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Author
McBride, Kaitlyn

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An evaluation of factors affecting child health outcomes in Africa

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Doctor of Philosophy in Health Policy and Management

by

Kaitlyn Brindle McBride

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ABSTRACT OF THE DISSERTATION

An evaluation of factors affecting child health outcomes in Africa

by

Kaitlyn Brindle McBride
Doctor of Philosophy in Health Policy and Management
University of California, Los Angeles, 2021
Professor Corrina Moucheraud, Chair

Despite substantial global progress in reducing child mortality, the burden remains high in sub-Saharan Africa. Although affordable and effective treatments exist, many children die each year because of poor access to medical care. Expanding access to treatment and reducing barriers to care are key to improving child health outcomes. My three-paper dissertation examines how access to health services was associated with care utilization and child mortality in sub-Saharan Africa. In Chapter 2 (Study 1), I evaluated the association between two dimensions of access -- geographic distance and quality of care -- on care-seeking during childhood illness among rural households in Malawi. I used geospatial methods to link national household survey data with health facility data, to estimate households' distance to health facilities and operationalize the quality of health services within households' service environments. In accordance with previous literature, I found that longer distances to care and poor health facility quality were associated with reduced care utilization of sick child care: each additional kilometer in distance between households' residence and health facilities was associated with a 5% reduction in the odds of care-seeking (aOR 0.95, 95% CI 0.91- 0.98; $p<0.05$); and those living in high quality health service environments were 36% more likely to have sought sick child care compared to mothers living in areas with low quality service environments (aOR 1.36, 95% CI 0.99 – 1.86, $p=0.05$). In an innovative new approach of

evaluating the interaction between these two components (distance and quality), I found evidence of a trade-off between these two factors: the effect of higher health service quality on care-seeking decreased as the average distance to health facilities increased, indicating that geographic distance to facilities may be the most important influence on sick child care utilization. In Chapter 3 (Study 2) I examined how policies to make health care free for children affected child mortality in sub-Saharan Africa. I used a quasi-experimental difference-in-differences research design to compare countries that have, and have not, removed user fees (out-of-pocket payments) for children's health services. I found that removing these fees was associated with a 19% reduction in the odds of infant mortality (aOR 0.81, 95% CI 0.72-0.91, p<0.001), and a 26% reduction in the odds of under-five mortality (aOR 0.74, 95% CI 0.70 – 0.87, p<0.001). The effects on reduced child mortality were strongest in the first year after the policy change, and attenuated over time. I expanded on these findings in Chapter 4 (Study 3) by examining differential effects of under-five fee removal policies across three key socioeconomic indicators: household wealth quintile, household residence (rural versus urban), and level of maternal education. I found that the impact of user fee removal on child mortality varied across all socioeconomic categories, and the largest reductions in child mortality were observed among children from the poorest households (1.7 percentage point reduction, 95% CI -2.42 - -0.009, p<0.001) and those residing in rural areas (1.4 percentage point reduction, 95% CI –0.019 - -0.008, p<0.001). Removing user fees also significantly narrowed socioeconomic disparities in child mortality across all indicators (household wealth, household residence, and level of maternal education). The greatest impacts of removing user fees (biggest reductions in child mortality) were observed among children from the poorest households: the gap in the predicted probability of child mortality between the wealthiest and poorest households prior to fee removal was 2.0 percentage points, and decreased to 0.6 percentage points after the policy change. Together, these papers provide new insights into factors influencing child outcomes in the highest-burden settings, which can be used to inform future research and policymaking about how to improve service coverage and access, and strengthen standards of health care delivery.

This dissertation of Kaitlyn Brindle McBride is approved.

James A Macinko Jr.

Sudipto Banerjee

Zachary Wagner

Corrina Moucheraud, Committee Chair

University of California, Los Angeles

2021

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VITA

B.A., History, 2010

Providence College

Publications

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CHAPTER 1: Introduction

Despite remarkable global progress in reducing child mortality, an estimated 5.2 million children under the age of five died in 2019[1]. The global burden of child mortality remains the highest in sub-Saharan Africa, which accounts for more than half of all under-five deaths[2]. Research shows uneven progress in the reduction of child mortality, as well as substantial socioeconomic disparities in health and in use of health services, within and across countries[3-6]. Child mortality reduction is a key objective in the Sustainable Development Goals (SDGs), which aims to reduce under-five mortality to 25 per 1000 live births in every country by 2030; however this will require accelerated progress in high-burden regions[7,8].

The leading causes of child death are common infectious diseases that can be prevented and treated with cost-effective public health interventions [9,10]. Interventions shown to improve child survival include preventive care and timely treatment through curative services. Recent gains in child survival have been attributed to the scale-up of these key health interventions, including increases in the uptake of vaccinations and oral rehydration therapy for diarrheal diseases, as well as increases in treatment-seeking for sick child care[11]. However, access to and coverage of these essential services remains inadequate, and are not reaching the most vulnerable populations[11-14].

Defining and operationalizing access to care

Health care access is a multi-faceted concept and has been defined in the literature in numerous ways[15-17]. Several frameworks have been developed to evaluate and clarify the multiple dimensions of access, including seminal frameworks from Andersen and Aday (1974), and Penchansky and Thomas (1981). Andersen and Aday theorized that access operates through multiple domains: characteristics of the health care delivery system (e.g. resources, distribution); population determinants, which are explained through three subcategories (predisposing, enabling, and need characteristics); and consumer satisfaction (costs, convenience, quality)[18]. The model demonstrates the interdependence of these access determinants[18,19].

Penchansky and Thomas present access as a more general concept, defined as a “fit” between those seeking health services and the health system[20]. The Penchansky and Thomas model employs five dimensions of access: availability (volume of providers and health resources); accessibility (geographic relationship from patient to provider); accommodation (health care organization and delivery), affordability (ability to pay for treatment) and acceptability (patient attitude towards health services and satisfaction with services); and these dimensions are all interrelated.

The framework by Peters and colleagues (2008) was introduced for evaluating disparities in access to health services in low- and middle-income countries, and builds upon the models by Andersen and Aday, and Penchansky and Thomas[21]. The model includes four main dimensions of access: availability (health workers, equipment), geographic accessibility (patient location relative to health services), financial accessibility (cost relative to clients’ ability to pay) and acceptability (user’s attitudes and expectations). Quality of care is central to all four dimensions of access[21].

In this dissertation, I adopt the framework by Peters et al. (2008) to define access as a function of geographical accessibility, quality and availability of health services, financial accessibility, and acceptability[21].

Geographic accessibility, defined as distance and travel time to health facilities, is a key factor in accessing care[19,22-24]. Numerous studies have evaluated the effect of geographic access on health care-seeking, finding a significant association between longer distances to care and poor care utilization, as well as higher risks of morbidity and mortality[23,25,26]. Other geographical barriers to accessing health care services including limited transport infrastructure (e.g., buses, trains) and poor quality roads, which may further deter individuals from seeking care at a health facility.[27,28]

Access to care also requires adequate *availability of high-quality* health services[29]. Low-quality care can lead to delays in diagnosis, inaccurate diagnosis, medication errors, or inappropriate treatment[30,31]. Evidence has shown that improvements in health facility quality are effective in increasing service utilization, due to perceived improvements in quality and care delivery (clinical and technical quality) and availability of essential supplies (visible improvements), which may lead to improved trust in the health system overall [32-35].

Financial accessibility is another critical component of access[36]. In many countries, user fees (out-of-pocket payments for medical services) are key approach to health financing[37], but evidence has shown that user fees lead to decreased care utilization for essential health services, particularly among women and children[37-42]. In addition to the direct cost of these health care, there are also indirect costs that may deter individuals from seeking care, such as transportation costs and lost wages[21].

Acceptability and trust of the health system is another significant determinant of care-seeking behavior; it may influence an individual's decision to treat an illness using home remedies rather than seek formal medical care, or may delay timely care[15,20,43]. The expected benefits of formal medical treatment also play a major role in the decision-making process to utilize care. An individual's perception of care is affected by social acceptability, as well as cultural and community norms towards formal care[44-46].

Overview of the dissertation

Child health interventions hold great promise for improved child survival, but barriers to care prevent individuals from accessing essential health services[47]. Strategies to improve the delivery of child health services require the identification of barriers to health care access for this vulnerable population. This dissertation aims to examine barriers to accessing care for under-five health services associated with care utilization and mortality in sub-Saharan Africa. I use different quantitative approaches to answer three research questions:

1. Does geographic accessibility or availability of high-quality care matter more for utilization of sick child care in rural areas in Malawi?
2. Do policies to make health care free for children reduce child mortality?
3. Do policies to make health care free for children reduce disparities in child mortality?

The first paper of the dissertation (Chapter 2) evaluates the association between access to high-quality care and distance on sick child health care utilization among rural households in Malawi. Prior evidence has shown that distance to care strongly influences child care utilization and health outcomes[25,48,49], however there is limited research on the association between access to high-quality care and care-seeking for sick children, nor about the trade-offs individuals may make between distance to care and quality of available services. This paper uses geospatial methods to estimate distance from households to health facilities and to operationalize the quality of services within a households' health service environment. Additionally, this study investigates which components of health facility quality matter most for utilization: diagnostic capacity, essential medicines, staff and training or equipment.

Chapters 3 and 4 of this dissertation (Studies 2 and 3) assess the effect of removing health care user fees for child health care services on infant and under-five mortality across six countries in sub-Saharan Africa, and provides the first multi-country evidence of the impact of these policies on child health outcomes. User fees have been identified as a major barrier to health service access[36,50]. Evidence has shown positive effects of user-fee removal on health-seeking behavior for child health care[42,51]; however research on the impact of fee removal on child health outcomes remains limited. In Study 2, a difference-in-differences (DD) quasi-experimental research design is used to examine the impact of user fee removal, comparing countries that removed user fees for under-five health services, between 2000 and 2014, compared to countries that maintained under-five user fees during this period. This study also examines the short-and long-term impact of user fee removal on child mortality, to evaluate whether the effects of fee removal were sustained over time.

Few studies have examined heterogenous effects of national user fee removal policies; and specifically, whether the effect of fee-removal is consistent across socioeconomic groups. In sub-Saharan Africa, socioeconomic status is a main contributor of disparities in childhood mortality[52]. Inequities in household wealth, maternal education and place of residence (rural versus urban), are associated with poor child outcomes, including reduced care utilization, and increased risk of child mortality[14]. Understanding differential effects of child health policies is critical, given substantial disparities in child survival and coverage of key child health services within and across countries. Chapter 4 (Study 3) examines differential effects of the under-five fee removal policy across three key socioeconomic indicators: household wealth quintile, household residence (rural versus urban), and level of maternal education. I also evaluate whether disparities in child survival narrowed between the lowest and highest socioeconomic categories.

Together, these papers identify key barriers to accessing care for child health services, and to provide empirical evidence for how policies and health system strengthening strategies can have a significant impact on child survival. Ensuring equitable and timely management of childhood illness is crucial for reducing morbidity and mortality, particularly among children from lower socioeconomic status households, who are most vulnerable to poor health outcomes.

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CHAPTER 2: Study 1: Evaluating the trade-off between distance and quality for sick child care-seeking among rural households in Malawi

Introduction

A high number of under-five deaths occur in low-income countries, and over half occur in sub-Saharan Africa[1,2]. Most child deaths are from common illnesses that can be easily managed or treated: pneumonia, diarrheal diseases, and malaria[3]. Ensuring prompt diagnosis and appropriate management of childhood illness is crucial for reducing morbidity and mortality.

Poor access to health care services results in poor health outcomes[4-7]. This paper will focus on two key constructs of access: geographic accessibility and quality of care.

Geographic accessibility of health care is a crucial determinant of health care utilization and health outcomes [8-13]. For example, research in western Kenya found that the rate of clinic visits by children under-five decreased for households located farther from health facilities[12]; and a study across 21 low- and middle-income countries found that living beyond 5 kilometers from a health facility increased the risk of neonatal mortality by 25 percent[14]. Additionally, low-quality care can cause delays in diagnosis, inaccurate diagnosis, medication errors, or inappropriate treatment, and is a key driver of poor health outcomes[15,16]. A study evaluating quality of health care across 137 low-and middle-income countries estimated that 5 million deaths were attributed to low quality health services[6]. Additionally, the availability of health care "inputs" -- such as health care workers, essential supplies and infrastructure-- may lead to non-utilization of health care [17,18]. A recent study in Malawi found higher odds of sick child healthcare utilization if the nearest facility had high structural quality (including availability of essential medication and equipment)[19].

These determinants may also interact: health care-seeking may be simultaneously influenced by both quality and distance if individuals are hesitant to travel far if quality of care is low, or conversely travel farther distances for higher-quality care [18,20]. Recent evidence from

Tanzania found that women traveled farther for health facilities offering more family planning services, and higher quality care[21]. However, there is relatively limited literature about the association between access to high-quality care and care-seeking for sick children under age five, and the trade-offs parents may make between distance to, and quality of, child care services: i.e., are parents willing to travel further for higher-quality services for their children, or does proximity matter most of all? Moreover, few studies have evaluated care-seeking choices specifically among rural households [22]. Research has shown strong rural–urban differences in health service utilization [23,24]. Rural residents are likely to travel significantly longer distances for health care and are more likely to delay seeking care compared to their urban counterparts, who are in close proximity to health services [25-27].

In this paper we apply geospatial methods to evaluate the role of distance and health service quality on sick child care utilization among rural households in Malawi. Malawi has made significant strides in reducing child mortality by scaling-up child health interventions[28,29], but continues to experience high rates of infant and child mortality [29]. Findings from this study can help identify ongoing gaps in child health services in rural areas of Malawi, and provide insights for health policymakers on how to increase access to care, to ultimately improve child health outcomes.

Methods

Study Setting

Malawi is a landlocked country located in southeastern Africa. Approximately 80% of Malawi's population of 18 million people live in rural areas. The Malawian health care system is divided into public and private sectors. The public health sector includes all government health facilities under Malawi's Ministry of Health (MOH). Health services in the public sector are free for users. The private sector includes non-governmental organizations, both not-for-profit organizations such as Christian Health Association of Malawi (CHAM, a large national network of faith-based facilities) and for-profit facilities, and these private facilities may charge client fees. Although Malawi has made significant progress and investments in the delivery of primary care services, the health system continues to experience shortages of resources and trained health care workers, fragmentation of services, and gaps in supply chain management and information systems [28,30].

Data sources

Health care-seeking: Data on care-seeking for child health services were obtained from the 2015-2016 Malawi Demographic and Health Survey (DHS)[31]. The Malawi DHS is a nationally-representative cross-sectional household survey; all women aged 15-49 in sampled households were eligible for a survey that included questions about symptoms of childhood illnesses (diarrhea, fever, or cough accompanied by short, rapid breathing) during the 2 weeks preceding the survey for all children under age 5 in the household and, for children with these symptoms, whether and what care was sought.

The Malawi DHS also collects the geographic coordinates of all sampled clusters using Global Positioning System (GPS) data. To protect the confidentiality of respondents, the locations of DHS household clusters are displaced from the true location by up to 2 kilometers (for urban points) and 5 kilometers (for rural points). Approximately 1% of rural clusters are randomly displaced up to 10 kilometers[32].

Health facility location and quality: Health facility data are from the 2013-2014 Malawi Service Provision Assessment (SPA) Survey [33]. The SPA surveys are also administered by the DHS program. The Malawi SPA is a cross-sectional census of all formal public and private health care facilities in Malawi (including hospitals, health centers, and clinics). Information about health facility services and quality was collected through facility inventory questionnaires and health provider interviews. SPA georeferenced the locations of all health facilities using GPS receivers (no displacement used).

Road Network: Malawi road network data (highways, road and footpaths), were obtained through OpenStreetMap (OSM) datasets [34-36].

Study Sample

The study sample includes 4,916 rural households with at least 1 recently sick child under age five. If a mother reported care-seeking at a facility type not captured in SPA (for example, health surveillance assistants (HSAs), mobile clinics, or private doctors), that household was excluded. Of the 977 health facilities in the Malawi SPA dataset, 920 (94%) reported providing child curative services and were included in the study sample.

Linking data between DHS rural households and SPA child health facilities:

Using ArcGIS 10.7.1 (ESRI), DHS household clusters and SPA facilities were geolocated and a "service environment" was defined around each household cluster. A service environment link reduces misclassification errors from DHS GPS displacement, by linking household clusters to all the facilities in their surrounding area, under the assumption that these represent the likely universe of locations where people from these households seek health care [37-39]. This method has been applied in previous studies [37,40], and is the recommended method for linking DHS household and SPA facility surveys [38].

We defined the service environment as all health facilities offering child services and located within 10 kilometers of each household cluster[37], using road network distance, a GIS method that calculates distance based on the travel path along a network of transportation routes (highways, roads, footpaths). Network distance produces a more accurate measurement of distance than straight-line point-to-point (Euclidean) distance by accounting for barriers and geographical features. Road data obtained from OSM was processed using ArcGIS to create the road network dataset. Straight-line (Euclidean) distance to the nearest health facility was conducted if road network distance could not be calculated (e.g. DHS cluster location had been displaced onto a river or body of water, or otherwise off the road network). Of the 4,916 households in the analytic sample, 4782 (98.3%) were linked to 758 unique health facilities (82.3% of all health facilities in the sample).

Variables

Outcome variable: The outcome variable was whether care was sought at a formal health facility (defined as a hospital, health center, or clinic) for a sick child under age 5 with reported illness—fever, symptoms of cough, accompanied by short, rapid breathing, or diarrhea—in the two weeks preceding the mother's interview.

Key Independent variables:

Geographic distance : average road network distance (kilometers) from each DHS rural household cluster, and all health facilities defined in that cluster's service environment

Health service quality: average service readiness in the service environment was defined using key indicators from the World Health Organization Service Availability and Readiness (SARA) tool: readiness for child preventive and curative care. Each health facility was assigned a child health readiness score, based on the availability of these care "inputs" (can range 0-100%) using the standard SARA methodology [41]. (**Table 1 Appendix** provides a detailed list of items that comprise the child service readiness score). A higher score indicates better service readiness (i.e., higher quality care). Within each service environment we assigned a summary value [38] and computed the mean service readiness score in the service environment; we then categorized households' service environments as having low (0-39), medium (40-59) or high health service quality (≥ 60), following a similar approach from prior studies [40,42].

Covariates:

Covariates selected for inclusion were based on review of the literature and factors associated with health service environment and care-seeking: households' average distance to health facilities, household wealth quintile (measured by asset index), and caretaker's sociodemographic characteristics: maternal education and maternal age [43,44]. We also adjusted for the number of health facilities within a households' service environment, as well as an indicator for month of mother's interview to account for seasonal variation that may affect childhood illness and roads navigability.

Statistical Analyses

Bivariate analyses were conducted to evaluate the association between care-seeking and household-level covariates among the entire sample, using t-tests for continuous variables and chi-square tests for categorical variables. Descriptive analyses of service readiness components across health facilities were also conducted.

A two-level multilevel logistic regression model was used to evaluate the association between health service quality and care-seeking, given that households (level 1) are nested within clusters (level 2). We also obtained the intra-class correlation coefficient (ICC) from the multi-level model (estimated by the ratio of population variance between household clusters to the total variance) to evaluate the total variability in the outcome (care-seeking) that is attributable to households within the same cluster [45,46].

Level of health service quality (low, medium, high) was tested as an interaction term with distance (kilometers) to determine whether the effect of higher quality on care-seeking was modified by households' average distance to health facilities. Stratified multi-level regression models were then estimated based on significant interaction effects. All statistical analyses were conducted using Stata v.14.0 (StataCorp., College Station, TX).

Sensitivity Analyses

We evaluated the association between individual service readiness components (e.g. diagnostic capacity, essential medicines, staff and training and equipment) and care-seeking to determine whether results were driven by one specific service readiness indicator. Additionally, to test the sensitivity of our results to the choice of distance cutoff for the service environment, we also specified alternative service environments using 8- and 12-kilometer radii. Using the 8-kilometer radius, 3790 households were matched to a service environment; and with the 12-kilometer radius, 4846 households were matched to a service environment.

