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Facility distance and child mortality: a multi-country study of health facility access, service utilization, and child health outcomes

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Abstract

Background: Access to health facilities remains limited in many resource-poor settings, and women and their children often have to travel far to seek care. However, data on distance are scarce, and it is unclear whether distance is associated with worse child health outcomes. We estimate the relationships between distance to facility, service utilization and child mortality in low- and middle-income countries.

Methods: Population-representative data are pooled from 29 demographic and health surveys across 21 low- and middle-income countries. Multivariable logistic models and meta-analysis regressions are used to estimate associations between facility distance, child mortality, and health care utilization in the pooled sample as well as for each survey.

Results: Compared with children who live within 1 km of a facility, children living within 2 km, 3 km, and 5 km of a facility have a 7.7% [95% confidence interval (CI): 0.927 – 1.251], 16.3% (95% CI: 1.020 – 1.327) and 25% (95% CI: 1.087 – 1.439) higher odds of neonatal mortality, respectively; children living farther than 10 km have a 26.6% (95% CI: 1.108 – 1.445) higher odds of neonatal mortality. Women living farther than 10 km from a facility have a 55.3% lower odds of in-facility delivery compared with women who live within 1 km [odds ratio (OR): 0.447; 95% CI: 0.394 – 0.508].

Conclusions: Even relatively small distances from health facilities are associated with substantial mortality penalties for children. Policies that reduce travel distances and travel times are likely to increase utilization of health services and reduce neonatal mortality.

Key words: Distance, antenatal care, facility delivery, child mortality, service availability

Key Messages

- We overcome two key methodological problems faced by previous studies: (i) measurement error in estimated distances due to incomplete and geo-scrambled location data; and (ii) insufficient sample size to be able to detect mortality outcomes.
- The systematic and standardized collection of distance data across countries allows us to infer the distribution of spatial distances and travel times within and across several low- and middle-income countries.
- Most of the literature has primarily focused on the most remote areas (> 5 km or > 10 km). We show that such distances are rather rare in most countries.
- We are able to show that distance to facilities does not only matter when facilities are far, but also within relatively narrow radiuses—relatively minor factors are likely to have substantial effects on health behaviours.
- We find that reducing distance to facilities may increase health care utilization and, more importantly, improve neonatal survival.

Introduction

Over the past two decades, low- and middle-income countries have made considerable progress towards reducing child mortality.[1] In spite of these achievements, however, nearly 18 000 children under the age of 5 years continue to die every day.[2,3] Many of these deaths might be avoidable if high quality obstetric and medical care was provided to mothers and their children, yet utilization of these services in these settings remains low.[4–6]

A large theoretical and empirical literature has highlighted the importance of geographical determinants for health care-seeking as well as for maternal and child health outcomes.[7–11] Two recent systematic reviews assessed the existing empirical evidence on the link between distance and child survival and found that, although a few studies report a significant relationship between facility distance and child health outcomes, the evidence of the associations between distance and child mortality is both limited and mixed.[12,13]

We think the existing literature suffers from two potential flaws: first, the distances usually contain measurement error by construction; and second, the studies have small sample sizes and low power to detect effects. In the absence of direct measures of facility distance and complete facility data, most of the literature to date has relied on imputing straight-line distances from households to facilities, which are subject to a substantial amount of measurement error,[14] are likely to lead to mismatches between households and facilities and are not able to capture local differences in topography and travel time.[13] Many previous studies also have attempted to estimate distances to facilities by matching household location data from public use surveys, such as the demographic and health surveys (DHS), to facility data without adjusting for the geo-scrambling of the true household locations in these surveys. In DHS surveys, for example, the geo-scrambling of clusters, which serves to protect respondent confidentiality, is carried out using a displacement algorithm by place of residence, in which urban clusters are displaced by up to 2 km and rural clusters are displaced by up to 5 km, with a further, randomly selected 1% of rural clusters being displaced by up to 10 km.[15] This displacement induces significant measurement error in any imputed distances and also biases the estimated effect of distance.[14]

In addition, there is an issue of sample size in reported studies. Whereas health service utilization is reported frequently and is relatively common, child mortality is a relatively rare event and analyses of the relationship between distance and child mortality using small sample sizes are likely to be insufficiently powered. Furthermore, a low absolute number of deaths in small samples can also give rise to a downward bias in estimates of the true effect size.[16]

In this study, we utilize health facility access data that were collected as part of the Service Availability Module in 29 DHS surveys from 21 low- and middle-income countries, and we investigate the relationships between distance to facility, service utilization (receipt of antenatal care and in-facility delivery) and child mortality within and across countries. The Service Availability Module provides, to our knowledge, the first set of population-representative data on both travel time and distance to the nearest health facilities, thereby allowing us to both characterize distances and time to health facilities and estimate the mortality penalty associated with larger distance to facilities in low- and middle income countries. From this module, we extract measures of actual reported distance and travel time from each surveyed cluster to the nearest health facility. This overcomes the measurement issues that arise from estimating straight-line distance measures based on geo-scrambled data. In addition, we report both individual and pooled results from the 29 surveys. The pooled results make use of a large sample size, giving us sufficient power to detect child mortality effects.

