Proximity to health services and child survival in low- and middle-income countries: a systematic review and meta-analysis

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ABSTRACT

Objectives: Few studies have systematically examined the effects of barriers such as distance to health facilities on child survival in low- and middle-income countries. Our primary objective was to estimate the effect of proximity to health facilities on child survival in low- and middle-income countries. The secondary objective was to compare effects in different age categories (perinatal (28 weeks of gestation to 1 week of age), neonatal (0–27 days), infant (0–11 months) and child (0–59 months) mortality).

Design: A systematic review and meta-analysis was conducted of studies published from 1980 to 2012 that assessed the effect of proximity to health facilities on child survival in low- and middle-income countries. Synthesis was by random-effects meta-analysis, and variation between studies was investigated by meta-regression.

Setting: Low- and middle-income countries.

Participants: 13 studies were included in the meta-analysis, 11 from low-income and two from middle-income countries and none were from remote areas.

Primary outcome measures: The primary outcome measures of interest were perinatal, neonatal, infant and child mortality.

Results: Overall, children who lived farthest from health facilities were more likely to die compared with those who lived closer (OR 1.32, 95% CI 1.19 to 1.47). This effect appeared stronger during the perinatal (OR 2.76, 95% CI 1.80 to 4.24) and neonatal (OR 1.98, 95% CI 1.43 to 2.72) periods compared with the infant (OR 1.18, 95% CI 1.0 to 1.38) and under-5 (OR 1.20, 95% CI 1.04 to 1.39) periods.

Conclusions: Proximity to health facilities appears to be an important determinant of under-5 mortality in low- and middle-income countries, especially in the perinatal and neonatal periods. Higher quality studies are needed, which examine the effect of access to health services on child survival, especially studies from remote areas and hard to reach populations.

ARTICLE SUMMARY

Article focus
- Only one previous study has reviewed the relationship between access to healthcare and under-5 mortality. This study did not attempt to pool data or perform a meta-analysis.
- This is the first meta-analysis that has reported associations between proximity to health services and child survival in low- and middle-income countries. We also assessed publication bias and quality of included studies.

Key messages
- Only a limited number of studies fulfilled our inclusion criteria. However, proximity to health services did appear to have a significant effect on child survival. This effect was stronger in perinatal and neonatal periods compared with infant and under-5 periods.
- The effect of proximity to health services did not appear to differ by region (Africa vs Asia) or by vaccine coverage at the country level.

Strengths and limitations of the study
- The strengths of the study include the detailed search strategy to find all eligible articles, the detailed investigations into sources of heterogeneity.
- Only a limited number of studies fulfilled our inclusion criteria, thus we were unable to perform a multivariable meta-regression analysis. However, we were able to perform detailed univariable analyses and assess the effect of important explanatory variables.

INTRODUCTION

Each day more than 20 000 children under the age of 5 die globally.[1] Nearly all of these deaths take place in low- and middle-income countries,[2] and most could be prevented with interventions delivered through health facilities.[3]

There have been many studies that have investigated socio-demographic determinants, use of child health services and child

mortality in low- and middle-income countries.[4] [5] However, there have been few studies that have examined the barriers to accessing health services, such as distance to health facilities in low- and middle-income countries. There is also little information from remote locations or the poorest countries with low gross national income per capita (GNI).

Important effects of proximity to health services on maternal health outcomes have been described in a number of systematic reviews.[6–8] However, only one study has reviewed the relationship between access to healthcare and under-5 mortality.[9] This study described traditional (distance to health services and cost of healthcare access) and non-traditional (social networks, time availability and female autonomy) measures but did not attempt to pool data or perform a meta-analysis. This study also did not assess the effect of health system barriers, such as GNI or rural and remote location. There also has been no systematic review of the effect of proximity to child health services on mortality in specific age categories. These data are needed to plan child health systems in hard to reach poor communities in low- and middle-income countries.

Thus, our primary objective was to estimate the effect of proximity to health facilities on child survival in low- and middle-income countries. The secondary objective was to compare effects in different age categories

(perinatal (28 weeks of gestation to 1 week of age), neonatal (0–27 days), infant (0–11 months), child (0–59 months) mortality).

