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ORIGINAL ARTICLE

Factors Associated with Infant Mortality in Malawi

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Objective: Despite the large reduction in infant mortality rates in the last two decades, the burden of infant mortality is still high in Malawi. Because few studies have specifically addressed the determinants of infant mortality in Malawi, this exploratory study identified a series of distal, intermediate, and proximal factors related to infant mortality using a conceptual framework that explains the risk in developing countries. The objective of this study was to examine the effects of family and socioeconomic factors on the risk of an infant dying before the age of 12 months.
Methods: In this study, we analyzed the 2004 and 2010 data of the Malawi Demographic and Health Surveys. This study adopted a cross-sectional study design involving 4,698 and 12,174 singleton births in the years 2004 and 2010, respectively. Multiple logistic regression models were used to estimate the effects of selected variables on infant mortality.
Results: In the multivariate logistic regression analyses, women who resided in wealthy urban areas were 58% less likely to report infant deaths than those in rural areas [odds ratio (OR) = 0.48]. Infants who were second or third in birth order were less likely to die before 12 months. However, cesarean section delivery was found to be a risk factor associated with infant mortality in the year 2004 (OR = 1.95). By contrast, women who were in the highest 20% of household wealth, who resided in the northern region, and were in the 20–29 age group were less likely to report infant deaths. However, cesarean section delivery (OR = 1.42), male infants (OR = 1.26), and small size at birth (OR = 1.63) were the significant predictors of infant mortality in the year 2010. Furthermore, the mother's education and household wealth were not significant predictors of infant mortality in Malawi.
Conclusion: The present study shows that improving the quality of life in rural areas, evenly distributing health care delivery services and other social economic factors across the nation, and improving maternal health care, neonatal care, and nutrient intake could decrease infant mortality in Malawi.

1. Introduction

Worldwide, more than 10 million children under the age of 5 years are reported to die each year. Of these infant deaths, 90% occur in developing countries owing to conditions that could be prevented with access to simple and affordable interventions.[1,2] Previous studies have reported that six countries account for 50% of worldwide deaths in children younger than 5 years, and 42 countries account for 90%.[3–5]

Of the 10 million infant deaths annually, 4 million deaths occur within the 1st month of life with approximately 40% constituting under 5 years mortality and more than 50% infant mortality worldwide.[6] Many of these deaths are related to the lack of adequate medical and nursing intervention at the time of birth. Hence, providing skilled care to mothers during pregnancy, as well as during and after birth and in particular in the first 28 days,[6] greatly contributes to child survival (www.who.int/pmnch/media/press_materials/fs/fs_newborndealth_illness/en/).

Previous studies also identified socioeconomic, maternal, cultural, household, environmental, biological, and health service utilization factors as determinants of infant mortality.[7–10] Other causes of death in children less than 1 year old are malnutrition, pneumonia, preterm birth complications, birth asphyxia, diarrhea, and malaria.[11–13] In sub-Saharan African countries, infectious diseases like meningitis and HIV/AIDS are also responsible for high rates of infant mortality.[14] Information about the distribution, causes, and time trends of infant mortality is of great importance in a country's health policy because the infant mortality rate has been widely used as an overall index of population health in many

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countries.[2,15] Infant mortality is also relevant to Millennium Development Goal 4, which calls for countries to reduce mortality rates by two thirds between 1990 and 2015.[16,17]

Recently, most less-developed countries have made significant strides in reducing infant mortality rates such that the global infant mortality rate has been reduced from a rate of 63 deaths per 1000 live births in 1990 to 35 deaths per 1000 live births in 2012 (www.who.int/gho/child_health/mortality/neonatal_infant_text/en). Despite the large reduction in infant mortality rates over the last two decades, the burden of infant mortality is still high in Malawi.[18] Because few studies have specifically addressed the determinants of infant mortality in Malawi, we adopted a conceptual model developed by Mosley and Chen (Diagram 1) for explaining the risk of child survival in this country. Mosley and Chen proposed that social and economic factors exert tremendous impacts on child mortality through biological mechanisms or proximal factors.[19] Based on this framework, the aim of this exploratory study was to examine family and socioeconomic factors related to infant mortality in Malawi.