Ethical review: The University of California Los Angeles Institutional Review Board classified this study as non-human subjects research and exempt from review.

Results

Household characteristics:

Most women (64.8%) with a recently sick child (with symptoms of diarrhea, fever, or acute respiratory infection) brought their child to a health facility (n=3187 of 4916 total in sample) (**Table 1**). Results from bivariate analyses indicate that household wealth index did not differ significantly between those who sought care and those who did not – however mothers with higher education were more likely to have sought care ($p<0.05$), as well as younger mothers ($p<0.05$). The majority of households (97%) had at least 1 health facility providing child health care services within a 10-kilometer service area. Households closer to health facilities were significantly more likely to have sought care at a health facility ($p<0.01$).

Table 1: Characteristics Among Rural Households, by Whether Care Was Sought At a Health Facility

Characteristic	Sought care at facility [1] N=3,187 (64.8) N (%)	Did not seek care at facility N=1729 (35.20) N (%)	P Value
Maternal Age (years) mean (se)	27.39 (0.12)	27.85 (0.21)	P<0.05
Maternal Education			
No Education	2363 (11.39)	252 (14.57)	
Some Primary	1965 (61.66)	1057 (61.13)	P<0.05
Complete Primary	342 (10.73)	151 (8.73)	
Secondary or above	517 (16.22)	269 (15.56)	
Household Wealth Index			
Poorest	842 (26.42)	446 (25.80)	
Poor	780 (24.47)	447 (25.85)	P=0.807
Middle	717 (22.50)	395 (22.85)	
Richer	583 (18.29)	302 (17.47)	
Richest	265 (8.32)	139 (8.04)	
1≥ child health facility within 10km			
Yes	3112 (97.65)	1670 (96.59)	P<0.05
No	75 (2.35)	59 (3.41)	
Average road network distance (km) to facilities, mean (se)	5.64 (0.06)	6.06 (0.08)	P<0.01

**p<0.1 **p<0.05 ***p<0.01.*

[1] Includes hospitals (private and public), health centers, health posts, and clinics.

Health facility characteristics:

The majority of child health facilities are located in rural areas (71.3%), and in the Southern region (45.7%) (**Table 2**). Health centers accounted for approximately half of all facilities, followed by clinics (36.9%) and hospitals (12.0%).

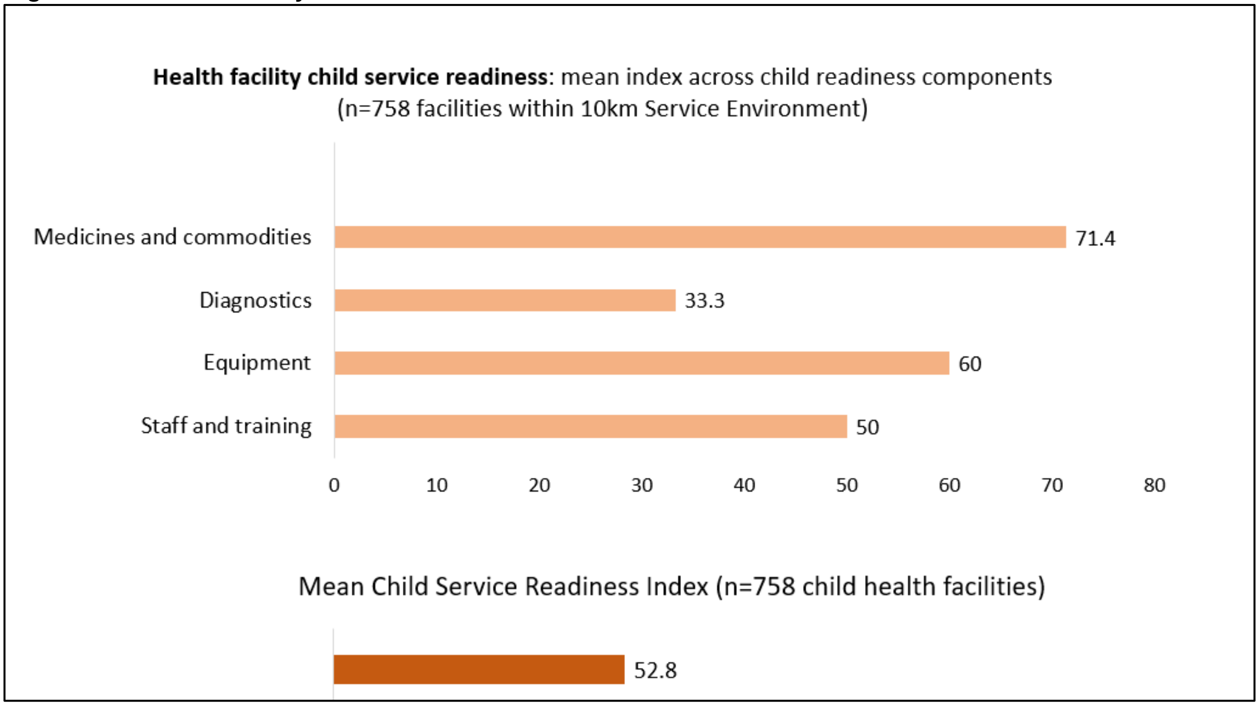
Table 2: Descriptive Statistics of SPA Health Facilities

Characteristic	%	N
Facility Type		
Hospital	11.9	110
Health Center	51.2	471
Health Post/Clinic	36.8	339
Managing Authority		
Public	49.6	457
Private	50.3	463
Location		
Urban	28.7	264
Rural	71.3	656
Region		
Northern	17.2	160
Central	37.1	344
Southern	45.6	416

Health service environment:

Of the 920 child health facilities, 758 (82.3%) were linked to rural households within the 10-kilometer service environment. **Figure 1** details health facility mean index scores across the child service readiness components (medicines and commodities, diagnostic capacity, equipment and staff and training). Facilities performed lowest in diagnostics and staff and training, and highest in medicines and commodities. The mean child service readiness index across 758 child health facilities was 52.8.

Figure 1: Health Facility Child Service Readiness



Association between health care-seeking, health service quality, and distance to care

Average distance was negatively associated with care-seeking: on average, each additional kilometer distance between residence and health facilities was associated with a 5% reduced likelihood of care-seeking (aOR 0.95, 95% CI 0.91- 0.98; p<0.05) (**Table 3**). Higher quality of the service environment (higher service readiness) was significantly associated with seeking care for a child's recent illness: mothers living in high quality health service environments were 36% more likely to have sought sick child care compared to mothers living in areas with low quality service environments (aOR 1.36, 95% CI 0.99 – 1.86 (p=0.052). Women living in areas with medium quality compared to low quality areas were 28% more likely to seek care, however this finding was not significant (aOR 1.28, 95% CI 0.94 – 1.73, p=0.11).

Overall, the effect of higher health service quality on care-seeking decreased as the average distance to health facilities increased: this finding was significant for medium quality (interaction term between distance and medium readiness (aOR 0.86, 95% CI 0.75 – 0.98, p<0.05), however was non-significant for high quality (aOR 0.89, 95% CI 0.78 – 1.02, p=0.10).

The intraclass correlation coefficient obtained from both fully adjusted multi-level models was 0.10, indicating that 10% of the total variance in the outcome (care-seeking), was attributed to households within the same cluster.

Table 3: Multivariable Logistic Regression of Care-seeking for Sick Children on Level of Health Service Quality and Distance

Level of health service quality	Unadjusted OR	Adjusted OR	Adjusted OR with interaction term
Low quality *(reference)*	1.00	1.00	1.00
Medium quality	1.25 (0.92 – 1.70)	1.28 (0.94 – 1.73)	3.14*** (1.35– 7.32)
High quality	1.32* (0.99 -1.79)	1.36* (0.99 – 1.86)	2.61** (1.11 – 6.14)
Road network distance (km)	0.95*** (0.91 – 0.98)	0.95**(0.91 – 0.98)	1.06 (0.95 – 1.20)
Health service quality x Road network distance (km)			
Low quality *(reference)*			
Medium quality	--	--	1.00
High quality			0.86**(0.75 – 0.98)
	--	--	0.89 (0.78 – 1.02)
Number of health facilities in 10km service area	1.00 (0.97 – 1.02	0.99 (0.96 – 1.03	1.07 (0.95 – 1.02)
Maternal age	0.96* (0.98 – 1.0)	0.99 (0.98 – 1.00)	0.99 (0.98 – 1.00)
Education			
No education *(reference)*	1.00	1.00	1.00
Some primary	1.26 ** (1.03 – 1.5)	1.20* (0.97 – 1.47)	1.19* (0.97-1.46)
Complete primary	1.5*** (1.14 – 1.97)	1.49** (1.12 – 1.99)	1.50*** (1.12 – 2.00)
Secondary or above	1.29*** (1.0 – 1.6)	1.17 (0.90- 1.53)	1.17 (0.90 – 1.52)
Household wealth			
Poorest *(reference)*	1.00	1.00	1.00
Poor	0.95 (0.81 – 1.11)	0.92 (0.76 – 1.10)	0.92 (0.77- 1.10)
Middle	0.96 (0.80 – 1.1)	0.92 (0.77 – 1.12)	0.93 (0.77 – 1.12)
Richer	1.02 (0.85 – 1.2)	0.99 (0.81 – 1.21)	1.00 (0.81 – 1.22)
Richest	1.02 (0.79 – 1.3)	0.95 (0.72 – 1.26)	0.95 (0.72– 1.26)

*Multilevel logistic regression model: household (Level 1); household cluster (Level 2). All models adjusted for month of survey interview. *** p<0.01, ** p<0.05, * p<0.1*

Given this suggestion of effect modification for the association between facilities' readiness to provide child health services and distance to facilities on care-seeking, we conducted a stratified analysis by households' average distance to health facilities: households <5.0 km versus households ≥ 5.0 km (**Table 4**). Among households closer to health facilities (average distance <5.0 kilometers), higher quality service environment was significantly associated with care-seeking: compared to households in the lowest quality areas, households living in the highest quality areas were nearly 2 times more likely to seek care (aOR 1.90; 95% CI 1.11 – 3.22, p=0.02); and those living in medium quality areas were 79% more likely to seek care (aOR 1.79, 95%CI 1.06 – 3.03, p=0.30). Although health service quality and care-seeking was positively associated for households further from facilities, the relationships were not significant.

Table 4: Stratified Multivariable Logistic Regression of Care-seeking for Sick Children on Level of Health Service Quality, Stratified by Distance to Care

Variables	Average road network distance <5.0km (n=1137)	Average road network distance ≥ 5.0km (n=3645)
Level of health service quality		
Low quality *(reference)*	1.00 (ref)	1.00 (ref)
Medium quality	1.79** (1.06 – 3.03)	1.06 (0.73 – 1.55)
High quality	1.90** (1.11 – 3.22)	1.12 (0.76 – 1.66)
Number of health facilities in 10km service area	1.04 (0.94 – 1.15)	0.98 (0.95 – 1.02)
Maternal age	0.98 (0.96 – 1.07)	0.99 (0.98 – 1.00)
Education		
No education *(reference)*	1.00	1.00
Some primary	0.82 (0.52 – 1.30)	1.33** (1.06 – 1.68)
Complete primary	0.87 (0.47 – 1.59)	1.80*** (1.30– 2.51)
Secondary or above	0.86 (0.51 - 1.51)	1.28 (0.95 – 1.72)
Household wealth		
Poorest *(reference)*	1.00	1.00
Poor	0.97 (0.66 – 1.43)	0.90 (0.74 – 1.11)
Middle	0.85 (0.57 – 1.26)	0.96 (0.78– 1.19)

Richer	1.15 (0.76– 1.76)	0.96 (0.76 – 1.21)
Richest	1.18 (0.71 – 1.97)	0.90 (0.63 – 1.26)

*Multilevel logistic regression model: household (Level 1); household cluster (Level 2). All models adjusted for month of survey interview. *** p<0.01, ** p<0.05, * p<0.1*

Sensitivity analysis results

Among the child service readiness components, staff and training was positively and significantly associated with care-seeking in a 10-kilometer service environment, but no other domains were associated (essential medicines, diagnostic capacity, and equipment) (**Appendix, Table 2**). Average distance to care was negatively associated with care-seeking across all models: each additional kilometer distance between household and health facilities was associated with a 5% reduced likelihood of care-seeking (p<0.05). When assessing "tighter" service environments (an 8-kilometer radius), child service readiness remained associated with care-seeking (households in the higher child service readiness area were 50% more likely to see care compared with those in the lowest level (p<0.01). In "wider" service environments (using a 12-kilometer area), child service readiness was not significantly associated with care-seeking (**Appendix, Table 3**).

Discussion

This study evaluates how distance and access to high-quality care may affect care-seeking for sick children in rural Malawi, by linking facility and household survey data. Most women (65%) reported having brought their sick child to a medical facility for diarrhea, fever, or symptoms of acute respiratory infection (ARI), which is higher than has been reported in other recent studies from elsewhere in Africa [47]; for example, a study by Adedokun and colleagues using Nigeria DHS found only 30% of mothers reported having brought their sick child to a medical facility [48].

Higher health service quality in a households' service environment was significantly associated with care-seeking for a child's recent illness: mothers living in high health service quality environments were significantly more likely to have sought sick child care compared to mothers living in areas with low quality. These findings are consistent with research in Haiti that found higher service readiness was associated with greater likelihood of facility-based delivery care [42].

In evaluating the association between distance and care-seeking, the odds of having sought care declined as the distance to health facilities increased. These findings are comparable to research in other countries (Zambia, Ghana, and Nepal) that identified distance to the nearest health facility as an independent predictor of health care utilization [10,18,49]. Our results also mirror results from a survey conducted among rural communities in Malawi where respondents reported distance and transport costs as the primary barriers to accessing care [50]. Evidence has shown that even a slight increase in distance to care results in lower care utilization, resulting in worse health outcomes. For example, research from Malawi found that each additional kilometer in distance to the nearest health facility decreased the probability of maternal health care use by up 2.4 percentage points[51].

Study findings also indicate that sick child care utilization is sensitive to both the quality of health services as well as distance to child health facilities; and there appears to be a trade-off between distance and quality for those households living relatively nearer to facilities. In stratified models, the effect of higher child service readiness on care-utilization for those living within 5.0 km of health facilities, was significant, comparing both higher and medium-level quality environments to low-quality areas; however, the impact of quality on care utilization among those living 5.0 km or greater was attenuated, and non-significant. This is consistent with research from rural Tanzania that found over half of caretakers did not utilize the closest facility for sick child care due to quality concerns (including lack of skilled health workers, poor services, and lack of drugs), and the likelihood of bypassing to a higher level facility increased with decreasing travel time[52].

The Government of Malawi recommends that every Malawian live within an 8km radius of a health facility.[53] Although most Malawians live within this range, people in rural districts are likely to travel much farther[54,55]. In our study, we found that the average distance to a child health facility among those who sought sick child care was 5.64 km; but was greater than 6.0 km among those who did not seek care. Although technically within the recommended 8-kilometer range, these results suggest that living 6km from a facility may deter use. Accessibility gaps among those in the most remote regions likely result from the uneven geographical distribution of facilities[56], and this may be improved by expanding the number of child health facilities in these areas.

Rural residents are more likely to travel long distances for care than urban residents, as well as have fewer options in choice of health facility [8-10,14]. Other geographic barriers including individual access to transportation (e.g. car, bike), road infrastructure, and cost of transportation, play a key role in the use of health care services [57]. In Malawi, fewer than 5% of households have access to a vehicle [58] and the majority of the roads are unpaved[59-61]. Although investments to improve quality of child health are critical to improve both utilization of care and health outcomes, investments are also needed to improve geographic access, including the availability of transportation to decrease travel time and enable timely access to care.

Our study provides new insights into the interaction between distance and quality care in rural health service environments. Substantial evidence has shown both the responsiveness of health care demand to distance from facilities, and to higher quality health service; however our findings highlight the potential trade-off between these two factors, suggesting that geographic distance to facilities may be the most important influence, even if high quality of care is offered. As a result, investments to improve care quality may be most beneficial to those living closer to health facilities. This is of concern given residents in rural areas have limited choice of care, and those living father from health facilities may be unwilling to seek any care for their sick child if quality of care remains poor, which may lead to worse child health outcomes. Even those willing to bypass the nearest facility for higher quality care may face financial implications at the household-level, as they incur added costs due to additional travel time and transportation [62]. This has implications for health policymakers, who may have to decide between expanding essential health services or improving quality; however, extended coverage of care (i.e. better geographic proximity) without high-quality care, will not be not sufficient to improve health outcomes [7].

To improve access to child health care in Malawi, investments to improve geographic accessibility and strategies to extend the coverage of high-quality care across health facilities are needed, particularly in rural and remote regions. Future studies should further examine the trade-offs caretakers make when deciding to seek sick child care, and in particular, examine other aspects of quality, including patients' views and perceptions of care and service quality, that may have the most influence on health-care seeking behavior.

Limitations

There are limitations to consider in this study. First, this study uses cross-sectional data and cannot be used to assess the casual effect of distance and service environment on use of sick child care.

Second, we were unable to match the exact facility where child's caregiver sought care, and we assumed that all facilities within the defined service area represented the service environment where mothers seek care. Thus, the impact of health environment's health service quality on care-seeking may be diluted in our use of an overall summary score of the service environment, and inability to link the facilities where mothers typically utilize health care.

Third, this analysis does not consider the recent scale-up and expansion of community health workers for child health service delivery. In Malawi, health-surveillance assistants (HSAs) play an important role in providing primary care services, particularly in rural and remote regions[63]. This study excludes those households reporting having sought care at other facilities, such as HSAs as these are not represented in the SPA survey; however of the 5,250 rural households identified in our sample, only 276 households sought care at a government HSA, representing 5% of rural households with a recently sick child in our sample. Future studies should evaluate the role of these types of services for delivering and providing care in rural and remote regions, and whether the continued scale-up of community-based care delivery could improve access to those farthest from care.

Study findings may also be biased due to differences in respondents' ability to recognize and recall symptoms from the previous 2 weeks. However, an analysis evaluating the accuracy of maternal report on care-seeking reported in DHS, compared to care-seeking reported by mothers in provider-documented events, was high, and determined to be a valid measure for estimating care-seeking for child illness [64].

This study also does not evaluate mother's perceived quality of sick child care at health facilities, or patient (child) experience, which may influence the decision to seek care, and where care is sought.

Additionally, there are potential errors in distance measurement estimates from DHS households to the health facilities due to random cluster displacement[32,37]. While this study improves upon prior studies by using road network distance rather than Euclidean, analyses are subject to misclassification error. However, a recent analysis compared distance estimates to health facilities, using accurate GPS coordinates of households versus displaced household coordinates from DHS[65]. The authors found that perturbed household location data in DHS biased the effect of geographic distance on outcomes toward the null; thus the effect of distance on care-seeking in this study may be attenuated.

Conclusion

This study highlights accessibility problems to high-quality child health services in rural Malawi. Longer distances to the nearest facility and poor health facility quality were linked with reduced utilization of sick child care among rural households. In Malawi, a high number of deaths among children under may be due to poor geographic access and lack of adequate healthcare. Investments to improve the quality of care as well as expansion of health facilities offering child health care, may reduce infant and child mortality.

CHAPTER 2: Appendix

Table 1: List of Child Service Readiness Components and Items

Child Health services: Preventive and Curative Care Service Readiness Index Items	
Staff and training, n=4	Guidelines for IMCI
	Guidelines for growth monitoring
	At least one staff member trained in IMCI
	At least one staff member trained in growth monitoring
Equipment, n=5	Child and infant scale
	Length/height measuring equipment
	Thermometer
	Stethoscope
	Growth chart
Diagnostics, n=3	Haemoglobin (Hb)
	Test parasite in stool (general microscopy)
	Malaria diagnostic capacity
Medicines and commodities, n=7	Oral rehydration solution packet
	Amoxicillin
	Co-trimoxazole syrup/suspension
	Paracetamol
	Vitamin A capsules
	Me-/albendazole cap/tab
	Zinc
Child health services: preventative and curative care. World Health Organization. *Service availability and readiness assessment (SARA): an annual monitoring system for service delivery: reference manual.* World Health Organization; 2013.	