METHODS

This study was conducted using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses) guidelines.[10]

Inclusion criteria

All studies (longitudinal/cohort, case–control and cross-sectional) that examined the associations between distance to health services and child mortality were reviewed. There were no language restrictions. Studies were excluded if they did not report on: original data (eg, editorials, reviews); all-cause child mortality (eg, studies that only reported on cause-specific mortality were excluded); children under the age of 5; an effect size (eg, OR, RR, HR) of the association between proximity to health facilities and child mortality; and if they were conducted in a high-income country. Studies were excluded from the meta-analysis if they did not include a multivariable analysis and if they did not specify the exact age at death (eg, perinatal mortality, neonatal mortality, infant mortality and under-5 mortality).

Figure 1 Flow diagram of search strategy.
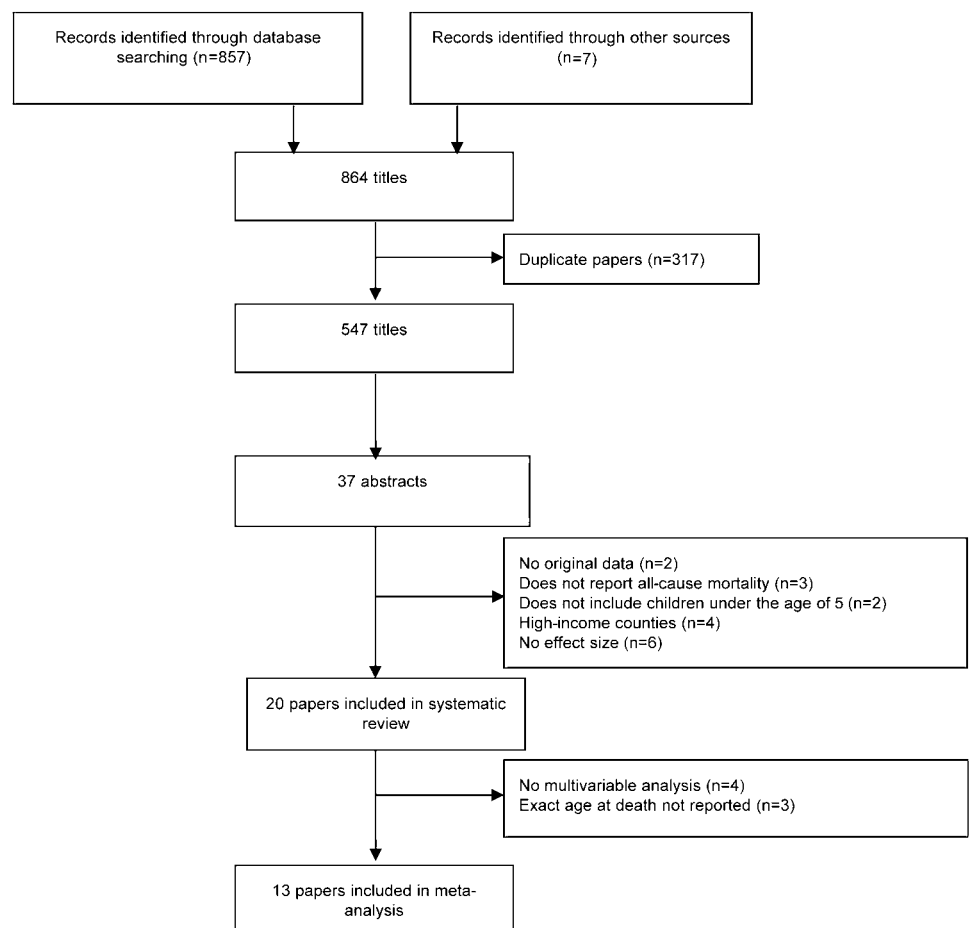
Search strategy

We searched PubMed, Embase, Medline, Global Health, Cab Abstract, Web of Science and Africa Wide Information to identify studies. The search was limited to literature published between the years 1980 and 2012. We also reviewed the reference lists of all eligible studies.