2. Methods

2.1. Study design and data sources

This is a cross-sectional study that utilized data from the 2004 and 2010 Malawi Demographic and Health Surveys (MDHSs) funded by the United States Agency for International Development. The datasets used for this study are available and can be downloaded from: http://dhsprogram.com/data/available-datasets.cfm. A stratified two-stage sampling method was used to draw samples representing the nation's population. The first stage was to select enumeration areas, as defined by the Malawi Population and Housing Census. The second stage was to randomly select households in each enumeration area. All three regions and 28 districts in Malawi were included in the surveys. These surveys covered indicators for social, economic, demographic, environmental, and health characteristics. For the children's information, MDHS only interviewed women who had given birth during the 5 years preceding the surveys. We further restricted samples to those women who had a child born at least 12 months before the interview; therefore each child had the same time length of observation. We also selected the oldest child interviewed by the MDHS to avoid clustering effects within the same family, which generated a sample with one child per mother, and we excluded multiple births (e.g., twins, triplets, etc.) owing to the fact that multiple births increase the risk of infant mortality. Hence, the final sample sizes were 4,698 and 12,174 singleton births for the MDHS 2004 and MDHS 2010, respectively. Informed consent for the survey was obtained from each respondent at the start of the individual interview. Ethical approval was obtained from the Malawi National Health Sciences Research Committee of the Malawi Ministry of Health.

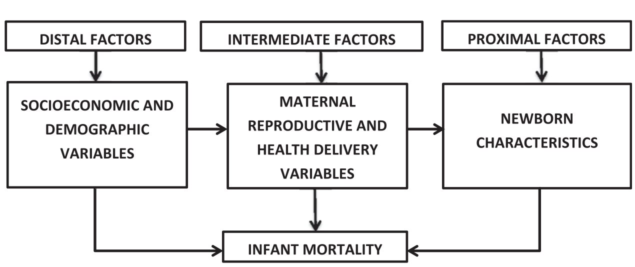

Diagram 1 Conceptual framework of factors associated with infant mortality in Malawi. *Note*. From "An analytical framework for the study of child survival in developing countries 1984" by W.H. Mosley and L.C. Chen, 2003, *Bull World Health Org*, *81*, pp. 140–5. Copyright 2003, WHO.[19] Adapted with permission.

2.2. Measurements of study variables

2.2.1. Outcome variable

Infant mortality was defined as the death of a child under the age of 1 year. This variable was measured as a binary response: yes or no. The survey questioned if the respondent had experienced the death of an offspring within 12 months prior to the survey.

2.2.2. Explanatory variables

Explanatory variables were grouped into three categories based on the conceptual model of this study: distal, intermediate, and proximal factors (Diagram 1). For distal factors, maternal education was categorized into three levels: no education, primary, and secondary and greater. Household wealth was categorized into five groups: poorest 20%, poorer 20%, middle 20%, richer 20%, and richest 20%. Household wealth was measured by the Household Wealth Index developed by MDHS teams using a principle component analysis among a variety of household characteristics and assets, such as electricity at home, source of cooking fuel, floor and roof materials, land ownership, radio, watch, bicycle, motorcycle, telephone, refrigerator, television, car, etc. Then, the factor score was categorized into five groups based on quintiles. Marital status was categorized into two groups: one group included those who were married and those who were living together with their partners, whereas the other group included those who were never married, or were separated, widowed, or divorced. Sex of the household head was classified as male or female. The variable of region was categorized as northern, central, and southern regions. The place of residence (urbanicity) was categorized as urban or rural. The religious affiliation of the mother was categorized into Roman Catholic, Protestant, and Muslim and others. Access to safe water was classified into two groups: houses with tap water piped into dwellings and those houses without piped water in their dwellings. Maternal ages were divided into four groups: 15–19 years, 20–29 years, 30–39 years, and 40–49 years. Birth order was classified as 1, 2 or 3, and 4+. For intermediate factors, we measured whether a mother had any experience regarding stillbirth/abortion. The other factor was whether the infant was delivered through a natural delivery process or through cesarean section (CS) delivery. The place of delivery was categorized as whether the mother had delivered the birth at home versus a government institution or other place. We also measured whether a woman had professionally assisted birth delivery. For proximal factors, the sex of the child was male or female. The size of the child at birth was categorized into three groups: smaller than average, average, and larger than average.