Methods

Ethical approval for this project was granted by the Harvard T.H. Chan School of Public Health Institutional Review Board (IRB), Protocol No. IRB13-2746.

Study population

We combine data from 29 DHS surveys with Service Availability Modules that were conducted between 1990 and 2011, resulting in a pooled sample of 124 719 mothers and 126 835 births across 7901 DHS clusters in 21 countries. The DHS surveys are nationally representative cross-sectional surveys that cover a range of health topics.[17] All surveys employ a two-stage cluster sampling design, stratifying by region and urban/rural residence and interviewing about 20 to 30 women aged 15 to 49 per primary sampling unit, each of which generally corresponds to a census enumeration area and which is randomly selected within each stratum. A total of 52 DHS surveys were collected; as described in Supplementary Table A2 (available as Supplementary data at *IJE* online); we excluded 23 surveys because they either did not have information on household wealth (one of the key confounders) or because the Service Availability Module only contained partial information on facility distance. Supplementary Figure A1 (available as Supplementary data at *IJE* online) shows the geographical distribution of the 21 countries that are covered in our sample.

Distance measures

All distance measures were based on data from the Service Availability Module, a special module that was administered at the cluster level as part of the routine DHS surveys. DHS clusters consist of about 20 to 30 households that are randomly selected from sampled census enumeration areas of approximately 1000 individuals.[18] In each cluster, three or four key informants with presumed knowledge about local availability of health services were identified and were jointly interviewed. Typical key informants were community leaders, religious leaders and local health service providers; at least one member had to be female.[19,20] In the interview, the informants were asked to identify the nearest facility of each type from the sampled cluster. For each type of facility, three questions are asked to identify distance and travel time:

1. 'How far in miles/kilometres is the [name of the health facility of interest] located from the centre of this village/community/locality?'
2. 'What is the most common mode of transportation that is used by people in the village/community/locality to go to this facility?'
3. 'How long (minutes/hours) does it take to go to the facility using the most common type of transportation?'

Following the interview, facilities that were mentioned by informants were visited by a DHS enumerator as a means to validate the data that were provided.

We utilise four available distance indicators in the Service Availability Module: (i) distance to the nearest hospital; (ii) distance to the nearest dispensary, doctor or low-tiered clinic; (iii) distance to the nearest mid-level clinic or health centre; and (iv) distance to the nearest maternal and child health centre, district-level clinic or primary health centre. We then calculate the minimum distance to any of these four types of facilities. We measure minimum distance to facility as an interval categorical variable with five categories: less than 1 km to a facility, which is our reference category; between 1 km and 2 km; between 2 km and 3 km; between 3 km and 5 km; between 5 km and 10 km; and greater than 10 km to a facility. We also use travel time categories as robustness checks.

Outcome variables

Our primary outcome of interest is neonatal mortality. We examine neonatal mortality (death within the first 28 days after birth) among all children born who would have been at least 29 days old had they survived to the survey date. We also report results in the Supplementary material (available as Supplementary data at *IJE* online) on additional child mortality measures, including: child mortality (death before age 5 years); post-neonatal infant mortality (death after 28 days but before age 1 year); and post-infant child mortality (death after age 1 but before age 5 years).[2] Details about our analytical sample for these additional mortality results are provided in the Supplementary data, available at *IJE* online. Finally, we analyse receipt of antenatal care and delivery in a health facility as secondary outcomes. A woman was coded to have received appropriate antenatal care for a given birth if she reported receiving at least four visits during pregnancy, which is the minimum number of visits recommended by the World Health Organization.[5]

Statistical analysis

We use multivariable logistic regressions to estimate the associations between distance to the nearest facility and our binary outcomes of interest. Regressions include mother-, child- and cluster-level controls. At the mother level, we control for wealth index of the household (in quintiles), mother's educational attainment group (no education, primary, secondary, higher), birth order, maternal age (in 5-year age groups), marital status and place of residence