Table 2: Multivariable Logistic Regression of Care-seeking for Sick Children on Service Readiness Quality Components

	Staff and Training	Equipment	Diagnostic Capacity	Medicine
Variables				
Level of health service quality				
Low quality *(reference)*	1.00	1.00	1.00	1.00
Medium quality	1.25** (1.03 – 1.51)	0.66 (0.36 – 1.20)	1.09 (0.86 – 1.39)	1.37 (0.78 – 2.40)
High quality	1.11 (0.91 – 1.37)	0.75 (0.42 – 1.33)	1.13 (0.88 – 1.45)	1.36 (0.79 – 2.34)
Road Network Distance (km)	0.95** (0.92 – 0.99)	0.95 ** (0.91 – 0.98)	0.95 ** (0.92 – 0.99)	0.95 ** (0.92 – 0.99)
Number of health facilities in 10km service area	0.99 (0.96 – 1.03)	1.00 (0.96 – 1.03)	0.99 (0.95 – 1.02)	0.99 (0.96 – 1.02)
Maternal age	0.99 (0.98 – 1.00)	0.99 (0.98 – 1.00)	0.99 (0.98 – 1.00)	0.99 (0.98 – 1.00)
Education				
No education *(reference)*	1.00	1.00	1.00	1.00
Some primary	1.20* (0.98 – 1.47)	1.20* (0.98 1.47)	1.19* (0.76 – 1.09)	1.20 * (0.98 – 1.46)
Complete primary	1.49***	1.49*** (1.12–	1.49 *** (1.12	1.49*** (1.12 –

	(1.12 – 1.99)	1.99)	– 1.98)	1.99)
Secondary or above	1.18 (0.91 – 1.54)	1.18 (0.91 – 1.53)	1.17 (0.90 – 1.52)	1.18 (0.91 – 1.54)
Household wealth				
Poorest *(reference)*	1.00	1.00	1.00	1.00
Poor	0.91 0.76 – 1.09)	0.91 (0.76 – 1.09)	0.92 (0.76 – 1.09)	0.92 (0.76 – 1.10)
Middle	0.93 (0.77 – 1.12)	0.93 (0.77– 1.11)	0.92 (0.77 – 1.11)	0.92 (0.77 – 1.11)
Richer	0.98 (080 – 1.21)	0.98 (0.80 – 1.21)	0.99 (0.81 – 1.21)	0.99 (0.81 – 1.21)
Richest	0.95 (0.75 – 1.25)	0.95 (0.72 – 1.26)	0.95 (0.72 – 1.25)	0.95 (0.72 – 1.25)

*Multilevel logistic regression model: household (Level 1); household cluster (Level 2). All models adjusted for month of survey interview. *** p<0.01, ** p<0.05, * p<0.1*

Table 3: Multivariable Regression Results of Care-seeking in 8- and 12km Service Area

	8km service environment (n=3970)	12 km service environment (n=4846)
Variables		
Level of health service quality		
Low quality *(reference)*	1.00	1.00
Medium quality	1.49*** (1.11 – 2.02)	1.09 (0.78 – 1.52)
High quality	1.50*** (1.11 – 2.03)	1.21 (0.86 – 1.71)
Road Network Distance (km)	1.00 (1.00-1.04)	0.94*** (0.91 -0.98)
Number of health facilities in 10km service area	0.98 (0.93 – 1.05)	0.99 (0.97 – 1.01)
Maternal age	0.99 (0.98 – 1.05)	0.98 (0.98 – 1.00)
Education		
No education *(reference)*	1.00	1.00
Some primary	1.20 (0.95 – 1.51)	1.23** (1.00 – 1.51)
Complete primary	1.46** (1.06 – 2.02)	1.55*** (1.17– 2.06)
Secondary or above	1.24 (0.92 – 1.66)	1.21 (0.93 – 1.57)
Household wealth		
Poorest *(reference)*	1.00	1.00
Poor	0.93 (0.76 – 1.13)	0.89 (0.75 – 1.07)
Middle	0.94 (0.77 – 1.13)	0.94 (0.78– 1.13)
Richer	1.00 (0.79 – 1.25)	0.99 (0.81 – 1.21)
Richest	0.94 (0.69 – 1.27)	0.93 (0.71 – 1.23)

*Multilevel logistic regression model: household (Level 1); household cluster (Level 2). All models adjusted for month of survey interview. *** p<0.01, ** p<0.05, * p<0.1*

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CHAPTER 3: Study 2: Does removing fees for child health services improve child survival? An evaluation of the impact of user fee removal on child mortality in sub-Saharan Africa

Introduction

Despite substantial progress in reducing global child mortality, from 12.6 million deaths in 1990 to 5.2 million in 2019, the number of deaths remains high, particularly in sub-Saharan Africa, which has the highest under-five mortality rate in the world[1]. Pneumonia, diarrhea and malaria remain the leading causes of child mortality worldwide – accounting for almost a third of all under-five deaths[2]. Poor access to health care is a key determinant of child mortality[3]. Prompt diagnosis and management of these diseases is critical for improving health outcomes and in reaching the Sustainable Development Goal target of reducing child mortality to 25 per 1000 live births in every country by 2030[4].

Several barriers to accessing health services for children under-five exist, including financial accessibility. User fees, defined as out-of-pocket payments by patients for medical services at facilities, have been identified as one of the primary barriers to health service utilization[5]. User fees were introduced for publicly provided services in several sub-Saharan African countries during the 1980s and early 1990s. Fees were recommended to improve health care quality and to serve as a revenue source for under-funded health facilities[6,7]. However, substantial evidence has shown that out-of-pocket payments for health services negatively affects demand for care, and can lead to delayed or foregone care[8].

In the early 2000s, many African countries began adopting national policies for user fee removal, or implemented exemptions from user fees for certain population groups, such as for pregnant women and children under-five[9]. For example, Ghana and Senegal removed fees for all facility delivery services in 2003 and 2006, respectively, and Sierra Leone abolished all charges for pregnant women and children under-five in 2010[10-12].

The goal of demand side-financing programs, such as user fee removal, is to increase the demand for health services [13-15]. Evidence has shown positive effects of user-fee removal on health-seeking behavior and improved care utilization for child health services, as well as for maternal care [16-19]. For example, in Jamaica, the odds of seeking sick child care nearly doubled following the implementation of a policy to remove health care fees for children[20]. Research examining the effect of user-fee removal on facility deliveries in Ghana, Senegal and Kenya, found the policy was consistent with a 5 percent increase in facility-based deliveries[17].

Evidence from other demand-side financing incentives, such as cash transfers and public health insurance, also show a positive impact on utilization and health outcomes through improved access to care. For example, a program in Nigeria in which households were offered a payment conditional on uptake of health services, led to a 8% increase in child survival[21]. In Mexico, the implementation of a public health insurance scheme targeted towards children under-five was associated with a 5% reduction in infant mortality[22].

Although a number of studies have highlighted the positive impact of demand-side policies to alter the demand for care, research on the impact of fee removal on child mortality remains understudied, and results are mixed. For example, one study evaluating the effect of user fee removal on health outcomes in Ghanaian children found the removal of user fees improved health care utilization, but found no difference in health outcomes (nutritional status and child mortality) between the intervention and control group[23]; however in the Philippines, a study by Quimbo et al., (2011) found fee removal led to a significant reduction in the likelihood of wasting and having an infection among poor children[24]. Existing research is also limited in generalizability – the majority of evidence comes from randomized control trials, and is restricted to individuals from one geographic region or country [19,25].

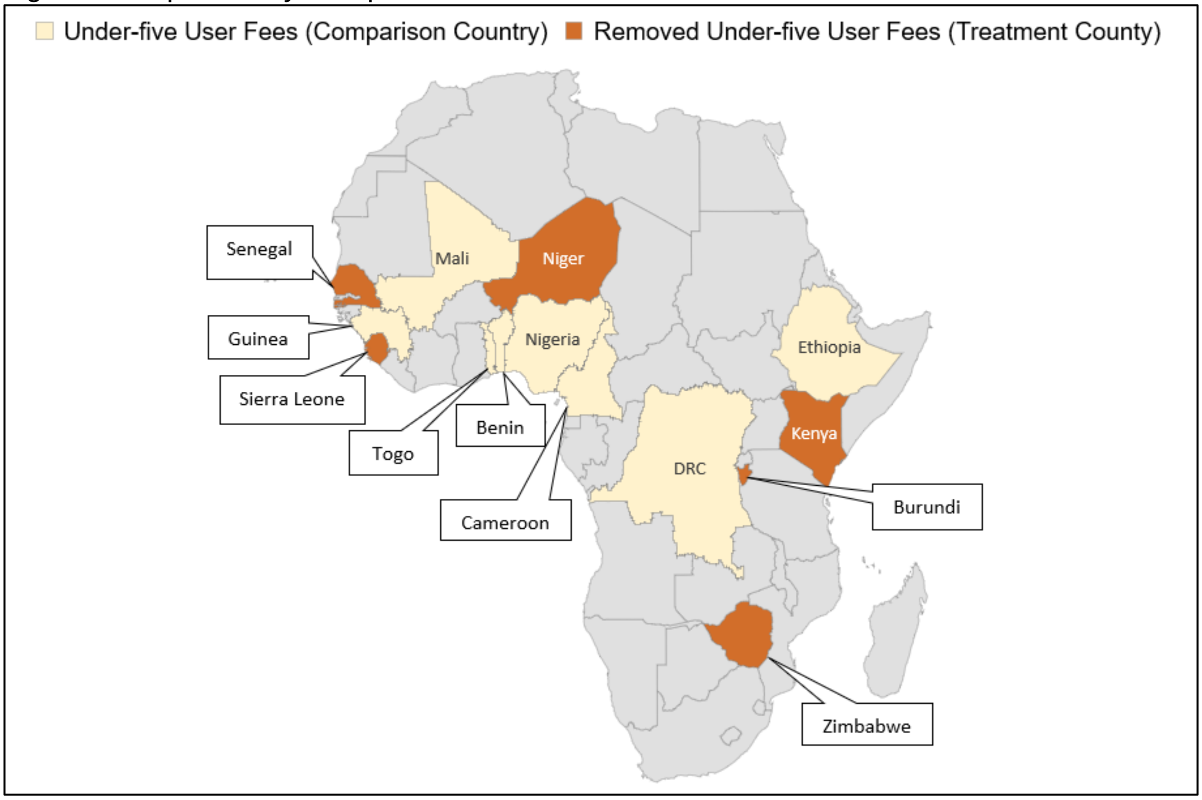
The objective of this study is to examine the impact of under-five fee removal on child mortality across six countries in sub-Saharan Africa using a quasi-experimental design (comparing countries that have, and have not, removed user fees). As more countries consider implementing fee removal policies, it is important to examine whether the policy improves child survival.

Methods

Study Sample

Study sample includes countries that removed user-fees for under-five child health services between 2000 and 2014: Kenya (2004); Burundi (2006); Niger (2007); Sierra Leone (2010); Zimbabwe (*phased roll out* 2011-2014); and Senegal (2014). A description of under-five fee removal policies are included in **Table 1, Appendix.** Comparison countries include those in the region that maintained under-five user fees during the study period: Cameroon, Benin, Democratic Republic of Congo, Guinea, Mali, Ethiopia, Togo and Nigeria **(Figure 1: Map of Countries).** Other criteria for identifying comparison countries included availability of surveys during the study period, following similar approach used in previous studies[16-18]. Excluded from the analysis are countries that never implemented user fees for under-five health care services; or removed under-five fees prior to 2000 (e.g. Zambia[26]). Information on under-five fee removal policies was obtained from multiple publications and articles, as well as government and World Bank documents[9,10,27-42].

Figure 1: Map of Study Sample Countries, With and Without Under-five User Fees



Study sample includes countries that removed user-fees for under-five child health services between 2000 and 2014: Kenya (2004); Burundi (2006); Niger (2007); Sierra Leone (2010); Zimbabwe (*phased roll out* 2011-2014); and Senegal (2014). Comparison countries include Cameroon, Benin, Democratic Republic of Congo (DRC), Guinea, Mali, Ethiopia, and Togo

Data Sources

<u>Child Mortality Data</u>

Birth history data for all countries was obtained from the Demographic and Health Survey (DHS) to create a panel of live births for each woman surveyed. DHS provides a full history of birth and mortality data for all years, not just years for which the DHS administered a survey[43]. This approach is similar to methods used in prior studies using multi-country DHS data to evaluate the effect of programs and policies on child mortality.[17,44,45] In DHS, full birth history (FBH) is included for each woman, including the date (month and year) and sex of each live birth, age and sex of each child, and age at death of each deceased child. Deceased children with missing observations for age of death were excluded from the sample, which represented less than 1%

of all births in the pooled dataset. To limit potential recall bias, we included only births fifteen years prior to the survey date.

Measures

Primary Outcomes – Infant and Under-five Mortality

A binary indicator was used to indicate whether the child died (y=1) or was alive (y=0) for each calendar year; this was applied for both infant and under-five mortality models. Infant mortality was defined as deaths at ages 0 to 11 months. Under-five mortality was defined as 0 months to 59 months[46].

Exposure to Treatment

Exposure to the under-five fee removal policy was measured by a binary indicator, of whether a country (or district, for Zimbabwe only), removed under-five user fees in a given year. Zimbabwe's under-five fee removal policy was rolled-out across districts from 2011-2014. In 2011 two districts removed user fees, and an additional 16 districts followed suit in 2012, and by 2014 user fees had been removed across all rural districts in the country.[38] Therefore, we classified a birth as being exposed to a user fee policy based on its geographic location (district) and year. DHS collects the geographic coordinates of all sampled household clusters using Global Positioning System (GPS).[47] District-level geospatial data for Zimbabwe was obtained from OCHA's Centre for Humanitarian Data [48], and linked to the DHS GPS data using geospatial methods in ArcGIS (10.7.1).

Covariates

Covariates selected for inclusion were based on review of the literature, and factors associated with under-five fee removal and child health outcomes. Individual- and household-level covariates include the child's gender, maternal age at birth, household wealth, mother's educational attainment, and rural or urban residence. Country-level time-varying confounders include per capita gross domestic expenditure[49], development assistance for health (DAH)[50], and country governance scores: political stability and absence of violence and government effectiveness[51]. All models include country-level fixed effects and district-level fixed effects for Zimbabwe, as well as year fixed effects, to control for secular trends. Standard errors were clustered at the country-level and district-level for Zimbabwe.

Statistical Analysis

A difference-in-differences (DD) model was used to estimate the impact of user fee removal on child mortality. Given the variation in treatment timing across countries (the implementation of the under-five fee removal policies across countries ranges from 2004 to 2014), the DD approach diverges from the traditional model (treatment vs control and pre vs post policy)[52]. A two-way fixed effect DD model was used to estimate the effect of under-five fee removal on infant and under-five mortality. The DD estimator is a weighted average of all two-group and two-period DD estimators in the data[52]. The estimator compares timing groups to each other, and includes a time-varying indicator for whether the treated unit (e.g. country, district) was treated in given period (year) [52].

1) *Model specification for infant and under-five mortality models*

$$Y_{ict} = \alpha + \lambda_t + \mu_c + X_{ict} + Z_{ct} + \beta Policy_{ct} + \varepsilon_{ict}$$

where Y_{ict} is the outcome of interest (mortality) for child *i* from country *c* in year *t*; α is an intercept; λ_t and μ_c are fixed-effects for year and country or district (for Zimbabwe), respectively; X_{ict} is a vector of individual-level covariates (child sex (binary), mother's age at birth (continuous), mother's education (categorical variable: no education, some primary, complete primary, secondary and above), household wealth index(categorical variable: poorest, poor, middle, rich and richest) and rural or urban residence; Z_{ct} represents time-varying country-level covariates (per capita GDP, DAH, and country governance scores). The coefficient *B* represents the average difference-in-differences estimate for the effect of the under-five fee removal policy.

To examine evidence of pre-existing differences in trends, and evaluate immediate and long-term effects of fee removal, an event study model was used:

2) *Model specification for infant and under-five mortality models*

$$Y_{ict} = \alpha + \lambda_t + \mu_c + X_{ict} + Z_{ct} + \sum \beta_t T_{ct} + \varepsilon_{ict}$$

where Y_{ict} is the mortality outcome variable for child *i* from country *c* in year *t*; α is an intercept; λ_t and μ_c are fixed-effects for year and country or district (for Zimbabwe), respectively; X_{ict} is a vector of individual-level covariates (child sex (binary), mother's age at birth (continuous), mother's education (categorical variable: no education, some primary, complete primary, secondary and above), household wealth index (categorical variable: poorest, poor, middle, rich and richest) and rural or urban residence; $\beta_t T_{ct}$ includes separate centered indicators, to measure the effect of the policy change (in event years), before and after the policy was implemented for each treatment country, following a similar approach applied in a previous study[53]; time (years) are set to 1 for years pre-and post (in event time) and set to zero for all comparison countries; *t* is centered in the year the policy is implemented, and ranges from -4 (4 years before under-five fee removal) to 3 years (3 after adoption of policy)[53]. Time (years) is limited to 4 years pre-policy to 3 years post to standardize the years (pre- and post-policy) that are available in event time among treatment countries[1]. For event time (years) outside of this

[1] Based on DHS availability, and the defined study period, time in event years (pre-post) policy varies across treatment countries. For Kenya, 4-pre and 10-post is available; for Burundi, 5 pre- and 11-post years; for Sierra Leone, 10-pre and 3-post; for Niger, 7-pre and 5-post; for Senegal, 10-pre and 3-post; and for Zimbabwe, up to 10-pre and up to 3-post across districts in the phased roll-out.

range, *t* is set to zero. The coefficient of interest (centered indicator) measures the effect of each time period relative to a defined reference period, which is standardized to -1, 1 year before policy implementation, for each respective country's implementation year. Difference-in-difference coefficients from the event study models were also plotted to visually evaluate pre- and post-trends for infant and under-five mortality.

Identifying Assumptions

There are key assumptions with the difference-in- differences method to consider. First, the parallel trends assumption; which in this study, I assume that in absence of the under-five fee removal (i.e. the treatment), post-treatment outcomes (child mortality) would follow similar trends[26]. And second, the common shocks assumption, which states that any events or changes occurring during or after implementation of the policy, will equally affect the treatment and comparison countries[54]. To address these issues, I conducted both visual and empirical tests for parallel trends, and conducted several robustness checks to confirm these assumptions hold.

Sensitivity Analyses

Several sensitivity analyses were conducted to assess the robustness of study findings. First, separate mortality models were conducted to evaluate the effect of under-five fee removal excluding neonatal deaths. In some countries, fee removal for children under age five was implemented jointly with fee removal for maternal health services (e.g. Sierra Leone and Niger); thus, a reduction in infant mortality may be due to reductions in neonatal deaths, as a result of increased delivery at health facilities, or improved antenatal care. Second, analyses were repeated excluding each country from the model one at a time, to determine whether results are sensitive to a single country. Third, analyses were run to test whether estimates were robust controlling for country-specific policies that varied across treatment and comparison countries (free malaria treatment and facility delivery policies [12,55-60]), as well as inclusion of other time-varying factors: government per capita health expenditure, and development assistance specific to newborn, child and maternal health. Fourth, we assessed whether the results were sensitive to alternative measures of effect size, by estimating linear poisson regression models to obtain adjusted risk ratios for infant-and under-five mortality[61]. Modified Poisson regression with robust variance is an appropriate method to evaluate binary data, and obtain efficient relative risk estimates[62].

Given that user fee policies were implemented throughout different times of the year, separate mortality models were tested using child-month observations as the unit of analysis, assigning exposure (i.e. treatment) in a given month. Separate child-year mortality models were also conducted excluding children born in the same year as the respective country's fee removal implementation, to evaluate for potential bias in childs' exposure time to treatment.