2.3. Statistical analysis

The study respondents' characteristics are presented as frequencies and percentages. Regarding the bivariate analyses, a Chi-square test was used to compare differences between children who survived more than 12 months and those who did not survive more than 12 months by the predictors.

To estimate the effects of the independent variables (distal, intermediate, and proximal factors) on the risk of an infant dying before the age of 12 months, a series of multivariate logistic regression models were used. Model 1 contained distal factors (e.g., socioeconomic, cultural, and household environmental variables). Model 2 contained intermediate factors (e.g., maternal reproductive and health care delivery variables) and distal factors. Model 3 contained proximal factors (e.g., the child's own variables) plus distal and intermediate factors. We intended to assess whether after controlling for intermediate and proximal factors, distal factors still had significant effects on infant mortality. All analyses were carried out using SAS software version 9.3 (SAS Institute, Cary, NC, USA) and all of the analyses were carried out separately for the years 2004 and 2010. The results of the multivariate logistic regression were reported as odds ratios (ORs) with their 95% confidence intervals (CIs) and a critical level of 5% statistical significance ($p < 0.05$). Furthermore, we carried out tests to examine the multicollinearity among our independent variables. The results showed that all of the variables had variance inflation factor (VIF) values of <10 and tolerance values >0.1 and thus did not have the problem of multipollinearity.

3. Results

3.1. Descriptive and bivariate analyses

In the 2004 MDHS, out of 4,698 live singleton births, 228 infants did not survive more than 12 months, whereas for the 2010 MDHS, out of 12,174 singleton births, 584 children did not survive more than 12 months. Table 1 presents descriptive statistics of the study variables.

Table 2 shows the bivariate relationships between the independent variables and infant mortality. Place of residence, maternal age, birth order, and CS delivery were significantly associated with infant mortality in 2004. Unexpectedly, the sex of the child and the size of the child at birth were not significantly associated with infant mortality. Table 2 also shows the bivariate relationships in 2010, and only the region, mother's age, birth order, CS delivery, sex of the child, and size of the child at birth were significantly associated with infant mortality.

3.2. Multivariate analyses

Table 3 presents the results of multivariate logistic regression analyses with the adjusted ORs for the 2004 data. Model 1 shows that compared to respondents who resided in rural areas, those who resided in urban areas were associated with a 57% decreased risk of infant mortality than their counterparts (OR = 0.43). The place of residence remained a significant factor for infant mortality in Model 2 (OR = 0.41) as well as in the full model, Model 3 (OR = 0.42). Unexpectedly, mother's education and household wealth were not significant predictors of infant mortality.

In terms of maternal reproductive factors, in Model 2, the birth order had a significant effect on infant mortality. Compared to infants who were born to mothers who had four or more children, those infants who were born to mothers with two or three children had a 41% lower risk of dying before 12 months (OR = 0.59). Birth order remained a significant factor even after controlling for all of the other characteristics in Model 3 (OR = 0.58). Delivery by CS had a significant increased effect on infant mortality compared to natural birth (OR = 1.94), and the effect remained significant after controlling for all of the other characteristics in Model 3 (OR = 1.95).

Table 4 presents results of the multivariate logistic regression analyses for the year 2010. Children who were from the richest households (Table 4, Model 1) had lower risks of infant mortality compared to those who were from middle-income households (OR = 0.60). The protective effects were retained in Model 2 (OR = 0.57) and Model 3 (OR = 0.56). Compared to children from the southern region of Malawi, children from the northern region (Model 1) had a lower risk of dying before 12 months (OR = 0.64). The region remained a significant factor in Model 2 (OR = 0.63) and in the full Model 3 (OR = 0.61).