The initial search aimed to be as inclusive as possible using search terms: ([newborn* OR babies OR infant* OR perinat* OR neonat* OR postneonat* pre-school OR child* OR under-five] AND [death* OR dead OR died OR mortalit* OR surviv*] AND [distance OR travel time OR geographi*] and [Access OR barrier] [Subheading] Limits: Human, 01 01 1980−02 01 2012]).

All titles and abstracts were reviewed independently by two reviewers. Papers likely to contain information on proximity to health services and child survival were then examined (figure 1). Studies were then appraised for methodological quality using an adaptation of the Downs and Black scoring system.[11]

Data extraction

The following information was extracted from every eligible study: key identifiers (author, publication year, title, country of origin), study characteristics (aim, research setting, target population, sample size), study methods (design, exposures, outcomes, variables included in multivariable analyses) and results (effect size (OR, HR, RR) 95% CI, SE).

We also collected data on potential explanatory variables, that is, variables that may explain variance in effect size. For each study, categories for explanatory variables were created after an initial review of the data as follows: age at death (perinatal, neonatal, infant, under-5), study design (prospective, retrospective), type of access measure (distance from health facility in kilometres (<5 km, ≥5 km), travel time in hours (<0.5 h, ≥0.5 h)). Access measures were also categorised as under-representative, representative and over-representative. For example, if a study categorised a distance measure as <5 km versus ≥5 km, it was classified as representative, and if a study categorised a distance measure as <3 km versus ≥3 km, it was classified as under-representative. Study location (rural non-remote, rural remote, urban) was categorised using the Accessibility/Remoteness Index of Australia (ARIA) rural remote index.[12] We also used data obtained from the 2010 WHO[13] and World Bank data sets[14] to divide countries into WHO region (African, South East Asian, Western Pacific, Eastern Mediterranean, European and American regions) and GNI band in $US per capita (low income, low middle income, high middle income, high income). There were no data available from the papers on the quality of the health centres or system, thus we decided to use the WHO/Unicef 2010 measles vaccine coverage data (<80%, ≥80%)[11] to provide an indication of health system functioning for children younger than 5 years.

Table 1 Characteristics of studies included in the meta-analysis, 1980−2012

	Perinatal (n=2)	Neonatal (n=2)	Infant (n=4)	Under-5 (n=5)	Total (n=13)
Study design					
Prospective	–	2 (100%)	2 (50%)	2 (40%)	6 (46%)
Retrospective	2 (100%)	–	2 (50%)	3 (60%)	7 (54%)
Access measure					
Distance (km/m)	2 (100%)	2 (100%)	4 (100%)	3 (60%)	11 (85%)
Travel time (h/min)	–	–	–	2 (40%)	2 (15%)
Access category					
Under representative	–	1 (50%)	1 (25%)	2 (40%)	4 (31%)
Representative	2 (100%)	1 (50%)	2 (50%)	3 (60%)	8 (62%)
Over representative	–	–	1 (25%)	–	1 (7%)
Gross national income					
Low income	1 (50%)	1 (50%)	4 (100%)	5 (100%)	11 (84%)
Lower middle income	1 (50%)	1 (50%)	–	–	2 (16%)
Upper middle income	–	–	–	–	–
Vaccine coverage (measles)					
<80%	2 (100%)	1 (50%)	2 (50%)	1 (20%)	6 (46%)
≥80%	–	1 (50%)	2 (50%)	4 (80%)	7 (54%)
Study location					
Rural remote	–	–	–	–	–
Rural non-remote	2 (100%)	2 (100%)	4 (100%)	5 (100%)	13 (100%)
Urban	–	–	–	–	–
Region					
African	1 (50%)	1 (50%)	3 (80%)	5 (100%)	10 (76%)
Asian	1 (50%)	1 (50%)	1 (20%)	–	3 (24%)

Table 2 Details of studies included in meta-analysis of the association of distance to health facilities and child mortality, 1980–2012