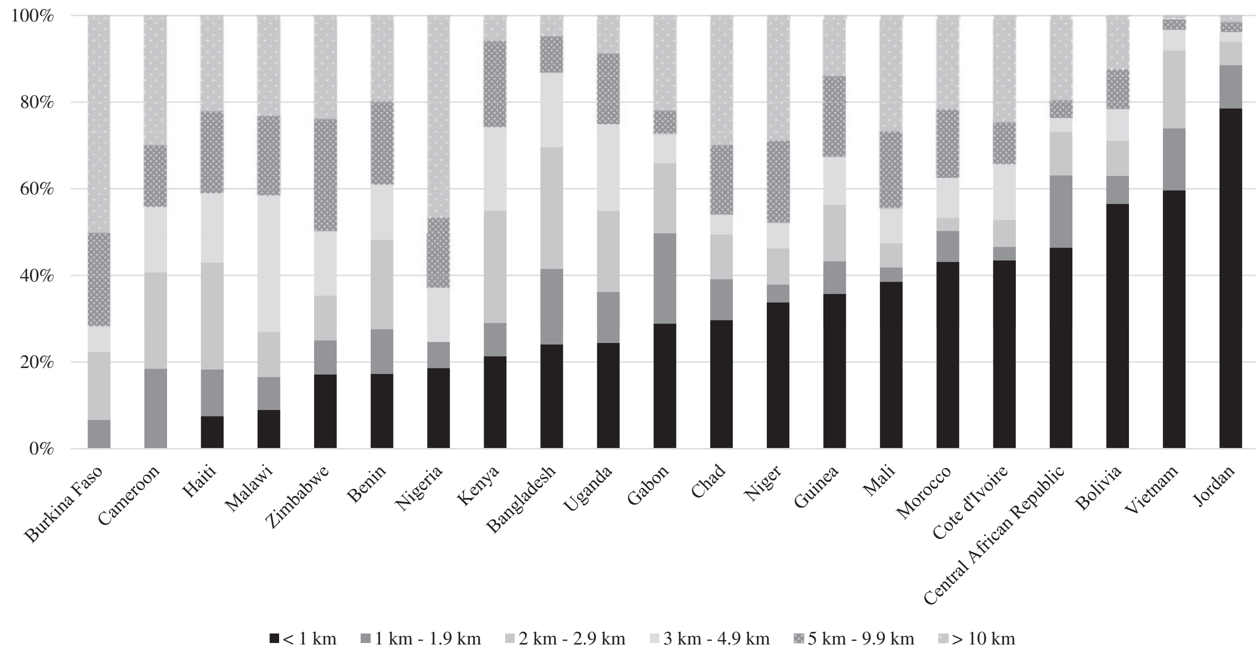

Figure 1. Distribution of distances to the nearest facility by country.

(urban/rural). The neonatal mortality regression also incorporates child-level controls, including the length of time from the child's birth date to the survey date, child sex and whether the birth was a single or multiple birth. To control for spatial differences in socioeconomic characteristics, we include average cluster wealth and average cluster educational attainment. Last, we include survey and year-of-birth fixed effects in all of our models to ensure our results are not affected by country or temporal trends. Standard errors are clustered at the primary sampling unit level to account for the complex DHS survey design. Regression coefficients are interpreted as odds ratios of the outcome which, in the case of rare outcomes such as child mortality, is approximately equal to the relative risk.[21] We conduct regression analyses separately for the full sample and for each survey. All analyses were performed using Stata, version 13.[22]

Results

Figures 1 and 2 respectively summarize the distances and travel times to the nearest facility across the 21 countries. The fraction of children born to households that are farther than 10 km from a health facility is largest in Burkina Faso (50.2%) and lowest in Vietnam (0.9%); similarly, the fraction of children born to households that are farther than 30 min away is highest in Burkina Faso (65.7%) and lowest in Jordan (0.2%). Table 1 describes the distribution of facility distances by DHS cluster and Table 2 describes the distribution of facility distances by birth. Both tables also separately present the distributions of clusters and births by urban and rural place of residence. As Table 2 indicates, 27.9% of children in our pooled sample are born to households that are within 1 km of a health facility, 9.1% are born to households that are within 2 km of a facility, 15.2% are born to households that are within 3 km, 12.1% are born to households that are within 5 km of a facility and 15.3% are born to households that are within 10 km of a facility. The remaining 20.4% of children are born to households that do not have a facility within a 10 km radius.

Tables 3 and 4 presents descriptive statistics for our health care utilization and child mortality outcomes. In our sample, 3.0% of children died in the neonatal stage, 3.4% died at the post-neonatal infant stage and 1.7% died in the post-infant child stage. Slightly less than two out of every five women (39.4%) received at least four antenatal care visits, and 42.6% of births were delivered in a health facility.