Table 1 Study variables of Malawi Demographic and Health Surveys (MDHS): 2004 versus 2010

Variable	MDHS	
	2004 (%) *N* = 4,698	2010 (%) *N* = 12,174
Survived >12 mo		
Yes	95.15	95.20
No	4.85	4.80
(A) Distal factors		
Mother's education		
No education	26.29	16.81
Primary	62.26	69.01
Secondary or higher	11.45	14.18
Household wealth		
Poorest	18.16	22.07
Poorer	20.88	22.02
Middle	23.16	22.40
Richer	20.86	19.38
Richest	16.94	14.13
Sex of household head		
Male	78.82	78.50
Female	21.18	21.50
Marital status		
Married/living together	85.14	85.79
Single mother	14.86	14.21
Region		
Northern	12.94	17.93
Central	35.63	34.00
Southern	51.43	48.07
Place of residence		
Urban	12.49	10.12
Rural	87.51	89.88
Religion		
Roman Catholic	21.24	18.94
Protestant	60.76	68.23
Muslim and others	18.00	12.83
Ethnicity		
Chewa	30.64	30.21
Tumbuka	9.41	10.37
Lomwe	19.37	15.99
Yao	16.14	10.77
Ngoni	10.37	12.89
Other	14.07	19.77
Access to safe water		
Tap/piped water	4.66	4.45
No piped water	95.34	95.55
(B) Intermediate factors		
Mother's age (y)		
15–19	5.47	4.60
20–29	55.49	54.51
30–39	27.93	32.27
40–49	11.11	8.62
Birth order		
1	19.18	18.31
2 or 3	35.50	35.77
4+	45.32	45.92
CS		
No	96.57	95.20
Yes	3.43	4.80
Previous stillbirth/abortion		
No	87.80	86.59
Yes	12.20	13.41
Place of delivery		
Home	28.32	25.34
Government institution	43.91	58.87
Other	27.77	15.79
Professional delivery		
No	41.38	27.94
Yes	58.62	72.06
(C) Proximal factors		
Sex of child		
Male	51.21	49.64
Female	48.79	50.36
Size of child at birth		
Larger than average	36.93	42.74
Average	49.05	43.32
Smaller than average	14.03	13.94

CS = cesarean section.

Table 2 Bivariate analysis of factors associated with infant mortality

Variables	MDHS Did not survive >12 mo	
	2004 (%) $N = 4,698$	2010 (%) $N = 12,174$
(A) Distal factors		
Mother's education		
No education	5.02	5.08
Primary	5.13	4.90
Secondary or more	2.97	3.94
Household wealth		
Poorest	4.92	4.61
Poorer	4.89	4.66
Middle	5.70	5.54
Richer	5.20	5.04
Richest	3.14	3.78
Sex of household head		
Male	4.64	4.74
Female	5.63	5.00
Marital status		
Married/living together	4.60	4.69
Single mother	6.30	5.43
Region	NS	**
Northern	3.62	3.57
Central	4.54	4.81
Southern	5.38	5.25
Place of residence	*	NS
Urban	2.04	5.36
Rural	5.25	4.73
Religion		
Roman Catholic	4.73	5.21
Protestant	4.96	4.58
Muslim and others	4.63	5.38
Ethnicity		
Chewa	4.86	4.68
Tumbuka	3.62	4.12
Lomwe	5.71	5.55
Yao	4.62	5.26
Ngoni	4.31	5.04
Other	5.14	4.32
Access to safe water		
Tap/piped water	2.74	4.98
No piped water	4.96	4.79
(B) Intermediate factors		
Mother's age (y)	*	***
15–19	8.56	7.50
20–29	4.45	4.05
30–39	4.80	5.22
40–49	5.17	6.48
Birth order	***	**
1	6.99	5.38
2 or 3	3.18	3.97
4+	2.38	5.21
CS	*	***
No	4.72	4.60
Yes	8.70	8.75
Previous stillbirth/abortion		
No	4.68	4.68
Yes	6.11	5.58
Place of delivery		
Home	4.81	4.42
Government institution	4.90	5.08
Other	4.83	4.02
Professional delivery		
No	5.14	4.56
(C) Proximal factors	NS	*
Male	4.82	5.28
Female	4.89	4.32
Size of child at birth	NS	***
Larger than average	4.57	4.04
Average	4.47	4.20
Smaller than average	5.63	7.89