First author	Study design	Country and year of publication	Years of data collection	Sample size	Number of deaths	Outcomes	Exposure (comparison groups)	Results
Included in meta-analysis								
Akello[17]	Case–control	Uganda, 2008	2006	180	60	Perinatal mortality	Distance from maternity centre (<5 km, 6–20 km)	OR =3.89 (1.96 to 7.74)
Becher[18]	Longitudinal	Burkina Faso, 2004	1999	10 122	1340	Infant mortality	Distance from health centre (<10 km, ≥10 km)	RR =1.33 (1.13 to 1.57)
Broeck[19]	Cohort	DR Congo, 1996	1989	776	57	Children who died between 0—<3 months	Distance from dispensary (<5 km, ≥5 km)	RR =1.6 (0.9 to 12.9)
Daga[20]	Cohort	India, 1993	1987	5200	–	Perinatal mortality	Distance from health centre (<5 km, ≥5 km)	OR =2.4 (1.78 to 13.32)
Diallo[21]	Cohort	Burkina Faso, 2011	2006–2007	864	40	Neonatal mortality	Distance from the health facility (<5 km, ≥5 km)	OR =2.1 (0.9 to 14.8)
Magnani[22]	Cross–sectional	Niger, 1996	1986	2075	443	Under-5 mortality	Distance from dispensary (<5 km ≥5 km)	OR =0.68 (0.49 to 0.94)
Malqvist[23]	Case–control	Viet Nam, 2010	2009	11 708	197	Neonatal mortality	Children living in remote area	OR=1.96 (1.40 to 12.75)
Moisi[24]	Longitudinal	Kenya, 2010	2003–2006	93 216	1599 under-5 and 1125 under-1	Infant and under-5 mortality	Travel time as continuous variable	HR =0.99 (0.095 to 1104) for under-5, HR = 0.98 (0.95 to 1.02) for infants
Mtango[25]	Case–control	Tanzania, 1992	1987	1160	610	Under-5 mortality	Distance from dispensary (<2 km ≥2 km)	OR =2.30 (1.53 to 13.45)
Paul[26]	Cross-sectional	Bangladesh 1991	1984	3781	149	Infant mortality	Distance from qualified physician (<2 miles, ≥2 miles)	OR =1.15 (0.90 to 11.18)
Rutherford[27]	Case–control	Gambia, 2009	2006	840	140	Under-5 mortality	Distance from health centre (<3 km, ≥3 km)	OR =1.80 (0.59 to 5.56)
Schellenberg[28]	Cross-sectional	Tanzania, 2008	2004	1414	559	Infant mortality	Distance from the health facility (<5 km, ≥5 km)	RR= 1.25, CI (1.0 to 1.5)
Shoeps[29]	Longitudinal	Burkina Faso, 2011	2007	24 555	3426	Infant and under-5 mortality	(Travel time as continuous variable)	HR= 1.12 (1.07 to 1.17)
Excluded from meta-analysis								
Adair[30]	Cross-sectional	Indonesia, 2011	2009	–	–	Infant and under-5 mortality	Travel time to health facility (<30 min, ≥30 min)	Descriptive
Ahonsi[31]	Cross-sectional	Nigeria, 1981–1986	1981–1986	3249	261	Neonatal and infant mortality	Distance to a maternity centre (<5 km, ≥5 km)	Descriptive
Byass[32]	Longitudinal	Ethiopia, 1987–2005	1987–2005	1884	122 infant death	Under-5 mortality	Distance from health centre (<5 km, ≥5 km)	HR =1.27 (0.87 to 1.84)

Continued

Table 2 Continued

First author	Study design	Country and year of publication	Years of data collection	Sample size	Number of deaths	Outcomes	Exposure (comparison groups)	Results
Ombok[33]	Longitudinal	Kenya, 2008	2002–2006	54 057	4194	Infant mortality	Distance from the health facility (<2.2 km, ≥2.2 km)	Descriptive
Sankoh[34]	Longitudinal	Burkina Faso, 2001	1993–1998	29 463	1031	Under-5 mortality	Children living > average distance from the village to health centre	Descriptive
Sartorius[35]	Longitudinal	South Africa	1992–2006	31 804	737	Infant mortality	Distance from the health facility (<5 km, ≥5 km)	IRR=1.18, p=0.607
Sartorius[36]	Longitudinal	South Africa	1992–2007	46 675	565	Under-5 mortality	Distance from the health facility (<5 km, ≥5 km)	Descriptive

We also planned to divide studies according to the type of care provided in the health facilities (eg, preventive care, acute care, emergency services). However, the health facilities were not described in sufficient detail. Where data were reported for multiple time periods, the most recent data were used.