Additionally, potential bias due to differential trends may accumulate over time, and longer-run estimates "may be more sensitive to violations of parallel trends than short-run estimates" [63]. Given the variation in policy adoption and pre—post years available across treatment countries throughout the study period, infant- and under-five mortality models were also run excluding observations from treatment countries outside of the standardized event time range (-4 years pre to 3-years post policy).

Ethical review: The University of California Los Angeles Institutional Review Board classified this study as non-human subjects research and exempt from review.

Results

Descriptive Statistics

Countries implementing under-five fee removal policies (i.e. treatment countries), on average, had lower gross domestic product (GDP) per capita, and a slightly lower percentage of the under-five population in 2000 (17.4 versus 17.9, per 100 total population), compared to comparison countries (**Table 1**). A higher percentage of households in fee-removal countries resided in rural areas, and were from the poorest households. Although treatment and comparison countries had similar proportions among children born to mothers with no education, a higher percentage of children in comparison countries were born to mothers who had completed secondary education or higher.

Table 1: Summary Statistics by Under-five Fee Removal Policy

	Treatment Countries N=387,807 (41.51%)	Comparison Countries N=546,497 (58.49%)
Country-level Characteristics		
Mean Government Effectiveness [a]	9.2	9.0
Mean Political Stability [b]	9.2	8.8
Mean GDP per capita ($)	801.7	1020.9
Mean Development Assistance for Health ($)	217,895	421,442
Mean, percentage of under-five population, per 100 total population (2000) [c]	17.4	17.9
Individual-and Household-level Characteristics		
Rural household (%)	73.9	69.9
Household Wealth Index (%)		
Poorest	27.7	25.0
Poor	23.0	21.5
Middle	19.7	20.1
Rich	16.0	18.2
Richest	13.3	15.1
Education (%)		
No Education	59.5	59.9

Some Primary	18.6	14.0
Complete Primary	9.8	7.6
Secondary or above	12.7	18.4
Mother's age at birth, mean	26.2	26.9
Under-five mortality (%)	2.1	2.8

Mean estimates across indicators obtained for entire study period (2000-2017), unless otherwise noted.
[a] Index standardized to normal units ranging from approximately 7.5 (weak) to 12.5 (strong).
[b] Index standardized to normal units ranging from approximately 7.5 (weak) to 12.5 (strong).
[c] World Population Prospects (2019) [64]

Regression Model Results

Results presented in **Table 2** indicate the under-five fee removal policy significantly reduced the odds of child mortality. In the fully adjusted model for infant mortality (Model 2), the user fee removal policy, on average, reduced the odds of mortality by 19% (aOR 0.81, p<0.001, 95% CI 0.72-0.91). In evaluating the effect on under-five mortality (Model 4), the policy reduced the odds of mortality among children under age 5 by 22% (aOR 0.74, p<0.001, 95% CI 0.63 – 0.87). The adjusted odds ratios infant and under-five mortality were similar in models including only country-and district-level fixed effects (Models 1 and 3, respectively). (Full results are presented in **Table 3, Appendix**).

Table 2: Adjusted Odds Ratios of Child Mortality[a,b]

	Infant Mortality		Under-five Mortality	
	Model 1	Model 2	Model 3	Model 4
	Country- and district-level FE	Adjusted for all covariates[a.b]	Country- and district-level FE	Adjusted for all covariates[a.b]
Policy	0.80** (0.70– 0.92)	0.81*** (0.72– 0.91)	0.73*** (0.62-0.85)	0.74*** (0.63– 0.87)

*p<0.05; **p<0.01, ***p<0.001
[a] Country-level covariates include GDP per capita, development assistance for health (DAH), political stability and government effectiveness.
[b] Individual-and household-level covariates include mother's age at birth, child sex, mother's education, household wealth, and rural or urban residence.

All models include year and country fixed-effects (FE). District-level fixed effects are included for Zimbabwe. Robust standard errors are clustered at the country-level and district-level for Zimbabwe

Event Study Results

In the four years leading up the policy change, estimates are not statistically different from zero, and the DD coefficients (adjusted odds ratios) are close to 1, suggesting minimal evidence of any pre-existing trends (**Figures 2a and 2b**). There is a clear reduction in the odds of infant mortality in the first year following policy implementation (aOR 0.83 $p<0.05$, 95% CI 0.70 – 0.98); although post periods 2 and 3 are not statistically significant, there remains a reduction in infant mortality post policy. For under-five mortality, there is also an immediate decrease in mortality in the year following policy implementation (aOR 0.77, $p=0.06$, 95% CI 0.60 – 1.01) (**Table 4, Appendix).**

Figures 2a-b: Event Study: Adjusted Odds of Child Mortality[a,b]

Figure 2a: Infant Mortality

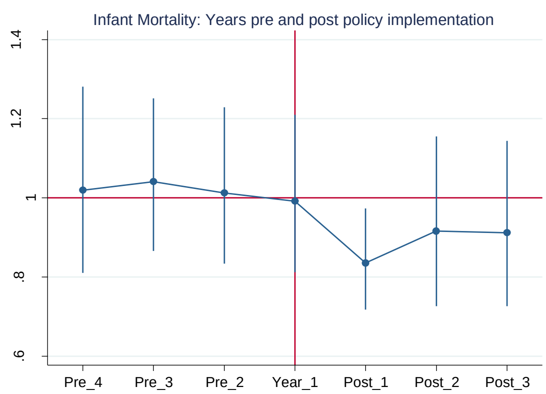
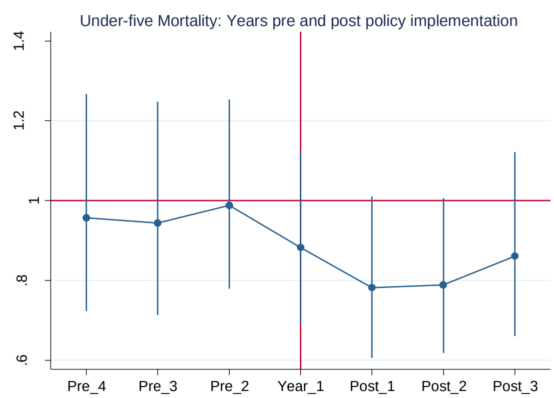


Figure 2b: Under-five Mortality



Event study model results: plotted adjusted odd ratios with 95% confidence intervals, years before and after under-five fee removal policy implementation.
[a] Country-level covariates include GDP per capita, development assistance for health (DAH), political stability and government effectiveness. Model also includes year and country fixed-effects (FE). District-level fixed effects are included for Zimbabwe.
[b] Individual- and household-level covariates include mother's age at birth, child sex, mother's education, household wealth, and rural or urban residence.
All models include robust standard errors, clustered at the country-level and district-level for Zimbabwe.

Sensitivity Analysis Results

Several sensitivity analyses were conducted to evaluate robustness of study results. First, deaths in the first 30 days of a child's life were excluded, for both infant and under-five mortality models (**Table 4).** The magnitude, direction and significance of results were comparable to the fully adjusted model for infant mortality (aOR 0.79, p<0.001, 95% CI 0.70 – 0.90); and under-five mortality (aOR 0.73, p<0.01, 95% CI 0.60 – 0.88).

Table 3: Adjusted Odds Ratios of Child Mortality, Excluding Neonatal Deaths

	Infant Mortality	Under-five Mortality
	Model 1 Adjusted for all covariates[a.b]	Model 2 Adjusted for all covariates[a.b]
Policy	0.79*** (0.70 – 0.90)	0.73** (0.60 – 0.87)

*p<0.05; **p<0.01, ***p<0.001
[a] Country-level covariates include GDP per capita, development assistance for health (DAH), political stability and government effectiveness. Model also includes year and country fixed-effects (FE). District-level fixed effects are included for Zimbabwe.
[b] Covariates include mother's age at birth, child sex, mother's education, household wealth, and rural or urban residence.
All models include robust standard errors, clustered at the country-level and district-level for Zimbabwe

Separate mortality models were also run, excluding each country at a time, to determine whether one country was driving results. The magnitude, direction and significance of the average treatment effect of the user-fee removal policy on infant and under-five mortality was comparable across all models excluding each treatment country (**Table 5**). Results were also consistent and comparable to the main model when excluding each comparison country. (**Appendix, Table 5**).

Table 4: Adjusted Odds Ratios[a,b] of Child Mortality, Excluding Each Treatment Country

	Model 1 Excluding Kenya	Model 2 Excluding Burundi	Model 3 Excluding Niger	Model 4 Excluding Sierra Leone	Model 5 Excluding Zimbabwe	Model 6 Excluding Senegal
Infant Mortality						
Policy	0.77*** (0.68 – 0.86)	0.82** (0.72 – 0.94)	0.81** (0.72 – 0.93)	0.80** (0.70 – 0.93)	0.81*** (0.72 – 0.91)	0.82** (0.72-0.92)
Under-five Mortality						
Policy	076** (0.63 – 0.91)	0.73** * (0.60– 0.89)	0.70*** (0.59 – 0.84)	0.70*** (0.59 – 0.84)	0.73*** (0.63– 0.86)	0.77*** (0.68 – 0.87)

*p<0.05; **p<0.01, ***p<0.001
[a] Country-level covariates include GDP per capita, development assistance for health (DAH), political stability and government effectiveness. Model also includes Year and Country fixed effects. District-level fixed effects are included for Zimbabwe.
[b] Covariates include mother's age at birth, child sex, mother's education, household wealth, and rural or urban residence. Model also includes year and country fixed effects. Under-five mortality models include child age (years). All models include robust standard errors, clustered at the country-level and district-level for Zimbabwe

Infant mortality models were also specified including indicators among countries that implemented free malaria treatment (aOR 0.79, p<0.001, 95% CI 0.70 – 0.89), and free maternal health services (free facility delivery policies) (aOR 0.85, p<0.05, 95% CI 0.74 – 0.99) during the study period[2]. Inclusion of other time-varying country indicators: government health expenditure per capita[65] and development assistance for health including only newborn, child and maternal health, (aOR 0.82, p<0.001, 95% CI 0.74 – 0.91) was associated with 18% reduction in odds of infant mortality[3]. Results were also robust in under-five mortality models.

Results from the poisson regression model for estimating adjusted risk ratios were similar in direction, magnitude and significance to the adjusted odds ratios. The relative risk for infant mortality was 0.80 (0.72 – 0.89, p<0.001) and 0.74 (0.63 – 0.85, p<0.001) for under-five mortality.

[2] Countries implementing free malaria treatment policies include Benin (2012), Democratic Republic of Congo (2008), Mali (2007) and Cameroon (2011). Countries implementing free facility delivery policies include Senegal (2006) and Kenya (2007)
[3] National health expenditure per capita was obtained from World Bank Indicators database. Data was available for all countries during the study period; except for Zimbabwe, data was only available from 2010-present

In estimating the effect of fee removal using child-month observations, estimates in the reduction of infant mortality following policy change were comparable to the main model (0.86, $p<0.05$; 95% CI 0.77-0.97). The model included country, district, and month-year fixed effects, adjusting for household and child-level characteristics, however time-varying covariates at the month-level were not available, and thus not included in this model.

Separate child-year mortality models were also run conducted excluding children born in the same year as the respective country's fee removal implementation, to evaluate for potential bias in childs' exposure time to treatment: the odds of infant mortality were reduced by 22% (aOR 0.78; $p<0.001$, 95% CI 0.68– 0.89), and 28% for under-five mortality (aOR 0.72, $p<0.001$, 95% CI 0.60 – 0.84).

Finally, we confirmed study findings from infant and under-five mortality models excluding the years before and after policy adoption to evaluate potential bias from differential trends that may accumulate over time: in these models, the odds of infant mortality were reduced by 15% (aOR 0.85; $p<0.01$, 95% CI 0.77 – 0.94); and the odds of under-five mortality reduced by 20% (aOR 0.80, $p<0.01$, 95% CI 0.72 – 0.89).

Discussion

This study found that the removal of health care user fees for children under-five led to a significant reduction in infant and under-five mortality. Results showed that that the odds of infant mortality were reduced by 19% following policy implementation, and 26% for under-five mortality. These findings are consistent with a previous evaluation in Burkina Faso that found a substantial reduction in child mortality following the implementation of a national policy removing fees for children-under five [66].

These findings also support evidence from prior studies indicating that cost is a significant barrier to health care utilization, leading to poorer health outcomes [17,18,67]. Prior research has shown, through both qualitative and quantitative evidence, that improved access to care through the removal of user fees leads to improved health outcomes due to increased utilization of care services, and more timely and prompt treatment[19,68]. Results from this study also complement evidence from Sierra Leone and Niger – two countries that implemented under-five fee removal policies. In Niger, user fee removal for children under-five was associated with a sudden increase in under-five health care consultations immediately after the policy was enacted[34], and in Sierra Leone, one study found significantly higher rates of healthcare seeking behaviors for sick children with diarrhea, malaria and pneumonia, following the implementation of the fee removal policy[69].

Across all mortality models, there were substantial socioeconomic gradients, consistent with prior research evaluating factors associated with child mortality[70,71]. The odds of infant mortality were 18% lower comparing children born to mothers with the highest education (secondary or above) compared to those with no education. There was a 30% decrease in odds comparing children from the wealthiest to those from the poorest households. Increased maternal age at birth and urban residence were also associated with lower child mortality.

We also found evidence of significant immediate effects of the policy on improved child survival, however findings from the event study model indicate the effect of the policy on child mortality was not sustained over time. These results mirror prior research from Zambia: the effect of user fee removal on increased care utilization begin to diminish nearly eighteen months after the policy change[34]. There is limited research on the long-term effects of user fee removal[60], however supply side-factors have been shown to play a critical role on sustainability of fee removal policies, which may affect demand for care, and subsequent health outcomes. Due to increased demand of services, facilities may have to extend hours, or patients may experience longer wait times, which may lead to decreased utilization of care services[13]. Further research into the long-term effects of fee removal policies on supply-side factors is needed to better understand sustainability of fee removal programs.

In many African countries there is limited financial protection for health services, and many individuals pay out of pocket for care[72,73], which has significant downstream effects, and may exacerbate socioeconomic disparities in access to care. Research from Ethiopia found that direct payment associated with diarrheal illness or pneumonia for children was a substantial economic burden for households; authors also found that poor and rural households were more likely to face impoverishment due to medical expenses for sick child care[74]. Although this study does not examine other important barriers to care, such as geographical access, quality of services, or service availability, enhancing coverage and equity of health services by eliminating direct payments of care is a critical step towards reducing childhood morbidity and mortality, and to achieving universal health coverage[75].

Limitations

First, all variables – including mortality outcomes and timing -- were self-reported, so misclassification or recall bias is possible[76]. However, the recall period was restricted to 15 years across all countries to control for potential misclassification.

Second, this study does not evaluate the effectiveness of fee removal policies across countries or evaluate how care quality may have been impacted due to changes in health system financing – factors that may influence child health outcomes.

Third, under-five fee removal policies, as well as other country-level reforms, were obtained from the literature (including related publications and program evaluation documents). Thus the accuracy of treatment exposure (at the month and year-level) may be imprecise.

Fourth, it is important to note that under-five fee removal policies varied across countries; some policies were implemented alongside other programs, such as fee removal for maternal care services; and in Zimbabwe, fee removal was part of a results-based financing initative[77]. Throughout the study period, there were also varying policies implemented at the national level (e.g. free facility delivery and free malaria treatment). Study findings however, were robust to several model specifications and adjustments, including exclusion of neonatal deaths and separate mortality models excluding one country at a time.

Fifth, although the event study framework is used to evaluate trends post-policy, only 3-years post policy were available across all countries, and it may be possible that trends in the reduction of child mortality may change over longer periods of time, or may differ across countries.

Finally, under-five fee removal policies were not identical across countries, and the pooled average effect may be sensitive to the exclusion of a single country; however, the reduction in infant and under-five mortality was consistent and remained significant across separate mortality models.

Conclusion

Study findings show that the removal of health care fees for child health services significantly improved child survival in sub-Saharan Africa. National policies to remove financial barriers to care are critical to improving health outcomes and advancing universal health coverage. Additional research is needed on the long-term effect of under-five fee removal policies on the quality of service provision and patient utilization, as well as other supply-side factors that may influence patient demand for care.

CHAPTER 3: Appendix

Table 1: Description of Under-five Fee Removal Policies

Country	Removal of under-five user fees (Month and Year)	Description of fee removal policy or fee-exemption	Source
Kenya	July 2004	Health care services for children under-five were exempted from payment, as well as other specific health conditions including malaria.	[27-29]
Burundi	May 2006	Health care services for children under-five were exempted from payment in public and private not-for-profit facilities. Fee-removal policy also applied to deliveries and cesarean sections.	[30,31,78]
Niger	April 2007	Curative health care services for children under-five were exempted from payment in public and private not-for-profit facilities. Fee-removal policy also applied to some maternal and reproductive health services including antenatal care and family planning.	[32-34]
Sierra Leone	April 2010	Health care services for children under-five were exempted from payment in public facilities. Fee exemptions also applied to pregnant women and lactating women.	[10,35]
Zimbabwe	July 2011; March 2012; January 2014	User fee exemption for under-five health care, scaled up between 2011-2014 in rural districts, implemented under the Health Transition Fund (HTF), as part of the Results-based Financing (RBF) program, with a focus on improving child and maternal care delivery. Fee exemptions also applied to maternal health care services.	[36-38]
Senegal	January 2014	Health care services for children under-five were exempted from payment, including consultations at health centers and hospitals, starting October 2013. Beginning January 2014, other priority child illnesses were included in the fee removal policy.	[39-42]

Table 2: Study Sample for Infant and Under-five Mortality

Country	Policy Implementation Year and Month	DHS Survey	Infant Sample No. observations	Number of infant deaths	Under-five Sample No. observations	Number of under-five deaths
Treatment Countries (n=6)						
Kenya	July 2004	2003, 2008, 2014	74,392	3,293	302,646	4,305
Burundi	May 2006	2010, 2016-17	52,814	3,210	213,331	4,658
Niger	April 2007	2006, 2012	42,224	2,663	163,010	5,213
Sierra Leone	April 2010	2008, 2013	42,170	4,501	159,838	6,534
Zimbabwe	July 2011; March 2012; January 2014[a]	2005, 2010, 2015	15,924	887	55,867	1,160
Senegal	January 2014	2005, 2010, 2012, 2014-2017	160, 283	7,319	633,690	10,233
Total			387, 807	21,873	1,528,382	32,103
Comparison Countries (n=8)						
DRC	-	2007, 2013-14	56,793	4,204	216,076	6,380
Cameroon	-	2007, 2011	32,381	2,154	120,513	3,478
Ethiopia	-	2000, 2005, 2011, 2016	68,406	4,656	272,062	6,344
Togo	-	2013-14	18,526	1,037	76,340	1,713
Nigeria	-	2003, 2008, 2013_14, 2018	169,894	12,234	675,183	21,336
Benin	-	2001, 2006, 2011-12, 2018	85,848	4.908	335,066	7,487
Guinea	-	2005, 2012, 2018	43,941	3,090	171,728	4,867
Mali	-	2001, 2006, 2012-13, 2018	70,708	5,179	262,802	8,042
Total			546,497	32,559	2,129,770	59,647

[a] *Fee-removal implemented in Marondera and Zvishavane rural districts in 2011; Binga, Chipinge, Kariba, Mutare, Gokwe, Nkayi, Mangwe, Gwande, Mwenzei, Chiredzi, Mutoko, Gweru, Chegutu, Mazowe, Centenary and Chikomba rural districts in 2012; and scaled up to remaining rural districts in 2014.*[38]
Live births from 2000-2016 included. For 'treatment' countries, pre-period identified as ≤10 years pre-policy implementation . Recall period limited to 15 years for all countries.