*$p < 0.05$; **$p < 0.01$; ***$p < 0.01$.
CS = cesarean section; MDHS = Malawi Demographic and Health Surveys; NS = not significant.

Table 3 Effects of (A) distal, (B) intermediate, and (C) proximal factors on infant mortality in 2004

(A) Distal factors

	Model 1 OR (±95% CI)	Model 2 OR (±95% CI)	Model 3 OR (±95% CI)
Mother's education			
No education	1.00	1.00	1.00
Primary	1.06 (0.77–1.46)	1.02 (0.73–1.43)	1.07 (0.76–1.50)
Secondary or higher	0.71 (0.39–1.32)	0.89 (0.63–1.21)	0.66 (0.34–1.28)
Household wealth			
Poorest	0.78 (0.51–1.18)	0.79 (0.52–1.20)	0.82 (0.54–1.25)
Poorer	0.81 (0.55–1.19)	0.82 (0.55–1.21)	0.83 (0.56–1.23)
Middle	1.00	1.00	1.00
Richer	0.99 (0.67–1.45)	1.01 (0.68–1.49)	1.04 (0.70–1.54)
Richest	0.80 (0.47–1.39)	0.84 (0.49–1.46)	0.88 (0.51–1.53)
Sex of household head			
Male	1.00	1.00	1.00
Female	1.00 (0.66–1.53)	1.06 (0.69–1.61)	1.04 (0.68–1.59)
Marital status			
Married/living together	1.00	1.00	1.00
Never/separated/ widowed	1.45 (0.92–2.29)	1.32 (0.84–2.09)	1.33 (0.84–2.10)
Region			
Northern	0.67 (0.36–1.26)	0.68 (0.36–1.26)	0.69 (0.37–1.29)
Central	0.78 (0.51–1.19)	0.77 (0.50–1.17)	0.76 (0.50–1.17)
Southern	1.00	1.00	1.00
Place of residence			
Urban	0.43 (0.22–0.82)**	0.41 (0.21–0.79)**	0.42 (0.22–0.82)**
Rural	1.00	1.00	1.00
Religion			
Roman Catholic	0.93 (0.66–1.31)	0.94 (0.67–1.33)	0.96 (0.68–1.35)
Protestant	1.00	1.00	1.00
Muslim and others	0.88 (0.52–1.49)	0.83 (0.50–1.43)	00.87 (0.51–1.47)
Ethnicity			
Chewa	1.00	1.00	1.00
Tumbuka	0.88 (0.43–1.80)	0.89 (0.43–1.83)	0.89 (0.44–1.84)
Lomwe	0.91 (0.55–1.49)	0.88 (0.53–1.43)	0.86 (0.52–1.42)
Yao	0.82 (0.44–1.54)	0.82 (0.43–1.53)	0.81 (0.44–1.55)
Ngoni	0.81 (0.48–1.37)	0.79 (0.47–1.35)	0.80 (0.47–1.36)
Other	0.94 (0.56–1.58)	0.94 (0.56–1.51)	0.96 (0.57–1.61)
Access to safe water			
Tap/piped water	1.11 (0.44–2.79)	1.07 (0.42–2.70)	0.89 (0.34–2.40)
No piped water	1.00	1.00	1.00