Results from the pooled analysis for our primary and secondary outcomes are reported in Table 5, and we plot these coefficients in Figure 3. We find that children who are born to households that are located within 2 km, 3 km and 5 km from a health facility have a 7.7% [95% confidence interval (CI): 0.927 – 1.251], 16.3% (95% CI: 1.020 – 1.327) and 25% (95% CI: 1.087 – 1.439) higher odds of dying in the neonatal period, respectively, when compared with children who are born to households that are within 1 km from a facility. Similarly, increased odds of neonatal mortality were found for children who are born to

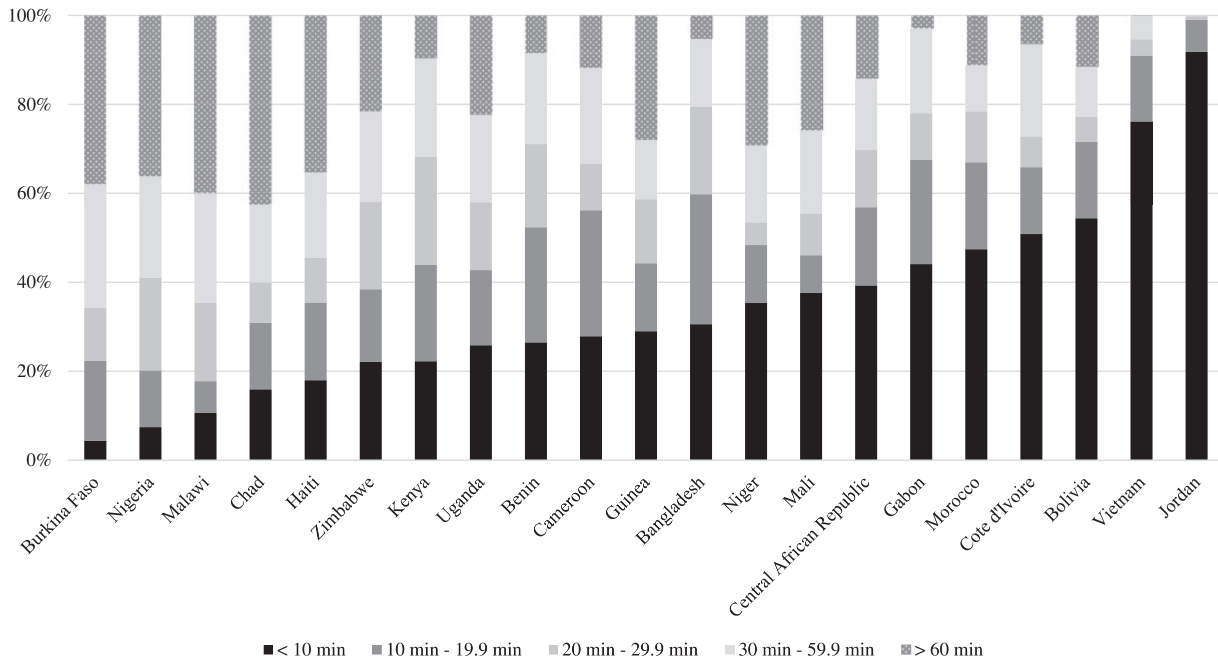

Figure 2. Distribution of times to the nearest facility by country.

Table 1. Descriptive statistics, distance to facility variables by cluster

Distance	Total (mean)	No. of cases	Urban (mean)	Rural (mean)
Distance to facility, < 1 km	0.318	2514	0.538	0.186
Distance to facility, 1-1.9 km	0.111	869	0.169	0.074
Distance to facility, 2-2.9 km	0.170	1340	0.160	0.175
Distance to facility, 3-4.9 km	0.116	915	0.058	0.150
Distance to facility, 5-9.9 km	0.133	1052	0.048	0.185
Distance to facility, > 10 km	0.153	1211	0.027	0.229
N	7901		3346	4555

All distance to facility measures are collected at the DHS cluster level. Each observation corresponds to a cluster.

Table 2. Descriptive statistics, distance to facility variables by birth

Distance	Total Mean	No. of Cases	Urban Mean	Rural Mean
Distance to facility, < 1 km	0.279	35387	0.534	0.177
Distance to facility, 1-1.9 km	0.091	11542	0.160	0.064
Distance to facility, 2-2.9 km	0.152	19279	0.158	0.150
Distance to facility, 3-4.9 km	0.121	15347	0.066	0.143
Distance to facility, 5-9.9 km	0.153	19406	0.050	0.194
Distance to facility, > 10 km	0.204	25874	0.031	0.272
N	126835		42746	84089

All distance to facility measures are collected at the DHS cluster level. Each observation corresponds to a birth.

households within a 5 to 10 km range of a facility [odds ratio (OR): 1.191; 95% CI: 1.042 – 1.363) and to children born in households located farther than 10 km from a facility (OR: 1.266; 95% CI: 1.108 - 1.445).