Statistical analysis

Our initial review indicated that effect sizes were heterogeneous and influenced by age at death. Thus, we decided to present risks stratified into four mortality categories (perinatal, neonatal, infant, under-5) and to use random-effects meta-analytic techniques to estimate pooled ORs within these strata. Mortality is a rare outcome, thus HRs and RRs were considered to approximate ORs in all studies.

Meta-regression analytic techniques were used to investigate the effect of age at death and other explanatory variables on the pooled estimates. Crude ORs and 95% CIs were calculated.[15] We planned to perform multivariable meta-regression analyses, but final models could not be constructed because the number of studies was too small. The risk of publication bias was assessed using Egger's test.[16] Statistical analyses were performed using STATA Release 12 statistical software (Stata, College Station).

RESULTS
Search results

We identified 864 studies published between 1 January 1980 to 1 February 2012 (figure 1). Eight hundred and fifty-seven were obtained from the database sources and seven were obtained from other sources (two were from reference lists and five from other sources). Five hundred and forty-seven studies remained after removing duplicates. The titles of these studies were all reviewed and 510 did not meet the inclusion criteria. Thirty-seven abstracts were reviewed, but only 20 papers were considered eligible for inclusion in our systematic review (figure 1). Thirteen studies were included in the meta-analysis. Characteristics of the 13 included studies are presented in table 1, and full details can be found in tables 2 and 3. Overall, 152 645 children were included (median number of children per study =2015, IQR 180−93 216) and 9748 died. One study was conducted in the Western Pacific region (Vietnam), two studies were conducted in the South East Asian region (Bangladesh and India) and the remaining 10 were conducted in the African region (Gambia, Kenya, Tanzania, Uganda, Niger, Nigeria, and DR Congo). Seven studies reported data on under-5 mortality,[22 24 25 27 29 30 37] 10 examined infant mortality,[19 24 26 28−31 33 35 37] six examined neonatal and perinatal mortality.[17 20 21 23 31 32] Three studies reported more than one type of mortality outcome.

Results of the quality assessment are displayed in figure 2. Full details can be found in tables S1 and S2 in the supplementary information. Overall, the proportion of studies meeting each quality assessment criteria

Table 3 Effect of explanatory variables on the association between proximity to health facilities and child survival

	Studies	Participants (total No. of children)	Subgroup estimates; OR (95% CI)	Univariable regression, OR (95% CI)	p
Age category					
Under-5	5	121 846	1.20 (1.04 to 1.39)	1	0.045
Infant	4	16 093	1.18 (1.00 to 1.38)	0.89 (0.56 to 1.42)	
Neonatal	2	12 572	1.98 (0.95 to 1.49)	1.50 (0.75 to 2.98)	
Perinatal	2	2134	2.76 (1.80 to 4.24)	2.12 (1.11 to 4.02)	
Study design					
Prospective	6	132 744	1.22 (1.07 to 1.40)	1	0.249
Retrospective	7	19 901	1.69 (1.19 to 2.41)	1.22 (0.73 to 2.05)	
Access measure					
Distance (km)	11	34 874	1.65 (1.32 to 2.06)	1	0.051
Travel time (h)	2	117 771	1.05 (0.93 to 1.19)	0.63 (0.36 to 1.11)	
Access category					
Under-representative	4	17 489	1.23 (0.86 to 1.77)	1	0.896
Representative	8	125 034	1.39 (1.20 to 1.61)	1.27 (0.69 to 2.32)	
Over-representative	1	10 122	1.33 (1.13 to 1.57)	1.06 (0.38 to 2.96)	
Region					
African	11	135 202	1.22 (1.10 to 1.35)	1	0.518
Asian	2	17 443	1.55 (0.79 to 3.01)	1.1 (0.59 to 1.97)	
Study location					
Rural remote	–	–	–	–	
Rural non-remote	13	152 645	–	–	
Urban	–	–	–	–	
Gross national income					
Low income	11	138 983	1.27 (1.12 to 1.45)	1	0.069
Lower-middle income	2	13 662	2.19 (1.74 to 2.76)	1.57 (0.83 to 2.94)	
Upper middle income	–	–	–	–	
Measles vaccine coverage					
<80%	6	38 451	1.71 (1.26 to 2.31)	1	0.418
≥80%	7	114 194	1.35 (1.04 to 1.75)	1.25 (0.76 to 2.15)	