(B) Intermediate factors

	Model 2 OR (±95% CI)	Model 3 OR (±95% CI)
Mother's age (y)		
15–19	1.50 (0.71–3.18)	1.44 (0.68–3.07)
20–29	1.13 (0.67–1.91)	1.09 (0.64–1.84)
30–39	0.99 (0.62–1.57)	0.95 (0.60–1.52)
40–49	1.00	
Birth order		
1	1.26 (0.78–2.03)	1.23 (0.76–1.99)
2 or 3	0.59 (0.38–0.90)**	0.58 (0.38–0.89)**
4+	1.00	1.00
Delivery by CS		
No	1.00	1.00
Yes	1.94 (1.08–3.51)**	1.95 (1.08–3.51)**
Previous stillbirth/ abortion		
No	1.00	1.00
Yes	1.28 (0.88–1.89)	1.21 (0.82–1.78)
Place of delivery		
Home	1.00	1.00
Government institution	1.40 (0.79–2.51)	1.39 (0.78–2.49)
Other	1.11 (0.71–1.70)	1.11 (0.72–1.71)
Delivery assisted by a professional		
No	1.53 (0.81–2.19)	1.29 (0.78–2.13)
Yes	1.00	1.00

Table 3 (*continued*)

(C) Proximal factors	
	Model 3 OR (±95% CI)
Sex of the child	
Male	0.99 (0.75−1.30)
Female	1.00
Size at birth	
Larger than average	1.01 (0.75−1.38)
Average	1.00
Smaller than average	1.29 (0.89−1.85)

$^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.01$.
CI = confidence interval; CS = cesarean section; OR = odds ratio.

Table 4 Effects of (A) distal, (B) intermediate, and (C) proximal factors on infant mortality in 2010

(A) Distal factors			
	Model 1 OR (±95% CI)	Model 2 OR (±95% CI)	Model 3 OR (±95% CI)
Mother's education			
No education	1.00	1.00	1.00
Primary	0.99 (0.79−1.24)	1.09 (0.86−1.38)	1.10 (0.87−1.40)
Secondary or higher	0.79 (0.56−1.11)	0.89 (0.62−1.28)	0.92 (0.64−1.34)
Household wealth			
Poorest	0.79 (0.15−10.1)	0.80 (0.62−1.03)	0.78 (0.61−1.00)
Poorer	0.82 (0.64−1.04)	0.82 (0.64−1.05)	0.78 (0.61−1.01)
Middle	1.00	1.00	1.00
Richer	0.91 (0.71−1.18)	0.90 (0.70−1.16)	0.88 (0.68−1.14)
Richest	0.60 (0.42−0.86)**	0.57 (0.40−0.81)**	0.56 (0.39−0.80)**
Sex of household head			
Male	1.00	1.00	1.00
Female	0.97 (0.76−1.23)	0.96 (0.75−1.22)	0.98 (0.76−1.25)
Marital status			
Married/living together	1.00	1.00	1.00
Never/separated/ widowed	1.20 (0.91−1.57)	1.14 (0.86−1.50)	1.00 (0.84−1.47)
Region			
Northern	0.64 (0.45−0.91)**	0.63 (0.44−0.89)**	0.61 (0.43−0.87)**
Central	0.97 (0.75−1.24)	0.95 (0.74−1.22)	0.97 (0.75−1.24)
Southern	1.00	1.00	1.00
Place of residence			
Urban	1.32 (0.96−1.81)	1.31 (0.95−1.80)	1.34 (0.97−1.85)
Rural	1.00	1.00	1.00
Religion			
Roman Catholic	1.14 (1.27−0.83)	1.14 (0.92−1.41)	1.33 (0.91−1.41)
Protestant	1.00	1.00	1.00
Muslim and others	1.14 (0.82−1.59)	1.18 (0.84−1.64)	1.16 (0.84−1.60)
Ethnicity			
Chewa	1.00	1.00	1.00
Tumbuka	1.27 (0.83−1.95)	1.25 (0.81−1.92)	1.25 (0.81−1.94)
Lomwe	1.15 (0.84−1.58)	1.15 (0.84−1.58)	1.16 (0.84−1.60)
Yao	1.00 (0.67−1.51)	0.99 (0.66−1.49)	0.98 (0.65−1.49)
Ngoni	1.07 (0.80−1.43)	1.04 (0.78−1.40)	1.08 (0.81−1.45)
Other	1.04 (0.76−1.42)	1.03 (0.75−1.41)	1.08 (0.79−1.48)
Access to safe water			
Tap water	1.28 (0.80−2.07)	1.28 (0.79−2.06)	1.29 (0.80−2.10)
No tap/piped water	1.00	1.00	1.00