We find similar results when we use travel time to the nearest facility instead of distance; children born to households that are located more than 60 min from a health facility have a 25.6% (OR: 1.256; 95% CI: 1.105 - 1.429)

Table 3. Descriptive statistics, mother-level outcomes and covariates

	Mean	SD	No. cases
Mother-level outcomes			
WHO Recommended ANC Visits (1 = yes)	0.394		49186
Delivery in a health facility (1 = yes)	0.426		53152
Mother-level covariates			
Wealth, quintiles	2.893	1.392	
Maternal education, none (1 = yes)	0.532		66323
Maternal education, primary (1 = yes)	0.271		33777
Maternal education, secondary (1 = yes)	0.176		21890
Maternal education, higher (1 = yes)	0.022		2727
Maternal age, years	28.214	7.041	
Marital status (1 = married)	0.865		107875
Urban (1 = yes)	0.284		35399
Cluster-level covariates			
Average wealth, quintiles	2.889	1.066	
Average education, highest level	0.682	0.616	
Distance to primary school, km	1.724	4.822	
N	124719		

Each observation corresponds to a mother.
SD, Standard deviation; ANC, antenatal care.

Table 4. Descriptive statistics, child-level outcomes and covariates

	Mean	SD	No. cases
Birth-level outcomes			
Child death (1 = dead)	0.082		10427
Neonatal death (1 = dead)	0.030		3806
Post-neonatal infant death (1 = dead)	0.034		4427
Post-infant child death (1 = dead)	0.017		2189
Birth-level covariates			
Birth order	3.876	2.651	
Multiple birth (1 = yes)	0.027		3383
Child sex (1 = female)	0.494		62705
Time from birth to survey date, months	24.311	16.115	
N	126835		

Each observation corresponds to a child.

higher odds of dying in the neonatal period than children who are born to households that are within 10 min from a health facility.

When compared with women who live less than 1 km from a facility, the odds of receiving at least four antenatal visits for women living more than 10 km from a facility are 38.8% lower (OR = 0.612, 95% CI: 0.559 – 0.671). Similarly, the odds of in-facility delivery are lower at greater distances, with the odds ratio for delivery for women living more than 10 km being 55.3% lower (OR = 0.447; 95% CI: 0.394 – 0.508) relative to women living less than 1 km away. As was the case in the neonatal mortality analysis, we find similar results when using travel time to the nearest facility.

In Figure 4, we plot the estimated effect of distance to facility on the odds of neonatal mortality for each of our 29 surveys. We find that being more than 10 km from a facility increases the odds of neonatal mortality in five surveys. In one survey, in Nigeria in 1990, being farther than 10 km from a facility appears to lower the odds of neonatal mortality, whereas no effect is observed in the remaining 23 surveys. We observe that the confidence intervals on the survey-specific estimates are quite large, and it may be that the lack of significance is a product of small sample sizes rather than a real null effect.

We provide robustness checks and additional results for child mortality at older ages in the Supplementary material (available as Supplementary data at *IJE* online). We show that our results are robust to: (i) using travel time rather than travel distance; (ii) restricting our range of facilities to inpatient facilities only, which include hospitals, mid-level clinics and health centres, maternal and child health centres, district-level clinics and primary health centres; and (iii) controlling for distance to nearest primary school. Our results also confirm that distance appears to have little effect on child mortality after the neonatal period.

Discussion

In this study, we used detailed health access data across 21 countries to show the empirical relationships between facility distance, child health and health service utilization. Our analysis has yielded three main results. First, we find that the majority of children in our sample of low- and middle-income countries live relatively close to a facility; on average, 52.2% of children live within 3 km from a health facility. In contrast to previous studies, we show that living farther than 5 km from a facility is relatively rare in most countries. Given that most of our data are from the 1990s and early 2000s, it is likely that such remoteness has become even rarer with increasing urbanization and global economic development. Whereas we find that longer travel distances are associated with lower health care utilization and higher mortality for children, the fact that most women live relatively close to facilities may reduce the case for making travel distance a policy priority.

Second, the degree of health system access varies remarkably across countries; for example, less than 2% of households live more than 10 km from the nearest facility in Jordan and Vietnam, whereas around half of all

