample for all variables except IPTp	Large sample for stockout & IPTp	Small sample for stockout & IPTp	Small sample for all variables except ANC
SP stockout				-0.154*	-0.129*	-0.142*	-0.014	-0.094	-0.129	-0.073	-0.059	-0.053
				(0.080)	(0.78)	(0.73)	(0.136)	(0.138)	(0.131)	(0.130)	(0.123)	(0.119)
ANC>4							0.069**	0.064*	0.044			
							(0.032)	(0.033)	(0.033)			
IPTp district										0.028	0.023	0.021
										(0.030)	(0.030)	(0.028)
SP stockout*ANC>=4							-0.122	-0.004	0.039			
							(0.159)	(0.162)	(0.154)			
SP stockout*IPTp district										-0.146	-0.128	-0.161
										(0.162)	(0.158)	(0.150)
Preterm delivery						-0.989***			-1.013***			-0.989***
						(0.128)			(0.133)			(0.128)
Birth interval						-0.046			0.021			-0.046
						(0.039)			(0.062)			(0.039)
Parity						0.028***			0.035***			0.028***
						(0.087)			(0.008)			(0.009)
HIV status						-0.061			-0.019			-0.005
						(0.306)			(0.031)			(0.031)
Education						-0.003			-0.001			-0.003
						(0.005)			(0.005)			(0.005)
Wealth index						0.0249			0.011			0.025
						(0.016)			(0.152)			(0.016)
Work status						0.049**			0.057**			0.049**
						(0.024)			(0.024)			(0.024)
Constant	3.218***	3.156***	3.140***	3.145***	3.145***	3.093***	3.162***	3.174***	3.131***	3.123***	3.127***	3.075***
	(0.059)	(0.045)	(0.053)	(0.050)	(0.053)	(0.080)	(0.063)	(0.065)	(0.075)	(0.052)	(0.054)	(0.079)
Observations	5,297	4,525	3,432	3,635	3,432	3,432	3,120	2,948	2,948	3,635	3,432	3,432
R-squared	0.011	0.010	0.011	0.011	0.011	0.083	0.013	0.014	0.082	0.012	0.012	0.088
Regional FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors in parentheses
*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

Table P.3: Robustness check using RIF unconditional quantile regression

Variables	Full birth weight	Post-2011 (start of stockout data)	Missing stockout quarter	Large sample for stockout only	Small sample with stockout only	Small sample for all variables except ANC & IPTp	Large sample for stockout & ANC	Small sample for stockout & ANC	Small sample for all variables except IPTp	Large sample for stockout & IPTp	Small sample for stockout & IPTp	Small sample for all variables except ANC
SP stockout				-0.263**	-0.252**	-0.271**	-0.082	-0.172	-0.223	-0.101	-0.048	-0.048
				(0.116)	(0.113)	(0.121)	(0.229)	(0.245)	(0.229)	(0.148)	(0.173)	(0.176)
ANC>4							0.106**	0.085*	0.055			
							(0.042)	(0.045)	(0.040)			
IPTp district										-	-	-
SP stockout*ANC>=4							0.094	0.039	0.088			
							(0.256)	(0.252)	(0.242)			
SP stockout* IPTp district										-0.284	-0.362	-0.395*
										(0.202)	(0.228)	(0.211)
Preterm delivery						-0.617***			-0.545***			-0.617***
						(0.074)			(0.077)			(0.079)
Birth interval						-0.057**			-0.030			-0.058**
						(0.030)			(0.031)			(0.027)
Parity						0.037***			0.057***			0.037***
						(0.009)			(0.011)			(0.010)
HIV status						-0.042			-0.063			-0.042
						(0.038)			(0.045)			(0.039)
Education						-0.002			0.006			-0.002
						(0.006)			(0.007)			(0.006)
Wealth index						0.048			0.039			0.047
						(0.031)			(0.032)			(0.031)
Work status						0.046			0.060**			0.046
						(0.029)			(0.030)			(0.030)
Constant	3.163***	3.163***	3.162***	3.182.***	3.178***	3.141***	3.078***	3.091***	2.932***	3.183***	3.179***	3.142***
	(0.020)	(0.018)	(0.020)	(0.020)	(0.020)	(0.088)	(0.041)	(0.045)	(0.095)	(0.022)	(0.019)	(0.085)
Observations	5,297	4,525	3432	3,635	3,432	3,432	3,120	2,948	2,948	3,635	3,432	3,432
R-squared				0.002	0.002	0.033	0.016	0.002	0.037	0.018	0.017	0.034

Bootstrapped standard errors (200 replications) in parentheses
*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$