Table 3: Adjusted Odds Ratios for Infant and Under-five Mortality

	Infant Mortality		**Under-five Mortality**	
	Adjusted Odds Ratio	95% Confidence Interval	Adjusted Odds Ratio	95% Confidence Interval
No Policy *(reference)*	-	-	-	-
Policy	0.81***	0.72 – 0.91	0.74***	0.63 – 0.86
Individual- and Household-level Covariates				
Household Wealth				
Poorest *(reference)*	-	-	-	-
Poor	0.97	0.92 – 1.01	0.96	0.89 – 1.03
Middle	0.91**	0.85 - 0.96	0.86**	0.80 – 0.94
Rich	0.84***	0.77 – 0.92	0.77***	0.69 – 0.86
Richest	0.70***	0.64 – 0.77	0.61***	0.55 – 0.67
Mother's age at birth	0.99*	0.99 – 0.99	0.99*	0.95 – 1.00
Maternal Education				
No education *(reference)*	-	-	-	-
Some primary	0.99	0.93 – 1.05	0.96	0.89 – 1.04
Completed primary	0.87***	0.82 – 0.91	0.80***	0.72 – 0.88
Secondary or above	0.82***	0.78 – 0.86	0.74***	0.65 – 0.84
Child Sex				
Male (reference)	-	-	-	-
Female	.82***	0.79 – 0.84	0.86***	0.84 – 0.88
Residence				
Urban *(reference)*	-	-	-	-
Rural	1.10***	1.05 – 1.16	1.13***	1.06 – 1.21
Country-level Covariates				
Low DAH *(reference)*	-	-	-	-
Medium DAH	1.13	0.91 – 1.34	1.17	0.94 – 1.45
High DAH	1.35	0.88 – 2.01	1.36	0.95 – 1.96
Low GDP *(reference)*	-	-	-	-
High GDP	1.05	0.91 – 1.26	1.00	
Political Stability	0.96	0.90 – 1.04	1.22*	1.00 – 1.48
Government Effectiveness	1.07	0.91 – 1.27	1.10	0.64 – 1.89

+p<0.1; *p<0.05; **p<0.01, ***p<0.001
All models include year and country/district-level fixed effects. Robust standard errors are clustered at the country-level and district-level for Zimbabwe.

Table 4: Event Study: Odds of Infant and Under-Mortality, Years Before and After Policy Implementation

	Infant Mortality		**Under-five Mortality**	
	Adjusted Odds Ratios	95% Confidence Interval	Adjusted Odds Ratios	95% Confidence Interval
Years Pre-Post Policy				
Policy_Pre 4 years	1.02	0.81 – 1.30	0.96	0.72 – 1.26
Policy_Pre 3 years	1.04	0.86 – 1.26	0.94	0.71 – 1.24
Policy_Pre 2 years	1.01	0.82 – 1.24	0.98	0.77 – 1.24
Policy Implementation	0.98	0.79 – 1.20	0.88	0.69 – 1.12
Post – 1 year	0.83*	0.70 – 0.98	0.78⁺	0.60 – 1.01
Post – 2 years	0.92	0.72 – 1.15	0.79⁺	0.62 – 1.00
Post – 3 years	0.89	0.69 – 1.16	0.86	0.66 – 1.11
Individual- and Household-level Covariates				
Household Wealth				
Poorest (*reference*)	-	-	-	-
Poor	0.97	0.92 – 1.01	0.96	
Middle	0.91**	0.85 – 0.96	0.86***	0.80 – 0.94
Rich	0.84***	0.77 – 0.92	0.77***	0.69 – 0.86
Richest	0.70***	0.64 – 0.77	0.61***	0.55 – 0.67
Mother's age at birth	0.99*	0.99 – 0.99	0.99*	0.99 – 1.00
Maternal Education				
No education (*reference*)	-	-	-	-
Some primary	.995	0.93 – 1.05	0.96	0.89 – 1.05
Completed primary	.864	0.82 – 0.91	0.80***	0.72 – 0.88
Secondary or above	.823	0.78 – 0.86	0.74***	0.66 – 0.84
Child Sex				
Male (*reference*)	-	-	-	-
Female	0.81***	0.79 – 0.84	0.86***	0.84 – 0.88
Residence				
Urban *(reference)*	-	-	-	-
Rural	1.10***	1.05 – 1.16	1.13***	1.06 – 1.21
Country-level Covariates				
Low DAH (*reference*)	-	-	-	-
Medium DAH	1.11	0.91 – 1.38	1.15	0.94 – 1.40
High DAH	1.36	0.91 – 2.04	1.37*	1.02 – 1.84
Low GPD per capita (*reference*)	-	-	-	-
High GPD per capita	1.03	0.87 – 1.21	1.18	0.98 – 1.42
Political Stability	0.95	0.88 – 1.03	0.91*	0.85 – 0.92
Government Effectiveness	1.00	0.82 – 1.22	0.96	0.60 – 1.55

⁺p<0.1; *p<0.05; **p<0.01, ***p<0.001
All models include year and country/district-level fixed effects. Robust standard errors are clustered at the country-level and district-level for Zimbabwe.

Table 5: Odds of Child Mortality[a,b], Excluding Each Comparison Country

	Model 1 Excluding Benin	Model 2 Excluding Cameroon	Model 3 Excluding DRC	Model 4 Excluding Nigeria	Model 5 Excluding Guinea	Model 6 Excluding Togo	Model 7 Excluding Ethiopia	Model 8 Excluding Mali
Infant Mortality								
Policy	0.84*** (0.75 0.93)	0.80*** (0.71 0.91)	0.79*** (0.71- 0.88)	0.84* (0.74- 0.97)	0.81** (0.71 0.93)	0.81*** (0.71 0.91)	0.79** (0.69 0.91)	0.80** (0.70 9.91)
Under-five Mortality								
Policy	0.76** (0.65 – 0.90)	0.74*** (0.63 0.87)	0.72** (0.61- 0.84)	0.77*** (0.68- 0.87)	0.74** (0.62- 0.87)	0.74*** (0.63– 0.86)	0.76** (0.67 – 0.86)	0.74** (0.63 – 0.87

*p<0.05; **p<0.01, ***p<0.001
[a] Country-level covariates include GDP per capita, development assistance for health (DAH), political stability and government effectiveness. Model also includes Year and Country fixed effects. District-level fixed effects are included for Zimbabwe.
[b] Covariates include mother's age at birth, child sex, mother's education, household wealth, rural or urban residence and birth order. All models include year and country/district-level fixed effects. Robust standard errors are clustered at the country-level and district-level for Zimbabwe.

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CHAPTER 4: Study 3: Evaluating differential effects of user fee removal: Does removing health care user fees for children improve disparities in child survival?

Introduction

Reducing childhood mortality is a global priority issue and a critical objective of the Sustainable Development Goals (SDGs). During the Millennium Development Era (2000-2015), global interventions reduced the under-five mortality rate by over 50%, from 91 deaths per 1000 live births to 43 deaths[1]. Despite this progress, substantial child health inequalities remain, within and across countries[2,3]. Estimates show children from rural areas are 1.7 times more likely to die before the age of five, and children from the poorest households are 1.9 times more likely[1].

In Sub-Saharan Africa, socio-economic disparities in child outcomes and access to care have been well-documented [4-8]. Previous studies have reported the association between child morbidity and socio-economic factors, such as household income, maternal education, and household residence[9,10]. Children from poorer households and residing in rural areas, and those born to mothers with no education, have significantly higher risks of adverse health outcomes[11,12]; they are also likely to have lower rates of care utilization (due to poor proximity to care and transportation costs)[13,14].

One of the driving factors of health disparities is wealth-based inequities. Out-of-pocket expenditures inhibit health care access, which reduces the likelihood of timely and adequate care, leading to adverse health outcomes[15]. Additionally, households can face indirect costs when accessing care, such as costs for transportation, or other losses including lost wages and productivity[16].

To address socioeconomic disparities, is it critical for health services to be financially accessible[3,17]. National policies to remove financial barriers to care – such as cash transfers, vouchers, and user fee removal for health services – have become an important strategy to decrease households' risk of catastrophic health expenditures, increase care utilization, and improve disparities in health outcomes[18]. The goal of these demand side financing programs (e.g. fee removal, cash transfers) is to increase the demand for health services[18-20]. Evidence has shown that demand-side interventions are overall successful in increasing use of health services. For example, user fee removal has shown positive effects on health-seeking behavior for child health care, as well as for maternal health services (e.g., antenatal care, facility delivery) [21-24]. Other demand-side programs, such as cash transfers and vouchers, have also shown consistent, positive impacts through improved access to care[25]. For example, a program in Colombia in which households were offered a payment conditional on uptake of child health services nearly doubled the use of preventive care[26].

Research has also shown differential effects of demand-side policies across population sub-groups; however, most of these studies have evaluated effects on utilization, rather than health outcomes. Evidence from Zambia examining heterogeneous effects of free public health care found increased uptake of services was driven primarily by individuals from lower socioeconomic backgrounds[27]. Similarly, research from Ghana evaluating the effect of fee removal on facility delivery found that the poorest women benefited the most following the policy change[28].

Although studies show consistent positive benefits of demand-side policies for the poorest households, effects across educational levels indicate the opposite: research on the effects of cash transfers on child outcomes in India, Mexico and Ecuador found that children of mothers with higher education benefited more from these programs (compared to lower educated groups). They had higher rates of vaccination coverage and better nutritional outcomes[29-31]. Similar findings were obtained from a study examining differential effects of delivery fee exemptions policies by maternal education. The authors found that the increase in facility deliveries was driven by the highest educated women; and results suggested the policy contributed to a widening of educational inequalities[22].

Research on differential effects by geographic region however, are mixed: one study carried out in Burkina Faso's Sahel region found that user-fee removal for sick child care was effective in increasing care utilization overall, but no effect was observed for populations living beyond 9 kilometers (km) from the nearest health facility[32]. However, an impact evaluation of a conditional cash transfer program on childhood vaccinations in rural Nicaragua found that program effects were stronger among subgroups of children living farther from facilities[31].

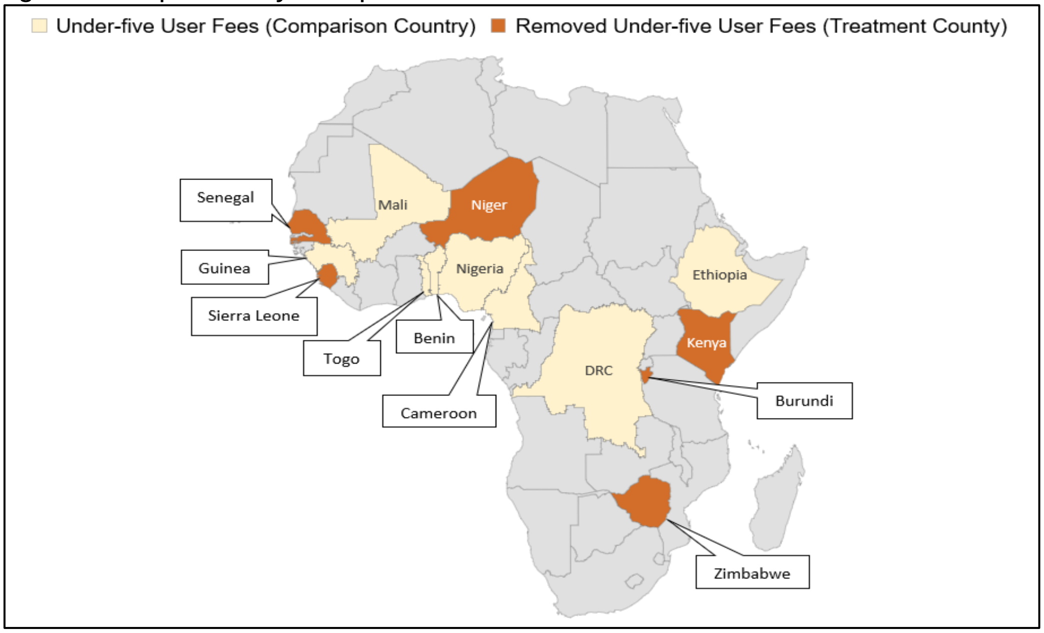
The objective of this study was to evaluate whether the effect of the fee-removal policy differs across key socioeconomic indicators: household wealth, place of residence (urban versus rural), and maternal education. In Chapter 3 of this dissertation (*Study 2: Does removing fees for child health services improve child survival? An evaluation of the effect of user fee removal on child mortality in sub-Saharan Africa*), I found that under-five fee removal policy led to a reduction in infant and under-five mortality; and, consistent with prior research[33,34], results showed that children born to mothers with less education and from poorer households, as well as those residing in rural areas, had higher odds of child mortality. Understanding heterogenous policy effects, and specifically, whether fee removal policies are successful at improving disparities for children, is critical to identifying whether national strategies aimed at improving access to care improves outcomes across socioeconomic groups.

Methods

Study Sample

The study sample includes sub-Saharan African countries that removed under-five user fees for child health services between 2000 and 2014: Kenya (2004); Burundi (2006); Niger (2007); Sierra Leone (2010); Zimbabwe (*phased roll out* 2011-2014); and Senegal (2014). A description of under-five fee removal policies are included in **Table 1, Appendix.** Comparison countries include those in the region that maintained under-five user fees during the study period: Cameroon, Benin, Democratic Republic of Congo, Guinea, Mali, Ethiopia, Togo and Nigeria **(Figure 1: Map of Study Sample Countries).** Excluded from the analysis are countries that never implemented user fees for under-five health care services; or removed under-five fees prior to 2000 (e.g. Zambia[27]). Information on under-five fee removal policies was obtained from multiple publications and articles, as well as government and World Bank documents[35-52]

Figure 1: Map of Study Sample Countries, With and Without Under-five User Fees



Study sample includes countries that removed user-fees for under-five child health services between 2000 and 2014: Kenya (2004); Burundi (2006); Niger (2007); Sierra Leone (2010); Zimbabwe (*phased roll out* 2011-2014); and Senegal (2014). Comparison countries include Cameroon, Benin, Democratic Republic of Congo (DRC), Guinea, Mali, Ethiopia, and Togo

Data Sources

<u>Infant Mortality Data</u>

Birth history data for all countries was obtained from the Demographic and Health Survey (DHS) to create a panel of live births for each woman surveyed, which provides a full history of birth and mortality data for all years, not just years for which the DHS administered a survey.[53]. This approach is similar to methods used in prior studies using multi-country DHS data to evaluate the effect of programs and policies on child mortality.[22,54,55] In DHS, full birth history (FBH) is included for each woman, including the date (month and year) and sex of each live birth, age and sex of each child, and age at death of each deceased child. Deceased children with missing observations for age of death were excluded from the sample, which represented less than 1% of all births in the pooled dataset. To limit potential recall bias, we included only births fifteen years prior to the survey date. [56]

Measures

Primary Outcome – Infant Mortality

A binary indicator was used to indicate whether the child was reported to have died (y=1) or was alive (y=0) for each calendar year. Infant mortality is defined as deaths at ages 0 to 11 months[57].

Exposure to Treatment

Exposure to the under-five fee removal policy was measured by a binary indicator, of whether a country (or district, for Zimbabwe only), removed under-five user fees in a given year. Zimbabwe's under-five fee removal policy was rolled-out across districts from 2011-2014. In 2011 two districts removed user fees, and an additional 16 districts followed suit in 2012, and by 2014 user fees had been removed across all rural districts in the country.[48] Therefore, we classified a birth as being exposed to a user fee policy based on its geographic location (district) and year. DHS collects the geographic coordinates of all sampled household clusters using Global Positioning System (GPS).[58] District-level geospatial data for Zimbabwe was obtained from OCHA's Centre for Humanitarian Data [59], and linked to the DHS GPS data using geospatial methods in ArcGIS (10.7.1).

Moderating Variables – Key Socioeconomic Indicators

<u>Household wealth quintile</u>: a composite measure (constructed by DHS using principal component analysis), which is comprised of a households' key assets, such as drinking water source, sanitation, and vehicle ownership[60]. Households are classified based on quintile of this asset measure, from poorest (lowest) to richest (highest)[61].

<u>Place of residence</u>: Household's place of residence, defined as either rural or urban. DHS adopts each country's own urban-rural definition.

Maternal education: categorical variable defined as no education, some primary, complete primary or incomplete secondary, and secondary education and above, based on woman's report.

Covariates

Covariates selected for inclusion were based on review of the literature and guided by the conceptual framework on factors associated with under-five fee removal and determinants of under-five child outcomes. Individual- and household-level covariates include the child's gender, maternal age at birth, household wealth, mother's educational attainment, and rural or urban residence. Country-level time-varying confounders include per capita gross domestic expenditure[62], development assistance for health (DAH)[63], and country governance scores: political stability and absence of violence and government effectiveness[64]. All models include country-level fixed effects (district-level fixed effects for Zimbabwe), and year fixed effects. Standard errors were clustered at the country-level and district-level for Zimbabwe.

Statistical Analysis

To first examine disparities in infant mortality across socioeconomic groups (e.g. between the poorest and wealthiest groups), we used a two-way fixed effects difference-in-differences (DD) logistic regression model (Model Specification 1). This model is analogous to the DD logistic regression model in *Chapter 3: Study 2;* and was used to calculate the predicted probabilities of infant mortality for each socioeconomic indicator: household wealth, place of residence, and maternal education.

1) *Model Specification for infant mortality model*

$$Y_{ict} = \alpha + \lambda_t + \mu_c + X_{ict} + Z_{ct} + \beta_1 Wealth_{ict\ t} + \beta_2 Residence_{ict} + \beta_3 Education_{ict} + \beta_4 Policy_{ct} + \varepsilon_{ict}$$

where Y_{ict} is the outcome of interest (mortality) for child *i* from country *c* in year *t*; α is an intercept; λ_t and μ_c are fixed-effects for year and country or district (for Zimbabwe), respectively; X_{ict} is a vector of individual-level covariates (child sex (binary), mother's age at birth (continuous); Z_{ct} represents time-varying country-level covariates (per capita GDP, DAH, and country governance scores). The key socioeconomic indicators are represented by β_1*Wealth* (five category variable: poorest [*reference*], poor, middle, rich and richest),, β_2*Residence* (urban [*reference*] and rural); and β_3*Education* (level of material education: no education [*reference*], some primary, complete primary and some secondary, and complete secondary or higher). The coefficient B_4 represents the average difference-in-differences estimate for the effect of the under-five fee removal policy.

We then estimated whether the effect of the policy was modified by household wealth, place of residence, and maternal education, with the following models:

2) *Model Specification for infant mortality models with interaction terms*

a. $Y_{ict} = \alpha + \lambda_t + \mu_c + X_{ict} + Z_{ct} + \beta_1 Policy_{ct} + \beta_2 Wealth_{ict} + \beta_3 Policy_{ct} * Wealth_{ict} + \varepsilon_{ict}$

b. $Y_{ict} = \alpha + \lambda_t + \mu_c + X_{ict} + Z_{ct} + \beta_1 Policy_{ct} + \beta_2 Residence_{ict} + \beta_3 Policy_{ct} * Residence_{ict} + \varepsilon_{ict}$

c. $Y_{ict} = \alpha + \lambda_t + \mu_c + X_{ict} + Z_{ct} + \beta_1 Policy_{ct} + \beta_2 Education_{ict} + \beta_3 Policy_{ct} * Education_{ict} + \varepsilon_{ict}$

where Y_{ict} is the outcome of interest (mortality) for child *i* from country *c* in year *t*; α is an intercept; λ_t and μ_c are fixed-effects for year and country or district (for Zimbabwe), respectively; X_{ict} is a vector of individual-level covariates; Z_{ct} represents time-varying country-level covariates (per capita GDP, DAH, and country governance scores); $Policy_{ct}$ is a binary variable set to 1 if child *i* resided in country *c* that removed under-five user fees in year *t,* interacted with the key socioeconomic indicator (household wealth, place of residence, or maternal education). Interaction term estimates are obtained by each household wealth quintile, by residence, and by each level of maternal education; and multiple interaction terms are included for multiple indicator categories (e.g. Policy*Poor, Policy*Middle, Policy*Rich, Policy*Richest).