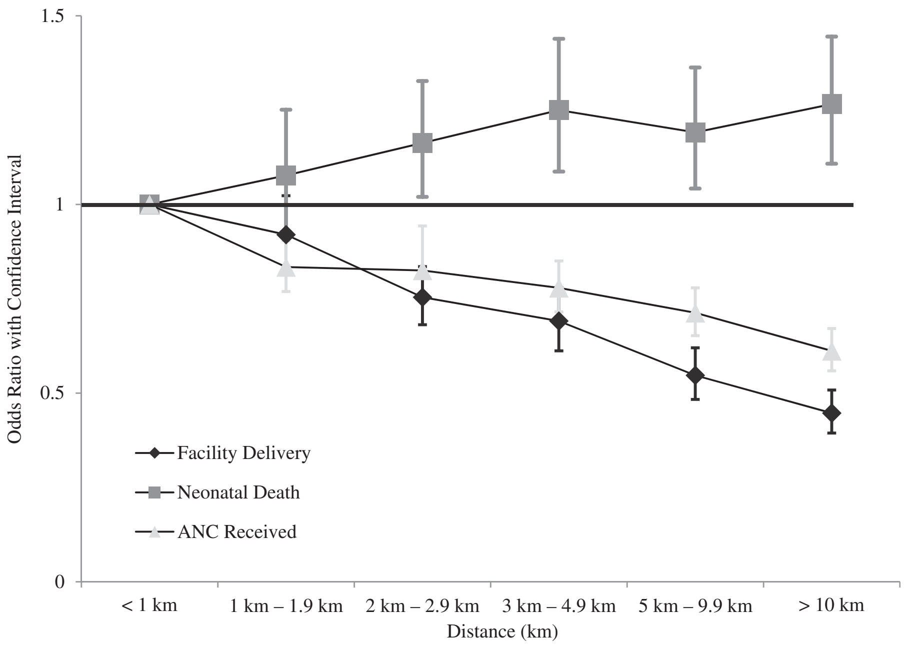

Figure 3. The effect of distance to health facility on antenatal care received, facility delivery and neonatal death: pooled analysis.

The results are based on the logistic regression results that are reported in Table 1. The odds ratios are for each distance category, compared with the reference group of living within 1 km of a facility. The error bars indicate the 95% confidence interval. The horizontal line at 1 represents the odds ratio value under the null hypothesis.

households in Burkina Faso and Nigeria do not have a facility within the same 10 km radius.

Finally, and perhaps most importantly from a health systems perspective, we find that even relatively small distances are associated with sizeable increases in utilization and neonatal mortality. Whereas most of the existing literature has focused on relatively large distances, our results suggest that average health outcomes deteriorate rather quickly with small distance increases. Moreover, we find that the differences in outcomes between households that are located within a moderate distance from a facility and more remote households are relatively small. For example, our findings show that estimates of the distance impact for women and children from households that are within 3 to 5 km from a facility, for both service utilization and child health outcomes are comparable to estimates for households that are located more than 10 km from the nearest facility.

We find a statistically significant effect on neonatal mortality of being 2 km or more from a facility; for longer distances, however, the point estimates of the effect sizes are all very similar and not statistically different from each other. In contrast, we find that the utilization effects seem to be increasing fairly linearly in distance. The point estimates for the effect of distance on mortality are similar above 2 km, but the confidence intervals are quite wide due to the fact that mortality, unlike utilization, is a fairly rare outcome. Indeed, in Figure 3, it would be possible to draw a linearly increasing relationship, between distance and the odds ratio of neonatal mortality, that remained within our confidence intervals of the estimated effect. It follows that although a reasonable interpretation of our results is that there is a cutoff in the effect of distance on mortality around the 2 km mark, our findings are also consistent with the possibility of a continuing effect on mortality as distance rises.

A 'gold standard' measure of distance would completely reflect the travel burden between locations.[23] We believe that our reported distance measures from the Service Availability Module more accurately quantify the difficulty of travelling to health facilities than previous approaches to estimating distance. Moreover, the spatial and temporal distance data from the Service Availability Module allow us to compare different metrics of distance and travel time to health services against each other. Relative to previous studies, our pooled approach gives us a much larger sample size and the statistical power to estimate how both health care utilization and neonatal mortality vary with distance.

Taken together, our results suggest that although average distances to health facilities in low- and middle-income countries are likely to be smaller than what is commonly perceived, improving access to facilities may still play a considerable role in further improving child health outcomes. One approach to reducing travel distances would be to build more facilities; however, having a large number of facilities, each with a low caseload, may increase costs and could lower

Table 5. The effect of distance and travel time to a health facility on neonatal death, receipt of antenatal care and facility delivery: pooled analysis