(B) Intermediate factors		
	Model 2 OR (±95% CI)	Model 3 OR (±95% CI)
Mother's age (y)		
15−19	1.00 (0.60−1.67)	0.99 (0.59−1.66)
20−29	0.61 (0.44−0.87)**	0.60 (0.43−0.86)**
30−39	0.82 (0.61−1.10)	0.82 (0.61−1.09)
40−49	1.00	—

Table 4 (*continued*)

(B) Intermediate factors		
	Model 2 OR (±95% CI)	Model 3 OR (±95% CI)
Birth order		
1	1.13 (0.82−1.56)	1.09 (0.79−1.52)
2 or 3	0.93 (0.72−1.20)	0.93 (0.72−1.21)
4+	1.00	1.00
Delivery by CS		
No	1.00	1.00
Yes	2.05 (1.50−2.80)***	1.94 (1.42−2.67)***
Previous stillbirth/ abortion		
No	1.00	1.00
Yes	0.88 (0.70−1.11)	0.87 (0.69−1.10)
Place of delivery		
Home	1.00	1.00
Government institution	0.96 (0.54−1.70)	1.02 (0.57−1.83)
Other	0.76 (0.44−1.31)	0.80 (0.46−1.39)
Delivery assisted by a professional		
No	0.89 (0.50−1.53)	0.91 (0.53−1.58)
Yes	1.00	1.00

(C) Proximal factors	
	Model 3 OR (±95% CI)
Sex of the child	
Male	1.26 (1.08−1.53)***
Female	1.00
Size at birth	
Larger than average	0.95 (0.78−1.15)
Average	1.00
Smaller than average	2.03 (1.63−2.52)***

$^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.01$.
CI = confidence interval; CS = cesarean section; OR = odds ratio.

In terms of maternal reproductive factors (Model 2), compared to children born to mothers aged 40−49 years, those who were born to mothers aged 20−29 years had a lower risk of dying before 12 months (OR = 0.61), and the significant relationship remained even in the full Model 3 (OR = 0.60). Model 2 also showed that infants who were delivered by CS were two times more likely to die before 12 months compared to those born through a natural birth (OR = 2.05). Delivery by CS remained a risk factor for infant mortality in the full model but with a reduced OR (1.94).

As for proximal factors, being male (OR = 1.26) was a risk factor for infant mortality. In addition, infants born with a size smaller than average were two times more likely to die compared to those of an average size (OR = 2.03) in Model 3.

4. Discussion

The multivariate analysis shows that when distal, intermediate, and proximal factors were simultaneously included in the regression models, only the place of residence, birth order, and delivery by CS had statistically significant effects on infant mortality in 2004. The significant predictors differed in 2010. In our 2010 data, household wealth, region, mother's age, delivery by CS, the sex of the child, and the size of the baby at birth had statistically significant effects on infant mortality.

This study found that in 2004 the place of residence was strongly associated with infant mortality. Those women who resided in rural areas were more likely to experience infant death than their counterparts. The significant effects of urban/rural residence on infant mortality remained significant even after adjusting for several other individual-level sociodemographic characteristics.

Previous studies also found this result, although with varying strengths of the relationships.[6,20,21] It is believed the urban/rural mortality differentials are attributed to various socioeconomic differences that exist within the country.[22] In addition, factors such as better education, more public infrastructure that provides sanitation services, safer water supply, better systems to handle household waste and excreta removal, and easier access to health care services that are more favorable in urban than in rural areas can also explain this relationship.[22]

This study also found regional variations in reporting infant deaths in 2010. The northern region was found to have much lower infant mortality risks compared to the southern region. Another study from Malawi reported similar findings.[23] The northern part of Malawi is considered to be economically stable compared to the other two regions, and the population density is not as high as in the other two regions.[18] Some people believe that because the northern region of Malawi trades with the bordering country, Tanzania, the economy of this area is much better.