The interpretation of the interaction term changes in a binary model[65,66]. In this analysis, predicted probabilities and average marginal effects were obtained from the interaction term coefficients to estimate the effects of the policy by each socioeconomic indicator. These estimates were obtained with the Stata margins command, using the delta method to obtain standard errors[67]. Predictive margins were presented graphically by household wealth, place of residence, and maternal education. The significance of partial interactions in the probability metric were also obtained using Stata's postestimation contrast commands, and to estimate the average difference in the effect of under-five user-fee removal across socioeconomic groups.[68,69]

One of the key identifying assumptions of the difference-in-differences analysis (comparing countries that have implemented under-five removal policies, versus those that have not) is the parallel trends assumption; which in this study, I assume that in absence of the under-five fee removal (i.e. the treatment), post-treatment outcomes (child mortality) would follow similar trends[27]. Additionally, given that this analysis evaluates differential effects of the under-five fee removal policy, pre-trends in mortality should also be similar across each socioeconomic group (i.e. across each household wealth quintile). To examine evidence of pre-existing differential trends, an event study model was used:

3) *Model Specification for evaluating pre-trends across each socioeconomic category*

$$Y_{ict} = \alpha + \lambda_t + \mu_c + X_{ict} + Z_{ct} + \sum \beta_t T_{ct} + \varepsilon_{ict}$$

where Y_{ict} is the mortality outcome for child *i* from country *c* in year *t*; α is an intercept; λ_t and μ_c are fixed-effects for year and country or district (for Zimbabwe), respectively; X_{ict} is a vector of individual-level covariates (child sex (binary), mother's age at birth (continuous), mother's education (categorical variable: no education, some primary, complete primary, secondary and above), household wealth index (categorical variable: poorest, poor, middle, rich and richest) and rural or urban residence; $\beta_t T_{ct}$ includes separate centered indicators, to measure the effect of the policy change (in years), before and after the policy was implemented for each treatment country, following a similar approach applied in a previous study[70]. Event time (years) is set to 1 for years pre-and post policy, and set to zero for all comparison countries; *t* is centered in the year the policy was implemented, and ranges from -4 (4 years before under-five fee removal) to 3 years (3 years after policy implementation).[70] Event time is limited to 4 years pre-policy to 3 years post-policy, to standardize the years available among treatment countries[4]. For event time outside of this range, *t* is set to zero. The coefficient of interest (centered indicator) measures the effect of each time period relative to a defined reference period, which is standardized to -1, 1 year before policy implementation, for each respective country's implementation year. Difference-in-difference coefficients from the event study models were also plotted to visually evaluate pre-and post-trends across each socioeconomic category (i.e. among only children from the poorest household wealth quintile). A total of 11 separate event study models were run.

[4] Based on DHS data availability and the defined study period, time in event years (pre-post) policy varies across treatment countries. For Kenya, 4-pre and 10-post is available; for Burundi, 5 pre- and 11-post years; for Sierra Leone, 10-pre and 3-post; for Niger, 7-pre and 5-post; for Senegal, 10-pre and 3-post; and for Zimbabwe, up to 10-pre and up to 3-post across districts in the phased roll-out.

Sensitivity Analysis

Sensitivity analyses were conducted to test the robustness of study results. First, mortality models were run excluding neonatal deaths to determine whether differential effects on infant mortality may be attributed to deaths in the first 30 days of life. In some countries, fee removal for children under age five was implemented jointly with fee removal for maternal health services (e.g. Sierra Leone and Niger); thus a reduction in infant mortality may be due to reductions in neonatal deaths, as a result of increased delivery at health facilities, or improved antenatal care. Second, results were obtained excluding each treatment country to determine whether results were sensitive to the inclusion of one country in the model. Additionally, separate infant mortality models were also conducted excluding children born in the same year as the respective country's fee removal implementation, to evaluate potential bias in exposure time, given that under-five fee policies were implemented at different times of the year across countries.

Ethical review: The University of California Los Angeles Institutional Review Board classified this study as non-human subjects research and exempt from review.

Results

Predicted Probabilities of Infant Mortality by Household Wealth, Residence, and Education

Figures 2a-c displays the fully adjusted predicted probabilities of infant mortality by household wealth quintiles, place of residence, and maternal education, obtained from the multivariable logistic regression model (*Model Specification 1*), using the margins command. Overall, the average probability of infant mortality was significantly lower among children from the wealthier households, those residing in urban areas, and children born to mothers with higher education, and there is a clear gradient across household wealth quintiles and maternal education. The greatest disparity was observed between children from the poorest and wealthiest households: on average, the probability of infant mortality among the poorest children was 6.9%, and 5.0% among the wealthiest.

Figures 2a-c: Predicted Probability of Infant Mortality Across Socioeconomic Indicators: Household Wealth, Place of Residence and Maternal Education

Figure 2a: Household Wealth

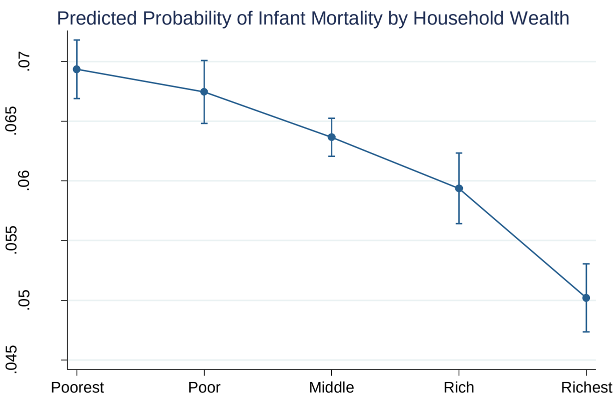


Figure 2b: Place of Residence

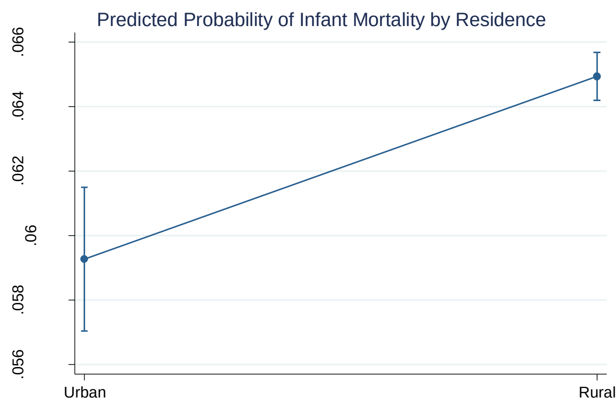
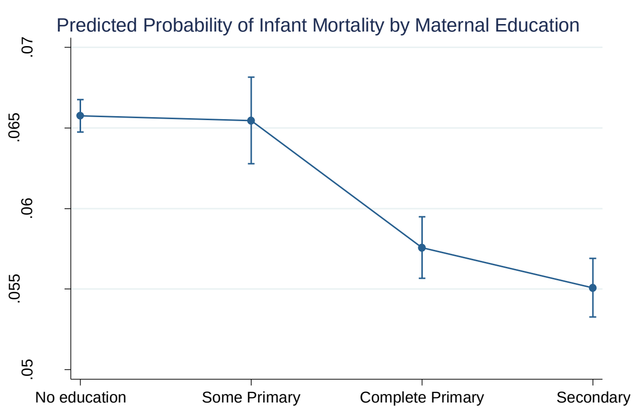


Figure 2c: Maternal Education

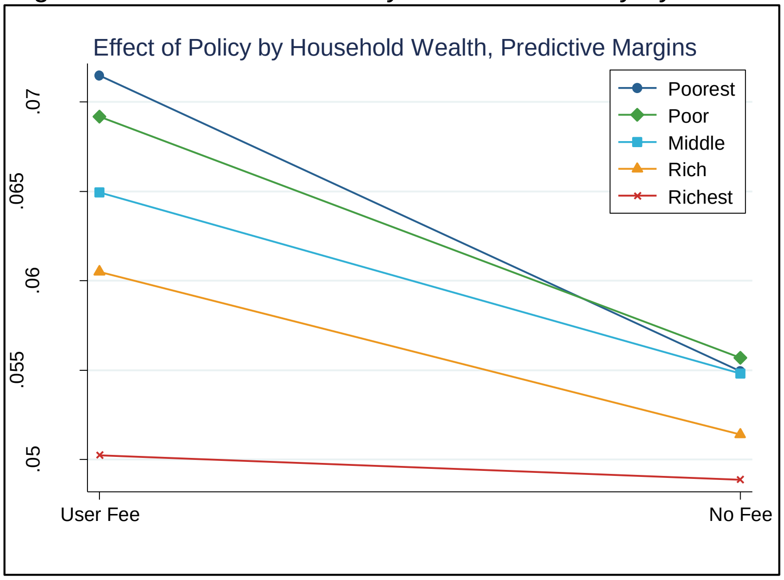


Figures 2a-c display the predicted probability of infant mortality based on logistic regression models. Model is adjusted for GDP per capita, development assistance for health (DAH), political stability and government effectiveness; mother's age at birth, child sex, and maternal education. Model also includes year and country fixed effects; district-level fixed effects are included for Zimbabwe. Robust standard errors are clustered at the country-level and district-level for Zimbabwe.

Effects of Fee Removal Policy on Infant Mortality by Household Wealth

Predicted probabilities of infant mortality were obtained from the multivariable logistic regression model including an interaction term between the household wealth and policy indicators (**Appendix, Table 3**). Probabilities of mortality were plotted to display the change in mortality before and after the policy change. Before the policy was implemented, the adjusted predicted probability of infant mortality among children from the poorest households was approximately 7.1%, decreasing to 5.4% after the policy was implemented (**Figure 3),** and this finding was significant (p<0.001). Among children from the wealthiest households, there was minimal, and non-significant change in the probability of death, decreasing from 5.0% to 4.8% (p=0.70) . Confidence intervals for the predicted probabilities by household wealth are included in **Figure 1, Appendix**.

Figure 3: Predicted Probability of Infant Mortality by Household Wealth



Adjusted average predicted probability of infant mortality, before and after user-fee removal by household wealth quintile, obtained from adjusted logistic regression interaction model.

Marginal effects and 95% confidence intervals were obtained to further quantify reductions in the probability of infant mortality across levels of household wealth. **Table 1** shows that the under-five fee removal policy was associated with significant reductions in infant mortality among households in the lowest wealth quintile (poorest) (ME=−0.017, *p*=<0.001), second-lowest quintile (ME=−0.013, *p*<0.001), and middle quintile (ME=−0.010, *p*<0.05); and was marginally significant among households in the second-highest quintile (ME: -0.009, p=0.061). Among the wealthiest households, there was a reduction in infant mortality post-policy, although this finding was not significant (p=0.771).

Table 1: Average Effect of Fee Removal Policy on Infant Mortality by Household Wealth

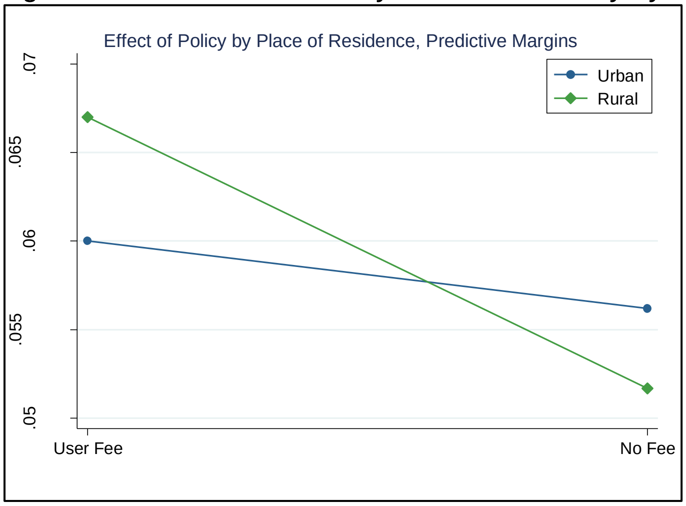
	Marginal Effects	95% CI	P Value
Poorest	-0.017	-0.024 , -0.009	p<0.001
Poor	-0.013	-0.021 , -0.005	p<0.001
Middle	-0.010	-0.019 , -0.001	p<0.05
Rich	-0.009	-0.018 , - 0.000	p=0.061
Richest	-0.001	-0.010 , 0.007	p=0.771

Table 1 displays the marginal effects in the change in probability of infant mortality, based on logistic regression models including an interaction of the policy and household wealth indicator. Model is adjusted for GDP per capita, development assistance for health (DAH), political stability and government effectiveness; mother's age at birth, child sex, and maternal education. Model also includes year and country-fixed effects; district-level fixed effects are included for Zimbabwe. Robust standard errors are clustered at the country-level and district-level for Zimbabwe.

Effects of Fee Removal on Infant Mortality by Place of Residence

In evaluating the predicted probabilities of infant mortality before and after policy change by place of residence, the probability of death among children from rural households decreased from 6.6% to 5.2%; and among children from urban households, from 5.9% to 5.7% (**Figure 4**). The probability of infant mortality was not significantly different by place of residence post-policy implementation (**Figure 2, Appendix**).

Figure 4: Predicted Probability of Infant Mortality by Residence



Adjusted average predicted probability of infant mortality, before and after user-fee removal by place of residence, based on adjusted logistic regression interaction model.

Table 2 show that the decrease in infant mortality following the policy change was statistically significant among rural households, and resulted in a 1.4 percentage point reduction (ME: -0.014, p<0.001); but there was no significant decrease among those from urban households (ME -0.002, p=0.548).

Table 2: Average Effect of Fee Removal Policy on Infant Mortality By Place of Residence

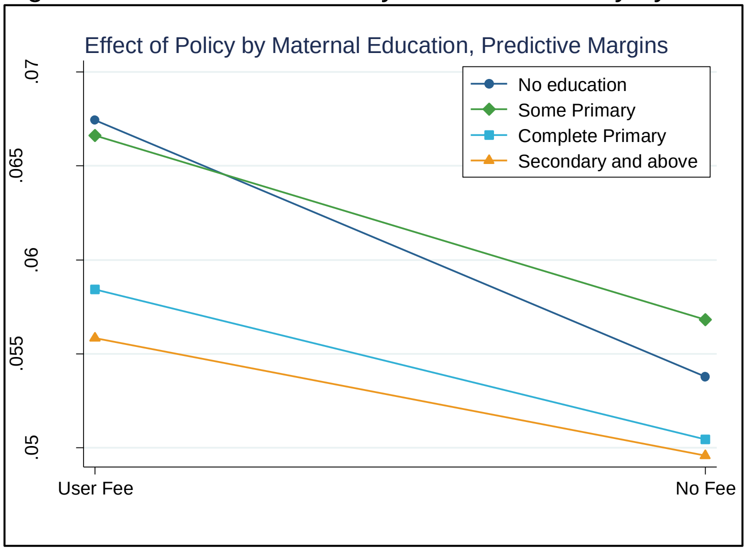
	Marginal Effects	95% CI	P Value
Urban	-0.002	-0.011 , 0.005	p=0.548
Rural	-0.014	-0.019 , -0.008	p<0.001

Table 2 displays the marginal effects in the change in probability of infant mortality, based on logistic regression models including an interaction of the policy and place of residence indicator. Model is adjusted for GDP per capita, development assistance for health (DAH), political stability and government effectiveness; mother's age at birth, child sex, and maternal education. Model also includes year and country-fixed effects; district-level fixed effects are included for Zimbabwe. Robust standard errors are clustered at the country-level and district-level for Zimbabwe

Effects of Fee Removal on Infant Mortality by Maternal Education

Figure 5 presents the predicted probabilities by maternal education levels: among children born to mothers with no education, the probability of infant mortality decreased from 6.7% to 5.3% (p<0.001); and from 5.5% to 4.8% among those born to mothers who completed secondary education or higher, although this finding was non-significant (p=0.289).

Figure 5: Predicted Probability of Infant Mortality by Maternal Education



Adjusted average predicted probability of infant mortality, before and after user-fee removal by maternal education, based on adjusted logistic regression interaction model.

The effect of the policy on infant mortality was largest among children born to mothers with no education (ME: -0.014, p<0.001), and smallest among children born to mothers with secondary education and higher, although this reduction was not significant (ME: -0.006, p=0.289).

Table 3: Average Effect of Fee Removal Policy on Infant Mortality by Maternal Education

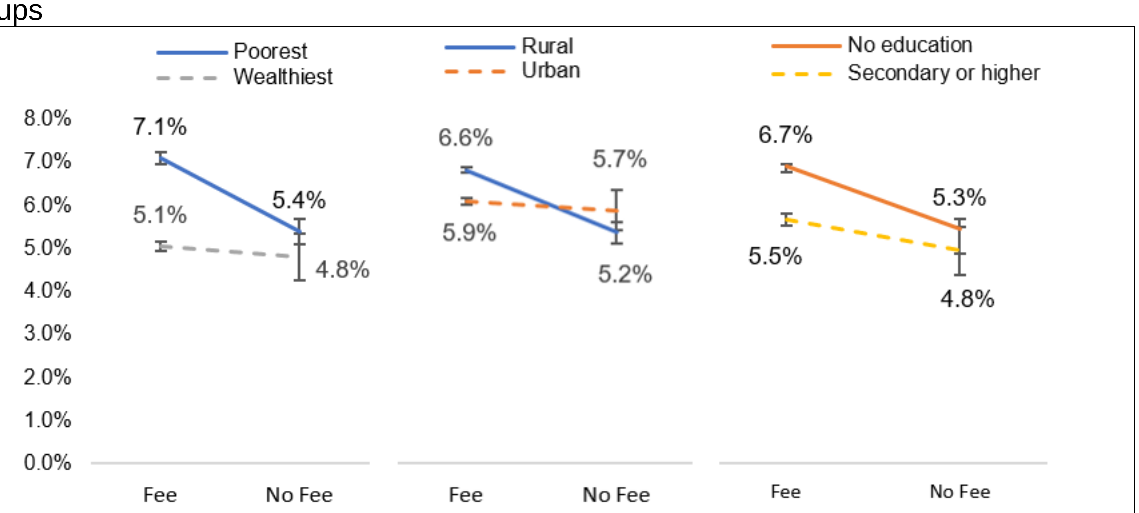
	Marginal Effects	95% CI	P Value
No Education	-0.014	-0.0185 , -0.0087	p<0.001
Some Primary	-0.009	-0.0173 , -0.0022	p<0.05
Complete Primary	-0.008	-0.0198 , 0.0039	p=0.188
Secondary or Higher	-0.006	-0.0178 , 0.0053	p=0.289

Table 3 displays the marginal effects in the change in probability of infant mortality, based on logistic regression models including an interaction of the policy and maternal education indicator. Model is adjusted for time-varying covariates: GDP per capita, development assistance for health (DAH), political stability and government effectiveness; mother's age at birth, child sex, and maternal education. Model also includes year and country-fixed effects; district-level fixed effects are included for Zimbabwe. Robust standard errors are clustered at the country-level and district-level for Zimbabwe

Policy Impact on Disparities in Infant Mortality Between the Highest and Lowest Socioeconomic Groups

Across all socioeconomic groups, disparities in the predicted probability of infant mortality significantly narrowed between the poorest and wealthiest households, and between rural and urban residents (**Figure 6).** For example, the gap in the average predicted probability of infant mortality prior to under-five fee removal between the richest and poorest households was 2.0 percentage points, and decreased to 0.6 percentage points after the policy change. The reduction in infant mortality among those born to mothers with no education versus mothers with secondary education or higher was less dramatic: the difference in the predicted probability of infant mortality between these groups before the policy was implemented was 1.2 percentage points, and decreased to 0.5 percentage points.

Figure 6: Predicted Probability in Infant Mortality, Between Lowest and Highest Socioeconomic Groups



Notes: Predicted probability of infant mortality, with 95% confidence intervals: poorest and wealthiest households; rural and urban households, and children born to mothers with no education versus mothers with secondary and higher. Models are adjusted for GDP per capita, development assistance for health (DAH), political stability and government effectiveness; mother's age at birth, child sex, and maternal education. Model also includes year and country fixed effects; district-level fixed effects are included for Zimbabwe. Robust standard errors are clustered at the country-level and district-level for Zimbabwe.