Variables	(1) Neonatal death	(2) Four ANC visits	(3) Facility delivery
Distance			
Reference Category: < 1 km			
Distance to facility: 1 km-1.9 km	1.077	0.834***	0.920
	(0.927-1.251)	(0.769-0.904)	(0.828-1.023)
Distance to facility: 2 km-2.9 km	1.163**	0.825***	0.754***
	(1.020-1.327)	(0.767-0.887)	(0.681-0.835)
Distance to facility: 3 km-4.9 km	1.250***	0.779***	0.691***
	(1.087-1.439)	(0.715-0.850)	(0.612-0.779)
Distance to facility: 5 km-9.9 km	1.191**	0.713***	0.547***
	(1.042-1.363)	(0.652-0.779)	(0.483-0.620)
Distance to facility: > 10 km	1.266***	0.612***	0.447***
	(1.108-1.445)	(0.559-0.671)	(0.394-0.508)
Time			
Reference Category: < 10 min			
Time to facility: 10 min-19.9 min	1.074	0.872***	0.794***
	(0.952-1.212)	(0.814-0.933)	(0.722-0.873)
Time to facility: 20 min-29.9 min	1.157**	0.807***	0.732***
	(1.015-1.319)	(0.745-0.874)	(0.659-0.814)
Time to facility: 30 min-59.9 min	1.223***	0.748***	0.602***
	(1.078-1.389)	(0.692-0.809)	(0.538-0.674)
Time to facility: > 60 min	1.256***	0.688***	0.477***
	(1.105-1.429)	(0.627-0.753)	(0.419-0.543)
N observations	125167	124719	124719

For column 1, the unit of observation is a birth. For columns 2 and 3, the unit of observation is a mother giving birth. The top half of the reports results when using categorical distance to the nearest health facility as the key exposure variable of interest, and the bottom half of the table reports results when using categorical time to the nearest health facility as the key exposure variable of interest. Odds ratios are presented with 95% confidence intervals in the parentheses below. Neonatal death (column 1) is defined as death between 0 and 28 days of age. Four ANC visits (column 2) reports whether the mother received at least four ANC visits for the birth. Delivery in a facility (column 3) reports whether the mother delivered the birth in a health facility or not. Distance (time) to facility is distance (time) from the cluster to the nearest health facility. Results are from logistic regressions that include cluster-, mother- and child-level controls. Cluster-level covariates are the average wealth index value of mothers in the cluster and the average educational attainment of mothers in the cluster. Mother-level controls are the household wealth index (in quintiles), educational attainment of the mother (no education, primary, secondary, higher), birth order, age of the mother (in 5-year age groups), mother's marital status and mother's place of residence (urban/rural). Child-level controls in the neonatal death regression include the length of time from the date of the child's birth to the survey date, the sex of the child and whether the birth was a single or multiple birth. Survey and year-of-birth fixed effects are included, and standard errors are clustered at the primary sampling unit level.

***P < 0.01; ** P < 0.05; *** P < 0.1.

the quality of service provision. Improving access to transport would not affect the distance required to travel but can have benefits through reducing travel times. We identify distance and travel times as a barrier, but additional research is required to establish the relative cost effectiveness of different policies that aim to address this issue.

There are several limitations to our study. The only health outcome that we evaluate is child (and more specifically neonatal) mortality. However, access to care is likely to affect child morbidity as well,[24] which we do not capture. We argue that the distances reported in the Service Availability Moduleare more reliable than straight-line distances estimated from scrambled coordinate data; however, the Service Availability Module data may have errors. Distances and travel times reported by the community may be subject to measurement error and reporting bias. The survey protocol is for enumerators to validate reported distances and travel times through visits to facilities, but a study of the Service Availability Module found that these facility follow-up visits were not always carried out.[19] In addition, the Service Availability Module does not contain any data on the quality of services that are received, which is likely to affect both service utilization and mortality outcomes.[24–26] For example, distances to rural facilities are, on average, farther than distances to urban facilities, but rural facilities may also have different levels of service provision. We control for urban versus rural place of residence in our regressions, but controlling for direct measures of the quality of facility services would be preferable. The same concern holds for other spatial