ranged from 5% to 100%. Most studies had clear objectives, documented selection criteria, provided a representative sample, defined the exposure/characteristics of participants under study and used appropriate statistical tests. However, some studies did not meet a number of other quality assessment criteria. Forty per cent reported a sample size calculation and only a third described potential selection bias. Fifty per cent described potential confounders and only a third adjusted for these potential confounders. Also, only 5% reported losses to follow-up, and only one made any adjustments for them in the analysis. Also, to assess whether any publication bias was likely, we performed funnel plots of the log OR against SE and a clear correlation was found (p≤0.0001).

Mortality estimates
Overall, proximity to health facilities appeared to have a significant effect on child survival (pooled OR 1.31, 95% CI 1.17 to 1.45) in the pooled 13 studies (figure 3). However, there was substantial heterogeneity between studies (p≤0.0001, I^2=89.1%). The stratified analyses indicated that there was a strong effect of proximity to health services on perinatal (summary OR 2.76, 95% CI

1.80 to 4.24) and neonatal mortality (summary OR 1.98, 95% CI 1.43 to 2.72) and no between-study heterogeneity (figure 3). Weak associations were detected for infant (summary OR 1.18, 95% CI 1.00 to 1.38) and under-5 mortality (summary OR 1.20, 95% CI 1.04 to 1.39), with substantial between-study heterogeneity (p≤0.0001; I^2 =88.0%) (figure 3).

Explanatory factors
Table 3 shows the results from the crude and adjusted meta-regression analysis of the effect of important factors (age category, study design, access measures, GNI, region, vaccine coverage) that were likely to predict variation in the effect size in the studies. The only factor that was significantly predictive was age at death. The effect of proximity to health services on mortality was significantly stronger during the perinatal period compared with the under-5 period (OR 2.12, 95% CI 1.11 to 4.02); effects also appeared important in the neonatal period; however, this result was not statistically significant (OR 1.50, 95% CI 0.75 to 2.98).