Contrasts of predictive probabilities were also obtained from the adjusted multivariate logistic regression models, to estimate the average treatment effect of the under-five fee removal policy. **Table 4** displays the magnitude of this effect, as well as the significance of these partial interactions within socioeconomic groups (i.e. between the poorest versus wealthiest households).

The difference in the effect of fee removal among the poorest children living in countries with fee removal, compared to children from the wealthiest households, was approximately 1.5 percentage points, and this finding was statistically significant ($p<0.05$). By place of residence, the effect of the policy led to a reduction of 1.12 percentage points in the probability of infant mortality ($p<0.001$), comparing children from rural households to urban households. Among levels of maternal education, the effect of the policy led to a reduction of 0.73 percentage points, comparing children born to mothers with no education to those with secondary education or higher, however this finding was non-significant (p=209).

Table 4: Average Difference in the Effect of Under-five Fee Removal on Infant Mortality, Between the Lowest and Highest Socioeconomic Groups

	Contrasts of predictive margins	95% Confidence Interval	P-value
Household Wealth – Poorest vs Richest (Interaction: No Under-5 Fees vs Under-5 Fees) * (Poorest vs Richest)	-0.0151	-0.0284 , -0.002	p=0.025
Place of Residence – Rural vs Urban (Interaction: No Under-5 Fees vs Under-5 Fees) * (Rural vs Urban Residence)	-0.0112	-0.0178 , -0.005	p<0.001
Maternal Education – No education vs Secondary Education and Higher (Interaction: No Under-5 Fees vs Under-5 Fees) * (No education vs secondary or higher)	-0.0073	-0.0188, 0.0041	p=0.209

Contrasts of predictive margins from multivariable logistic regression models estimating effect of under-five fee removal policy on infant mortality, with interaction between policy and socioeconomic indicator. Models are adjusted for GDP per capita, development assistance for health (DAH), political stability and government effectiveness; mother's age at birth, child sex, and maternal. Model also includes year and country fixed effects; district-level fixed effects are included for Zimbabwe. Robust standard errors are clustered at the country-level and district-level for Zimbabwe.

Pre- and Post-Policy Trends by Household Wealth, Place of Residence and Maternal Education

Pre-policy trends by socioeconomic position were evaluated between the policy and comparison countries across each key indicator. Overall, there was minimal evidence that trends in infant mortality across household wealth quintiles, rural and urban residence, and by maternal education differed between the treatment and comparison countries (**Appendix, Figures 4 – 14**). The only exception was among children born to mothers with primary education, four years before policy implementation (aOR 1.25, 95% CI 1.07 , 1.46, $p<0.01$). These findings indicate that compared to comparison countries, children from treatment countries had on average, higher odds of infant mortality relative to the period before policy implementation. Across most socioeconomic categories, the adjusted odds ratios showed an immediate decrease in infant mortality, one year after policy implementation.

Sensitivity Analyses Results

Predicted probabilities and marginal effects were obtained excluding deaths in the first 30 days of life (**Appendix, Tables 3-5**). Overall, findings excluding neonatal deaths were comparable to main study results; however, the magnitude in reduction of overall probability in infant mortality following fee removal was lower across all socioeconomic indicators.

Predicted probabilities and average marginal effects were also obtained excluding one treatment country. Overall, results were consistent with main findings: the marginal effect on infant mortality was greatest among children from the poorest households, those from rural areas, and born to mothers with no education (**Appendix, Table 6**). Findings were also robust across socioeconomic groups when excluding children born in the same year of each country's fee removal implementation.

Discussion

The study found that removing under-five user fees significantly narrowed socioeconomic disparities in infant mortality. These results also confirm the importance of subgroup analyses when evaluating national policies, especially for policies targeted towards improving access to care for vulnerable populations.

In this study, children from the poorest households benefited the most from fee removal: the probability of infant mortality decreased from 7.1 to 5.4 percentage points. Among the wealthiest households there was also a decrease in the probability of infant mortality following user-fee removal (from 5.0% to 4.8%), however this reduction was non-significant. Prior evidence has shown that out-of-pocket expenditures inhibit health care access, which reduces the likelihood of timely care, and leads to adverse health outcomes[15]. Research indicates that increased care utilization for children mediates the relationship between user fee removal (i.e. removal of out-of-pocket payments for care) and improved health outcomes (mortality)[18]. Given that financial barriers are typically the greatest barrier to care utilization, those from poorer households are most likely to benefit, and may increase their care use to a greater extent than those from wealthier households (for which cost is not a barrier).

Results from this study also show that under-five fee removal policies significantly narrowed disparities in infant mortality between children from rural versus urban households; and these findings are in line with research from Burkina Faso: Zombré and colleagues found that the impact of under-five fee removal on care utilization was modified by proximity to care – specifically, user fee removal attenuated the relationship between households' distance to health facilities and sick care utilization.[71] Compared to urban residents,. rural residents are more likely to travel long distances for care and have fewer options in choice of health facility [72-75]. Removing user fees may help to alleviate the total costs of accessing care, such as transportation costs. Although this study does not measure geographic proximity to care, study findings suggest that fee removal has been beneficial even for residents living farther away from health facilities.

We also found that narrowing of disparities was smallest by maternal education (compared to place of residence and household wealth). Since under-five fee removal policies have been focused on financial barriers to care, they may not differentially impact outcomes by educational attainment beyond how this is correlated with income. These findings highlight how complementary policy approaches may be needed to address other social determinants that influence disparities in child outcomes.

Reducing the risk of catastrophic health care spending by reducing out-of-pocket payments for care is a critical step towards improving access and providing financial protection[76,77]. Prior evidence evaluating the impact of fee removal on household expenditures found that removing user fees reduced households' financial burden by 6.2 percentage points, and among the poorest households, the policy was associated with a 12 percentage point decrease [77,78] Although fee removal does not eliminate indirect costs of care, they may defray the overall costs of accessing care, leading to higher likelihood of care utilization.

Overall, results from this study indicate that user fee removal for children under-five significantly narrowed socioeconomic disparities in infant mortality and provides further evidence that health outcomes for the most socioeconomically disadvantaged groups can be improved by removing financial barriers to care. Future research should evaluate differential effects on child utilization outcomes, as well as the long-term impact on demand for care.

Limitations

First, although this study controls for important time-varying confounders, bias by unmeasured variables is possible. For example, if the quality of services among countries removing user fees changed differentially over time compared to countries that retained fees, this may influence child health outcomes, and thus bias study results.

Second, all variables – including mortality outcomes and timing -- were self-reported, so we cannot rule out possible misclassification or recall bias. This analysis also only focused on three key socioeconomic indicators. Other social determinants of health, such as health literacy[79] or maternal autonomy[80-82], may further advance our understanding of how policies may affect utilization and health outcomes.

Third, information for country-level under-five fee removal policies was obtained from sources that may be imprecise. We mitigated this by seeking information across several sources, including publications and program evaluation documents.

Fourth, other factors that may affect care-seeking and subsequent care utilization– such as perceived quality of health care, was not measured in this study. Utilization is a complex decision process and a myriad of factors may predict whether treatment is sought in low-income settings[83]. Future research should evaluate differential effects on sick child care utilization, as well as the long-term impact on demand for care.

Additionally, this analysis did not evaluate variation of policy implementation across countries. For example, some national policies for removing fees for child health services were implemented alongside fee removal for maternal care (e.g. Sierra Leone). By excluding each country in separate mortality models, we assessed the extent to which country-specific factors may be affecting the results found here; but the results were robust so we feel country heterogeneity is not a major concern. However, future research should evaluate heterogeneity in outcomes within countries, if feasible.

Finally, we could not evaluate long-term effects of fee removal on infant mortality. Future studies should consider whether the benefits of fee removal across the most disadvantaged groups are sustained over time; as well as whether factors like service quality or availability are impacted by new health care financing policies.

Conclusion

The removal of under-five user fees reduced disparities in infant mortality between wealth groups in sub-Saharan African countries. This highlights the importance of implementing financial protections to reduce disparities in health outcomes. Future research evaluating the impact of demand-side policies on utilization and health outcomes should consider differential effects across key social and economic indicators, as well as how these policies may differentially influence behavior patterns across these groups.

CHAPTER 4: Appendix

Table 1: Description of Under-five Fee Removal Policies

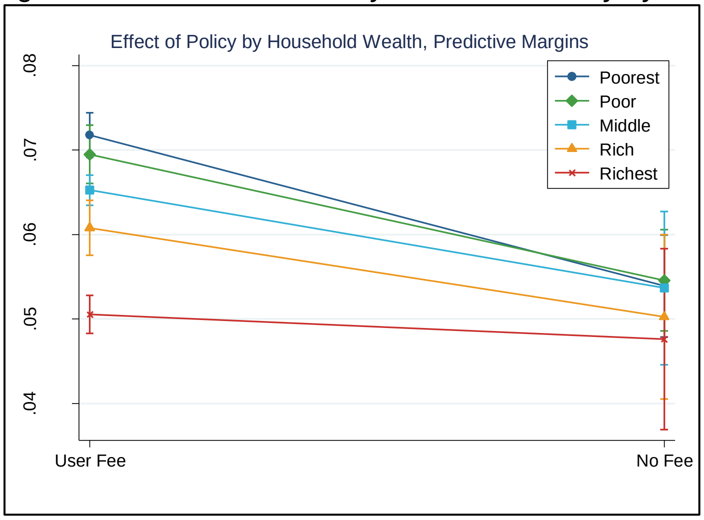
Country	Removal of under-five user fees (Month and Year)	Description of fee removal policy or fee-exemption	Source
Kenya	July 2004	Health care services for children under-five were exempted from payment, as well as other specific health conditions including malaria.	[35-37]
Burundi	May 2006	Health care services for children under-five were exempted from payment in public and private not-for-profit facilities. Fee-removal policy also applied to deliveries and cesarean sections.	[38,39,84]
Niger	April 2007	Curative health care services for children under-five were exempted from payment in public and private not-for-profit facilities. Fee-removal policy also applied to some maternal and reproductive health services including antenatal care, and family planning.	[41,43,44]
Sierra Leone	April 2010	Health care services for children under-five were exempted from payment in public facilities. Fee exemptions also applied to pregnant women and lactating women.	[42,45]
Zimbabwe	July 2011; March 2012; January 2014	User fee exemption for under-five health care, scaled up between 2011-2014 in rural districts, implemented under the Health Transition Fund (HTF), as part of the Results-based Financing (RBF) program, with a focus on improving child and maternal care delivery. Fee exemptions also applied to maternal health care services.	[46-48]
Senegal	January 2014	Health care services for children under-five were exempted from payment, including consultations, at health centers and hospitals, starting October 2013. Beginning January 2014, other priority child illnesses were included in the fee removal policy.	[49-52]

Table 2 : Study Sample

Country	Policy Implementation Year and Month	DHS Survey	Infant Sample No. observations	Number of infant deaths
Treatment Countries (n=6)				
Kenya	July 2004	2003, 2008, 2014	74,392	3,293
Burundi	May 2006	2010, 2016-17	52,814	3,210
Niger	April 2007	2006, 2012	42,224	2,663
Sierra Leone	April 2010	2008, 2013	42,170	4,501
Zimbabwe	July 2011; March 2012; January 2014[a]	2005, 2010, 2015	15,924	887
Senegal	January 2014	2005, 2010, 2012, 2014-2017	160, 283	7,319
Total			387, 807	21,873
Comparison Countries (n=8)				
DRC	-	2007, 2013-14	56,793	4,204
Cameroon	-	2007, 2011	32,381	2,154
Ethiopia	-	2000, 2005, 2011, 2016	68,406	4,656
Togo	-	2013-14	18,526	1,037
Nigeria	-	2003, 2008, 2013_14, 2018	169,894	12,234
Benin	-	2001, 2006, 2011-12, 2018	85,848	4.908
Guinea	-	2005, 2012, 2018	43,941	3,090
Mali	-	2001, 2006, 2012-13, 2018	70,708	5,179
Total			546,497	32,559

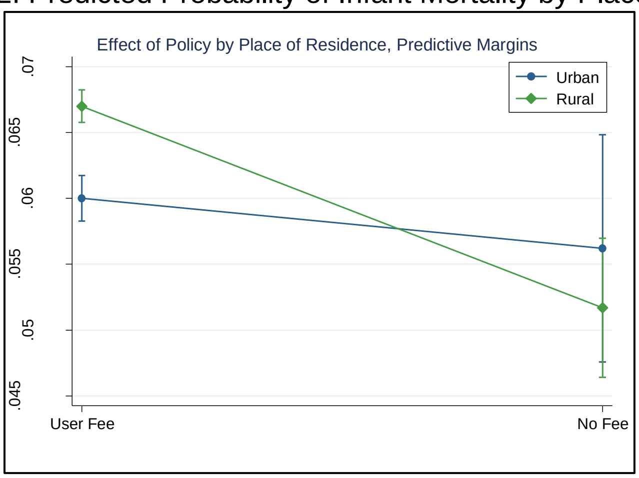
[a] *Fee-removal implemented in Marondera and Zvishavane rural districts in 2011; Binga, Chipinge, Kariba, Mutare, Gokwe, Nkayi, Mangwe, Gwande, Mwenzei, Chiredzi, Mutoko, Gweru, Chegutu, Mazowe, Centenary and Chikomba rural districts in 2012; and scaled up to remaining rural districts in 2014.[48] Live births from 2000-2016 included. For 'treatment' countries, pre-period identified as ≤10 years pre-policy implementation . Recall period limited to 15 years for all countries.*

Figure 1: Predicted Probability of Infant Mortality by Household Wealth



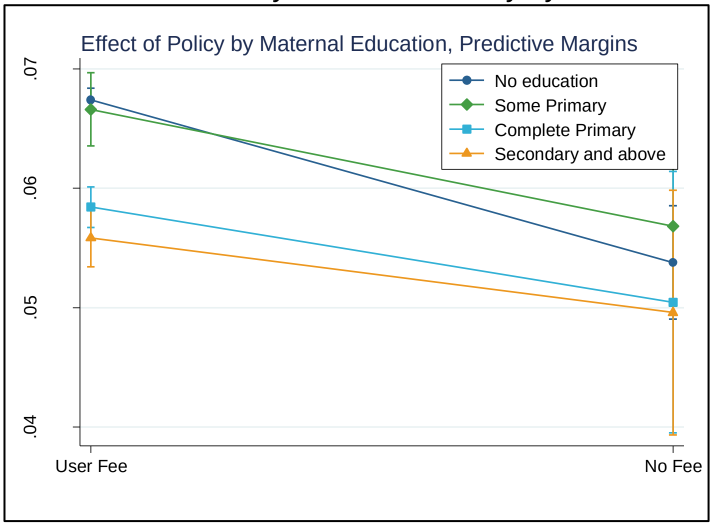
Adjusted average predicted probability of infant mortality, before and after user-fee removal by household wealth quintile, based on adjusted logistic regression interaction model, with 95% CIs

Figure 2: Predicted Probability of Infant Mortality by Place of Residence



Adjusted average predicted probability of infant mortality, before and after user-fee removal by household wealth quintile, based on adjusted logistic regression interaction model, with 95% CIs

Figure 3: Predicted Probability of Infant Mortality by Maternal Education



Adjusted average predicted probability of infant mortality, before and after user-fee removal by household wealth quintile, based on adjusted logistic regression interaction model, with 95% CIs

Figures 4 – 14: Event Study Framework Results: Adjusted Odds of Infant and Under-Mortality, Years Before and After Policy Implementation: Household Wealth, Place of Residence, and Maternal Education

Household Wealth (Figures 4-8)

Figure 4:

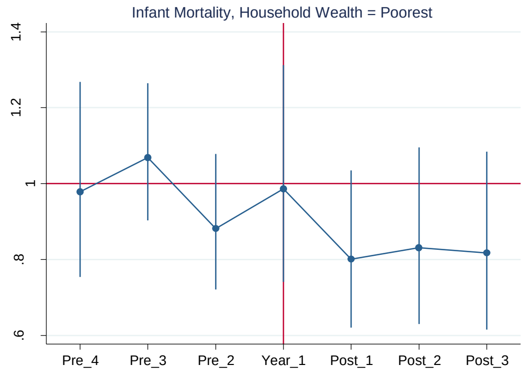


Figure 5

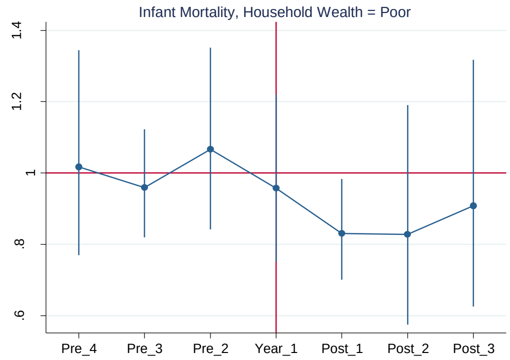


Figure 6

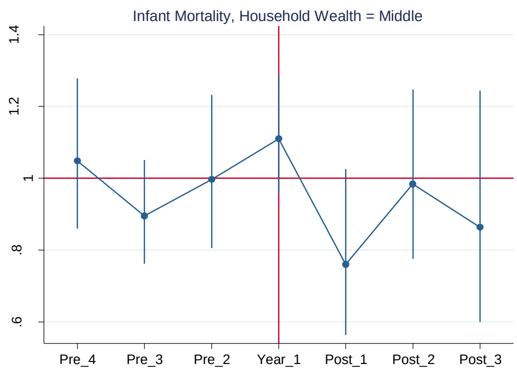


Figure 7

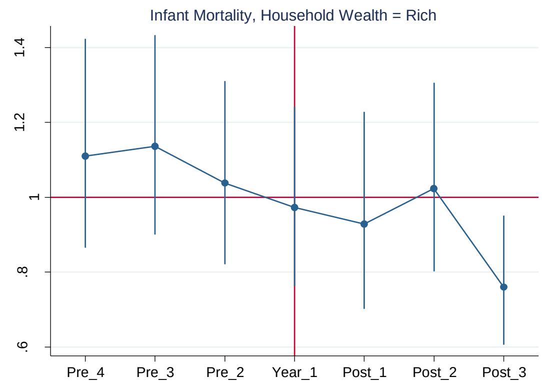
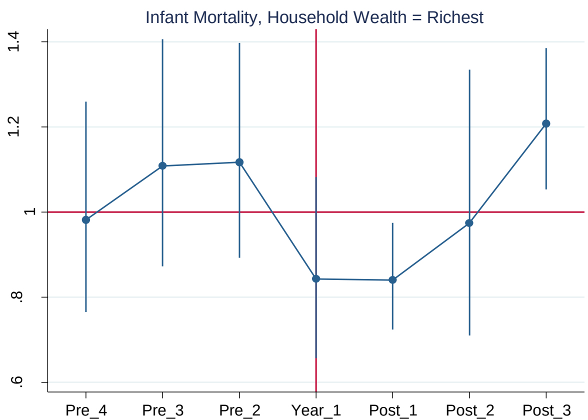


Figure 8



<u>Place of residence (Figures 9-10)</u>

Figure 9

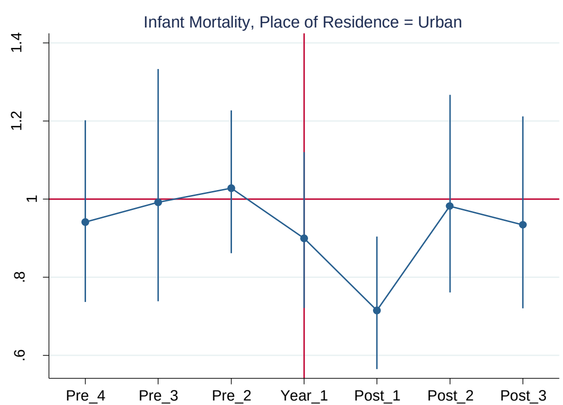
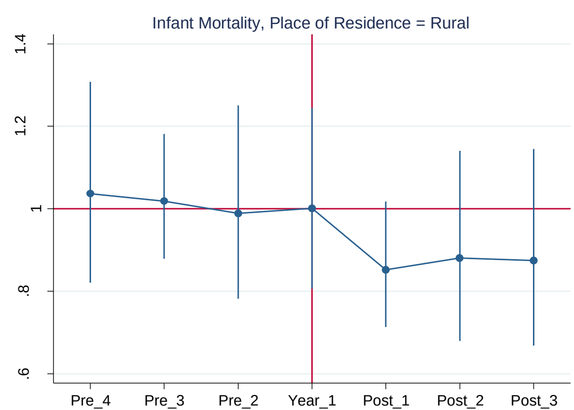