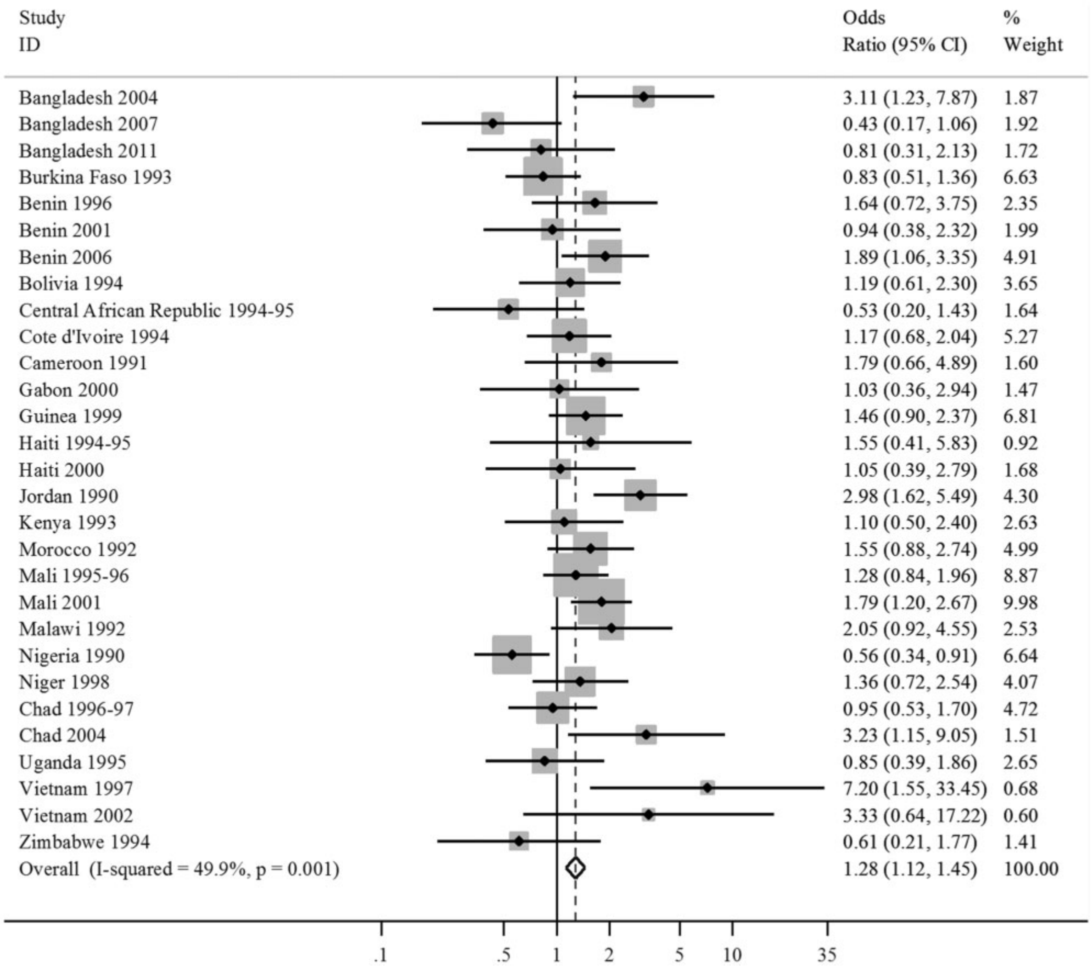

Figure 4. The effect of distance to health facility on neonatal death: survey-specific analysis.

We report odds ratios for those who live farther than 10 km when compared with the reference group who are within 1 km of a facility. In some surveys, there was no reported cluster that was farther than 10 km from the nearest facility, so the next maximum categorical distance from the facility was plotted instead. These surveys (with their maximum categorical distances in parentheses) are: Bangladesh 2004 (5 -9.9 km); Burkina Faso 1993 (5-9.9 km); Cameroon 1991 (-9.9 km); Vietnam 1997 (3-4.9 km); and Vietnam 2002 (3-4.9 km). The results are based on survey-specific logistic regression with the same set of covariates as described in Table 1. The square gives the estimated odds ratio and the error bars give the 95% confidence interval. The solid vertical line at 1 represents the odds ratio value under the null hypothesis.

confounders—even though we control for some household- and cluster-level covariates, it is possible that distance to other infrastructure types may be correlated with health facility access and will therefore confound the results. Although we show that controlling for school access does not affect our main results in one of our robustness checks, residual confounding cannot be fully excluded.

The DHS wealth index quintiles are a measure of relative wealth of the household within each country. Our use of survey fixed effects implicitly adjusts for any factors, such as average national income per capita, that are the same for all households within the same survey. It would be preferable to construct wealth measures that were directly comparable across countries; however, such procedures are difficult conceptually and because different surveys measure different household assets.[27]

These measurement problems, and the possibility that they are confounders in our observational study, imply that we must be circumspect about drawing policy conclusions from our results. Direct evidence from policy interventions or experiments would be required to overcome these concerns.

Conclusions

Our findings suggest that health facility distance is a key predictor of health service utilization as well as neonatal mortality. Policies and programmes that improve access in more remote areas through, for example, increasing the number of facilities or reducing travel times through increased access to transport, are likely not only to yield substantial increases in the coverage rates of critical public health interventions, but also may substantially contribute to further reductions in under-5 mortality.

Supplementary Data

Supplementary data are available at *IJE* online.

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Author contributions

M.K. was responsible for conducting the main statistical analysis, conducting the literature review, drafting and reviewing the main text and coordinating review among authors; G.F. contributed substantially to the analysis of the data and write-up of the manuscript; and D.C. contributed substantially to the conceptual development of the paper, assisted with the review of the manuscript and supervised the finalization of the results. All named authors contributed to the overall conceptualization, analysis, writing and finalization of the paper.

Conflict of interest: None.

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