Our results showed that household wealth (the richest 20%) had a protective influence against infant mortality in the multivariate analysis in the year 2010. Previous studies have reported similar findings.[24] The protective effects of household wealth remained significant even after we controlled for maternal factors, health care delivery factors, and infant biological factors. It is believed that child survival is largely compromised in economically disadvantaged families through greater exposure to disease infections, insufficient food intake, and lack of access to vaccinations and basic health care.[25,26]

Our study observed a U-shaped pattern of infant mortality in 2010 with respect to maternal age. The lowest infant mortality risks were reported in women who were within the age range of 20–29 years. Similar patterns were found in a previous study.[27] In the US, infants who were born to mothers of 15 years old or younger had a higher risk of dying (3.2 per 1000) than those who were born to mothers of 23–29 years old (0.8 per 1000).[28] One study suggested that the higher infant mortality risks of younger mothers may be related to socioeconomic factors and biological immaturity; hence, it could be an indicator of poverty.[28]

Our study showed that a high infant mortality risk was associated with babies delivered by CS. Similar findings were reported in previous studies.[29,30] In our study, a cesarean delivery was the only significant predictor of infant mortality in these two cohort years, 2004 and 2010. In a study conducted in the US, it was reported that overall neonatal mortality rates for cesarean births were 2.9 times more than for vaginal births.[30] Another study in the US also demonstrated a significant higher risk of neonatal death for infants delivered by CS at 22–25 weeks of gestation compared to natural births.[31]

Our study revealed that birth order was related to infant mortality in the year 2004. Malawi national vital statistics reported that the risk of mortality was higher for the first birth than for the second birth, and the risk then increased as the birth order increased (www.nber.org/perinatal/2004/Doc/Infant%20Mortality%20Final%20Data_2004.pdf). Similarly, a study in Finland found that families having two children had protective effects compared to their counterparts, even after controlling for parental age at birth, parental education, and household wealth.[32] It has been argued that high risks of mortality among first births and higher-order births are because of the mother's age, multiple births, and family socioeconomic status.[33]

This study confirmed that sex is an important predictor of infant mortality in 2010. Male infants were at 26% higher risk of dying before 1 year compared to female infants. This result is consistent with previous studies.[6,34–36] Some studies explained that male babies are particularly at risk of dying in early life owing to their genetic and biological makeup, with boys considered biologically weaker and more susceptible to diseases and premature death.[6,37] Pongou[37] suggested that both the environment and child biology increase the mortality of male infants, but the effects were substantially smaller than the literature suggested. In a study conducted in rural Malawi investigating the mortality risk among 1–2-year-old children, a twofold mortality risk was found among boys compared to girls.[38]

We found that the infant mortality risk was also significantly higher in babies who were born with a small birth size. Small birth size as a determinant of infant mortality was reported in some previous studies although different studies reported variations in the strength of the relationship.[11,24] Birth size is considered a proxy that reflects a mother's nutritional status, the quality of care rendered to the mother, and the health status of the mother during pregnancy.[39]

This study had some limitations. First, secondary data sources were used in this study. Some important variables thus could not be included in the analyses. Second, this study was subject to a recall bias of risk factors. Some women might not have been able to correctly recall information about their pregnancy, delivery, and postdelivery conditions. Third, the cross-sectional nature of this study design cannot determine the causal relationship between independent variables and the outcome variable. Finally, we did not explore HIV/AIDS-related variables with respect to infant mortality. A mother's HIV status may be an important confounder in the relationship between socioeconomic status and infant mortality.

In conclusion, our study shows that improving the quality of life in rural areas, evenly distributing health delivery services and other social economic factors across the nation, and improving maternal and child health services would decrease infant mortality in Malawi. The relationships emphasized above have some very important policy implications for the regional and national health care rendered to women and their children in Malawi.

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