Figure 10



Maternal Education (Figures 11-14)

Figure 11

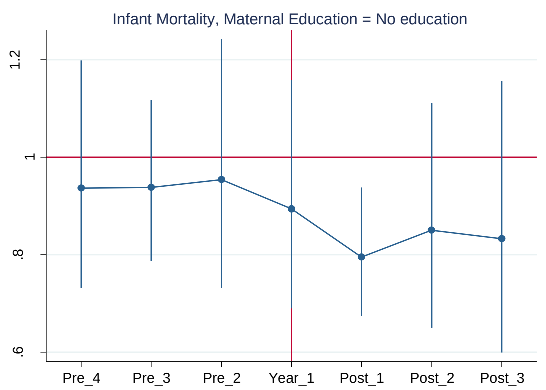


Figure 12

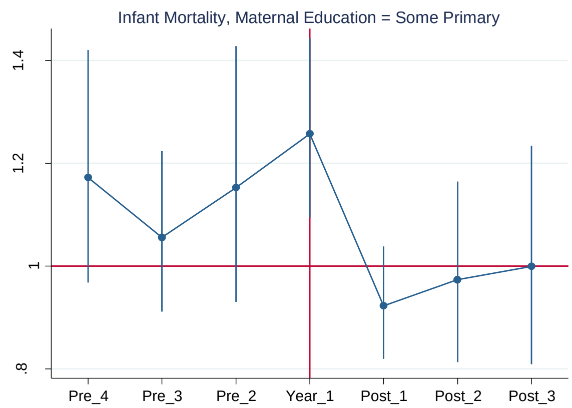


Figure 13

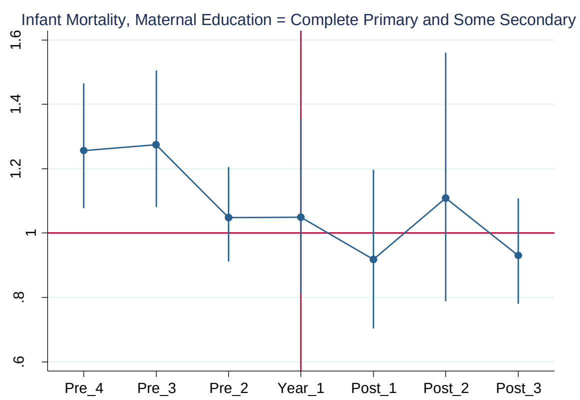


Figure 14

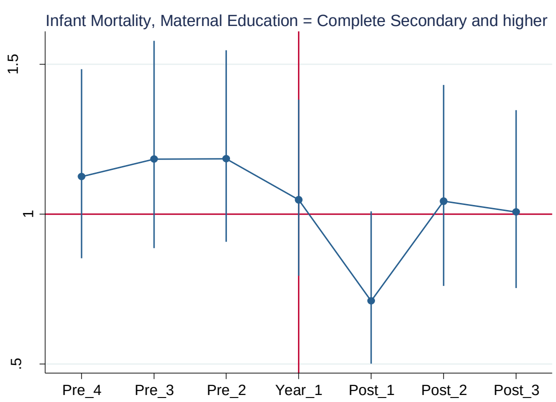


Table 6: Average Effect of Fee Removal Policy on Infant Mortality by Household Wealth, Excluding Neonatal Deaths

	Marginal Effects	95% CI	P - Value
Poorest	-0.010	-0.014 , -0.006	p<0.001
Poor	-0.006	-0.011 , -0.002	p<0.01
Middle	-0.006	-0.013 , -0.000	p<0.05
Rich	-0.004	-0.011 , 0.002	p=0.24
Richest	-0.000	-0.005 , 0.004	p=0.84
Marginal effects obtained from multivariable logistic regression models including an interaction term between fee removal policy and household wealth. Model is adjusted for GDP per capita, development assistance for health (DAH), political stability and government effectiveness; mother's age at birth, child sex, place of residence (rural versus urban) and maternal education. Model also includes year and country fixed effects; district-level fixed effects are included for Zimbabwe. Robust standard errors are clustered at the country-level and district-level for Zimbabwe.			

Table 7: Average Effect of Fee Removal Policy on Infant Mortality by Place of Residence, Excluding Neonatal Deaths

	Marginal Effects	95% CI	P - Value
Urban	-0.003	-0.011 , 0.005	p=0.455
Rural	-0.013	-0.019 , -0.008	p<0.001

Marginal effects obtained from multivariable logistic regression models including an interaction term between fee removal policy and place of residence. Model is adjusted for GDP per capita, development assistance for health (DAH), political stability and government effectiveness; mother's age at birth, child sex, household wealth and maternal education. Model also includes year and country fixed effects; district-level fixed effects are included for Zimbabwe. Robust standard errors are clustered at the country-level and district-level for Zimbabwe.

Table 8: Average Effect of Fee Removal Policy on Infant Mortality by Maternal Education, Excluding Neonatal Deaths

	Marginal Effects	95% CI	P - Value
No Education	-0.007	-0.0105 , -0.0051	p<0.001
Some Primary	-0.005	-0.0102 , -0.000	p=0.052
Complete Primary	-0.004	-0.0111 , 0.0015	p=0.136
Secondary or Higher	-0.001	-0.008, 0.0052	p=0.632

Marginal effects obtained from multivariable logistic regression models including an interaction term between fee removal policy and maternal education. Model is adjusted for GDP per capita, development assistance for health (DAH), political stability and government effectiveness; mother's age at birth, child sex, household wealth and place of residence. Model also includes year and country fixed effects; district-level fixed effects are included for Zimbabwe. Robust standard errors are clustered at the country-level and district-level for Zimbabwe.

Table 9: Average Effect of Fee Removal Policy on Infant Mortality, Excluding Each Treatment Country

Treatment Country	**Excluding Kenya**	**Excluding Burundi**	**Excluding Niger**	**Excluding Sierra Leone**	**Excluding Zimbabwe**	**Excluding Senegal**
Wealth Index						
Poorest	-0.016**	-0.019***	-0.016***	-0.015***	-0.016***	-0.017***
Poor	-0.016***	-0.013*	-0.014**	-0.014**	-0.013**	-0.013**
Middle	-0.014***	-0.007	-0.009	-0.012*	-0.010*	-0.010
Rich	-0.014**	-0.005	-0.008	-0.009	-0.008	-0.009
Richest	-0.005	-0.002	-0.000	-0.003	-0.001	-0.001
Place of Residence						
Urban	-0.007	-0.001	-0.001	-0.001	-0.002	-0.003
Rural	-0.016***	-0.014***	-0.014***	-0.013***	-0.013***	-0.014***
Maternal Education						
No education	-0.014***	-0.014***	-0.013***	-0.013***	-0.013***	-0.014***
Some Primary	-0.013***	-0.007	-0.009**	-0.009**	-0.009**	-0.010*
Complete Primary	-0.016***	-0.002	-0.009	-0.007	-0.007	-0.007
Secondary and above	-0.011	-0.003	-0.008	-0.008	-0.004	-0.003

*p<0.05; **p<0.01; ***p<0.001

Table 9 displays the marginal effects in the change in probability of infant mortality, based on logistic regression models including an interaction of the policy and each socioeconomic indicator. Model is adjusted for GDP per capita, development assistance for health (DAH), political stability and government effectiveness; mother's age at birth, child sex, household wealth and maternal education. Model also includes year and country-fixed effects; district-level fixed effects are included for Zimbabwe. Robust standard errors are clustered at the country-level and district-level for Zimbabwe

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CHAPTER 5: Discussion

This dissertation examined how access to children's health care services is associated with care utilization and child mortality in sub-Saharan Africa. Reduction of child morbidity and mortality are priority goals in the Sustainable Development Goals (SDG) era[1]. Despite substantial improvements in child health worldwide, the burden remains high, particularly in sub-Saharan Africa, which has the highest under-five mortality rate in the world [2]. The leading causes of under-five morbidity and mortality could be prevented and treated through public health interventions, however access to care remains inadequate, and is not reaching those most in need[3].

This dissertation evaluated barriers to accessing care for children under-five by addressing three research questions:

1. Does geographic accessibility or availability of high-quality care matter more for utilization of sick child care in rural areas in Malawi?
2. Do policies to make health care free for children reduce child mortality?
3. Do policies to make health care free for children reduce disparities in child mortality?

Summary of Findings

Chapter 2 of the dissertation (Study 1) examined the role of health service quality and geographic distance on sick child care utilization. This study found that better geographical accessibility (nearer distance to care) and increased availability of quality care was associated with higher odds of utilization of sick child care in rural areas of Malawi. In evaluating the interaction between these two components of access (distance and quality), the effect of higher health service quality on care-seeking decreased as the average distance to health facilities increased -- suggesting that geographic distance to facilities may be the most important influence on sick child care utilization. This study provides new insights into the trade-offs caretakers make when deciding to seek care for their sick child.

The second study of the dissertation (Chapter 3) evaluated the impact of policies removing financial barriers for child health services on child mortality across six countries in sub-Saharan Africa, using a quasi-experimental difference-in-differences design. There is limited research on the impact of removing fees for children's health care on child health outcomes, and this study offers the first multi-country evidence of the success of these policies. Results showed the policy led to a substantial reduction in infant and under-five mortality, adding new evidence to the literature showing that cost is a significant barrier to health care utilization[4-6]. In evaluating the short- and long-run effects of the fee removal policy, results demonstrated significant immediate effects on improved child survival, however the impact was not sustained over time.

The third paper of the dissertation (Chapter 4) examined differential effects of this policy change across groups. I found that policies to make health care free for children significantly narrowed socioeconomic disparities in infant mortality, and the greatest reduction in mortality following policy change was observed among children from the poorest households. Results from this study provide new evidence of the impact of free health care policies, and underscore the importance of implementing financial protections to reduce disparities in child health outcomes.

Cross-cutting Findings from Dissertation

The three papers of this dissertation expand our understanding of how access to care influences child outcomes. Health care access is a complex concept, incorporating both supply- and demand-side components[7,8]. In this dissertation, barriers to utilizing child health services were examined along multiple intersecting components of access: affordability, geographic proximity, and the quality and availability of care[9]. Access was also evaluated through the interaction of individual and household-level socioeconomic determinants – place of residence, wealth, and education – that directly and indirectly affect utilization of services and child health outcomes. The findings presented here highlight two main themes:

1. Access is an ***interplay of interrelated and interdependent constructs*** that interact to influence care utilization and health outcomes.

2. By evaluating ***heterogeneous impacts*** of policy change, we can identify differential effects across sub-groups and assess how policies can ameliorate disparities and increase equity.

1. Evaluating access components as interrelated and interdependent constructs

Many studies in the health services literature have examined access as separate, distinct dimensions[3]. However, to understand how health policies and services can improve child health outcomes, access should be examined as the interplay of these components[10,11].

These constructs can affect one another in cyclical, non-linear ways. For example, quality of care influences the decision to seek care, and patient satisfaction and experience can influence future care-seeking decisions. Similarly, geographic availability can also interact with the quality of care: an individual's willingness to travel for care may depend on their expectations about quality of care and availability of essential care resources.

In Chapter 2 (Study 1) when analyzed independently, geographic distance to and quality of care were significantly associated with care utilization. However, findings from the interaction of these components suggested that distance to care may be the most important influence on care utilization: results showed that the impact of higher quality care on care utilization was attenuated when distance to care increased. This potential trade-off underscores the importance of carefully considering whether investing in improvements in care quality will lead to better health outcomes. Policies focused on just one access component (for example, only improving quality of care) may be insufficient to improve child health care outcomes, particularly when such trade-offs are present.

The cost of services is also a major barrier to receiving health care, but may interact with other access determinants, including the availability of high-quality health services. Prior evidence has shown that removing health care user fees may have unintended consequences on the quality of care delivered[12]. Payments for health services are determined by health care financing policies, which affect the organization and delivery of health care services, as well as the quality of care at facilities. The quality of care also has a direct impact on child health outcomes (mortality). In Chapter 3 (Study 2) the removal of financial barriers to care (user fees) was associated with substantial improvements in child survival; however, results also suggested that the effect of user fee removal on mortality may be diminished over time. Reduced facility revenue from the removal of user fees may limit the ability to purchase key supplies, like drugs, or hire additional staff to handle increased patient volumes[12,13]. If quality of care suffers, health outcomes may not improve; and this may have negative downstream effects on patient demand for care. Policies that fail to view access as a multi-dimensional concept may prevent long-term success of programs[11,14].

The relationship between financial accessibility and health outcomes is also dependent on household socioeconomic characteristics like wealth. Household income affects the ability to pay out-of-pocket for medical care, such as for preventive and curative services, as well as for essential medicines[15,16]. High costs may force individuals from poorer households to forgo or delay treatment, which leads to poor health outcomes; while individuals from wealthier households can afford these costs, and are likely to see better health outcomes as a result[16-18]. In Chapter 4 (Study 3) we found that the impact of user fee removal for children was greatest among those from lower socioeconomic backgrounds, and particularly among the poorest households. By evaluating differential effects of health policies through the interaction of individual-level factors, policy-makers can better understand socioeconomic implications of policies.

2. Evaluating policies at the national-level masks important sub-national disparities and differential effects across sub-groups

Findings across the three studies also underscore the importance of evaluating care utilization and health outcomes at sub-national levels. Disaggregating analyses to evaluate sub-national impacts of health policies and interventions is critical because national averages may hide important sub-national disparities[19,20]. For example, although coverage and utilization of essential child health services has improved in many African countries, within-country inequalities in the use of health care remain[21]. Analyzing outcomes at local geographic levels and by socioeconomic status demonstrates whether interventions have differential effects across population sub-groups, and informs policymakers where to target efforts to reach the populations most in need[22-25].

Geographic proximity to care is an important determine of care utilization and is frequently cited as a main access barrier; however, disparities in under-five outcomes and care coverage may be obscured by geographic aggregation. The rural-urban gap is frequently noted in the literature; and rural residents are more likely to travel long distances for care and have fewer options in choice of health facility [26-29]. Compared to their urban counterparts, rural and remote populations also experience worse access to quality care and have poorer health outcomes[30]. Chapter 2 evaluated outcomes among rural households in Malawi, and findings showed that even among this population sub-group, there was substantial variation in the average distance to the nearest health facility. Households in remote areas may face even greater challenges to obtaining quality services and care from skilled health care workers than rural populations living closer to urban centers[31]. Differentials in socioeconomic inequalities within each sub-group (rural and urban) are also linked to disparities in care utilization, and wealthier individuals are likely to have greater access to quality health care services, including better access to specialized clinical services[32]. The interdependence of these factors is evident here, as socioeconomic status influences and interacts with geographic location and households' health service environment, which also influences households' access to high-quality care services. Research disaggregating geographic and health inequalities between rural and urban populations, as well as within these sub-groups, can better capture underlying disparities. This can also guide efforts to ensure equitable distribution of quality health care services[10].

Evaluating heterogeneous impacts of policies can also highlight differential effects across socioeconomic sub-groups, to determine whether policies are effective in reaching targeted groups. For example, few studies have evaluated whether the effects of user fee removal policies widened or narrowed socioeconomic disparities. Individuals from lower socioeconomic backgrounds generally fare the worst in terms of health intervention coverage and care access, which leads to poor health outcomes. This was evident in Chapter 3 (Study 2), which found that children from rural areas and from the poorest households, as well as those born to mothers with no education, faced the highest risk of child mortality. In Chapter 4 (Study 3) we evaluated differential effects of the policy across key socioeconomic groups, and found that removing financial barriers to care were successful at narrowing disparities in child survival, and this was most pronounced between children from the poorest versus the wealthiest households. We also found that under-five fee removal policies significantly narrowed disparities in infant mortality between children from rural versus urban households – suggesting that removing out-of-pocket payments for care may help to alleviate other indirect costs of accessing care, such as opportunity cost of time, lost wages, and transportation costs[9]. Although policy impacts measured at the national scale, as done in Chapter 3, are critical for evaluating outcomes at the population-level, they can obscure progress made at more granular levels, and within important sub-groups.

In contrast to these findings, evidence from other national-level programs and interventions have shown that some interventions fail at reaching the most vulnerable groups, and may even widen socioeconomic disparities. For example, a review on differential effects of cash transfer programs found overall, interventions showed positive effects among the populations targeted; however more granular evidence showed some programs had larger benefits for higher educated and wealthier groups, rather than for the poorest populations[22]. And research evaluating the impact of national vaccination interventions in Kenya, Ghana, and Cote d'Ivoire found that inequality in immunization coverage persisted over time, and the policy favored the most-socioeconomically advantaged households[23]. These studies also suggest that multisectoral approaches integrating action on social determinants may be needed to fully address inequities in health outcomes[31,33] Interventions that just eliminate financial barriers to care, such as cash transfers, or programs that fail to reach more vulnerable populations, may not succeed if geographic and social environments (e.g., cost of transportation, cultural practices, community sanitation) present barriers that continue to drive inequities in health outcomes[24,34]. This was evident in Chapter 4 (Study 3): despite substantial gains in child survival among the least socio-economically advantaged groups, results showed that disparities remained: the poorest children and those born to mothers with no education continued to experience the highest rates of child death. To close persistent inequality gaps, integrated complementary-level approaches are needed to address other social and economic determinants influencing care utilization and health outcomes.

Future Research

The three studies in this this dissertation highlight several areas for future research. First, there is a need for additional research on facility utilization patterns, as much is still unknown about the trade-offs individuals make when deciding to seek care, and how this may differ by individual characteristics such as education level, geographic location and household income, which have shown to influence health care-seeking behaviors and the perception of health services. Future studies should consider differential utilization outcomes across key social and economic indicators, as well as how policies may differentially influence behavior patterns across socioeconomic groups.

Second, research is needed to better understand how other specific care quality components, such as child-provider clinical interactions, may influence care-seeking decisions and subsequent health outcomes. For example, research suggests that quality of care can be substantially improved when the care provided is client-centered. Negative interpersonal interactions among health care workers may hinder the delivery of high-quality patient care, as well as future utilization of care services[35]. Qualitative evidence on the decision-making process could provide additional insight into the logistical and financial barriers caretakers face, as well as patients' views and perceptions of care and service quality, that may have the most influence on care utilization.

Additionally, there is a need for more research evaluating heterogeneous impacts of policies and interventions across population sub-groups. Despite recent gains in child health outcomes, research shows uneven progress in the reduction of child mortality across regions, as well as substantial heterogeneity in outcomes within countries. By disaggregating policy impacts, researchers can identify groups that experience that greatest barriers to care, to enable equitable distribution of resources.

Conclusion

Findings from this dissertation provide new empirical evidence on the effects of health system policies and strategies to improve child survival in the highest-burden settings. The SDGs explicitly incorporate a focus on the strengthening of service delivery to increase access, coverage, and quality of child health services[36]. Substantial gains in child survival will be possible by expanding access to preventive and curative public health interventions that target the leading causes of under-five morbidity and mortality, and that can reach the most vulnerable populations. Estimates indicate that if every country met the SDG target on under-five mortality, the lives of 10 million children could be saved between now and 2030[37]. To achieve this goal, it is essential that policymakers and decision-makers examine access as the interplay of multiple components when designing policies to ensure a sustained impact on child health outcomes, and to improve equitable access to care.

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