The effect of proximity to health services also appeared stronger in studies from countries with higher GNI (OR) and in countries with higher vaccine coverage
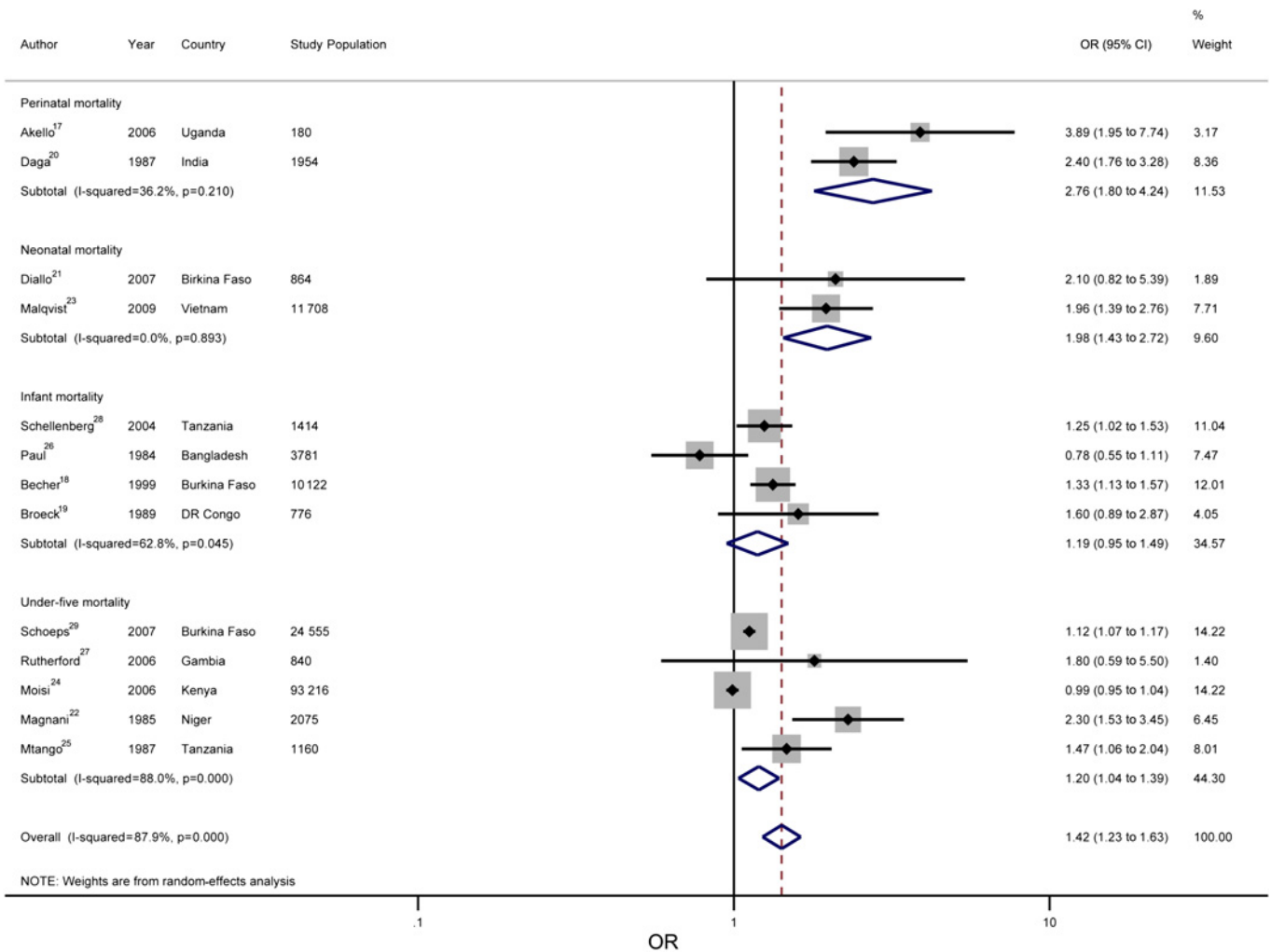
Figure 2 Meta-analysis of the association between proximity to health centres and child survival in 13 studies, 1980−2012.

(OR). However, these results were not statistically significant. The effect of study location (remote, rural, urban) could not be studied as there were no remote or urban studies included in the analysis. A multivariable analysis also could not be performed due to insufficient study numbers.

Figure 3 Proportion of studies meeting the quality assessment criteria.
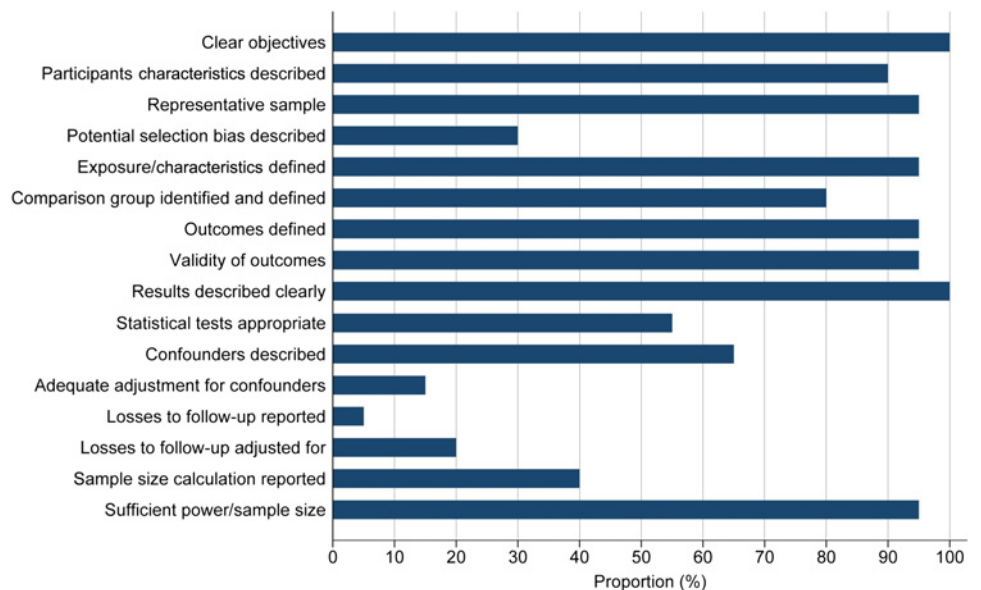
DISCUSSION

Our study demonstrated that proximity to health facilities is an important determinant of under-5 mortality in low- and middle-income countries especially in the perinatal and neonatal periods. Proximity to health facilities appeared to be more important in countries with well-functioning health systems and higher GNI.

This is the first systematic review that has reported associations between proximity to health facilities and child survival. The studies included in our meta-analysis indicated that children living within 5 km or 30 min travel time from a health centre had a decreased perinatal and neonatal mortality risk compared with children who lived further away. However, only a limited number of studies fulfilled our inclusion criteria. Data were also heterogeneous and inconclusive for older infants and children. There has been only one other systematic review that has examined the relationship between access to healthcare and under-5 mortality.[9] This study was limited to sub-Saharan Africa and indicated that distance to health services and cost of healthcare access were likely to be important but did not attempt to pool data or specify effects by age at death. In contrast, there have been many systematic reviews reporting the influence of distance to health services on maternal health outcomes.[6–8] These studies indicate that there are strong links between emergency obstetric care services and maternal health outcomes and that well-functioning referral systems are also needed.

We also reported that proximity to health facilities was associated with stronger effects in richer countries with well-functioning health systems than poorer countries. This is likely to be due to the better quality of healthcare provided in the facilities in the richer countries. However, most studies included in our meta-analysis did not describe the type or quality of healthcare provided in the facilities, thus we were not able to examine the impact of quality of care on child mortality outcomes. Indicators have recently been developed for monitoring progress in quality of neonatal and child healthcare in low- and middle-income countries.[38] Further studies should be conducted using these indicators to describe quality as well as access to care.

Interestingly, the effect of proximity to health centres did not appear to differ between Asian and African countries despite the great differences in healthcare provided in these regions. However, there were no studies from the Eastern Mediterranean, American or European regions, and information about proximity to healthcare and child survival in these regions is urgently needed. We also planned a priori to examine effects in remote and hard to reach populations. However, no studies in our meta-analysis were located in populations classified as remote.

Overall, the quality of the included studies was good. Most studies had clear objectives, documented selection criteria, provided a representative sample, defined the exposure/characteristics of participants under study and used appropriate statistical tests. However, few studies adjusted for these potential confounders and only 5% reported losses to follow-up.

Our review had some limitations. First, only a limited number of studies fulfilled our inclusion criteria, thus we were unable to perform a multivariable meta-regression analysis. However, we were able to perform detailed univariable analyses and assess the effect of important explanatory variables. Second, the variability in the access measure (ie, distance in kilometres, travel time in hours) and in the categories chosen limited the comparability of the studies. No studies incorporated topography and terrain in their access measurement or used more sophisticated measures of modelling travel time. However, in nine of 13 studies, the same categories were used (<5 km vs ≥ 5 km and <0.5 h vs ≥ 0.5 h) and results appeared similar in the stratified meta-analysis and meta-regression analyses. Third, there was marked heterogeneity in the studies included in the infant and under-5 mortality analyses. However, the age-specific stratified analyses for perinatal and neonatal mortality were very homogeneous. Also there appeared to be an interesting gradation of effect; most marked for perinatal, followed by neonatal and least for infant and under-5 mortality. Additional studies that examine effects at these different ages are needed.

Our article has important implications for policy and programme development. We reported that proximity to health facilities is an important determinant of mortality in low- and middle-income countries in the perinatal and neonatal periods but not in the postneonatal period. Proximity to health facilities appeared to be most important in countries with well-functioning health systems, regardless of GNI. Children and families require better access to health services in low- and middle-income countries especially during the perinatal and neonatal periods. Higher quality studies are needed, which examine the effect of access to health services on child survival in low- and middle-income countries, especially studies from remote areas and hard to reach populations.

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