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RESEARCH ARTICLE

Associations between early marriage, women's empowerment, and infant mortality in Sub-Saharan Africa

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Abstract

Sub-Saharan Africa (SSA) is characterized by high gender inequality and a high rate of early marriages of girl children, which could have a negative influence on child health outcomes and child mortality in the region. This study examined the influence of child marriage on infant mortality in selected countries in SSA. We used Cox proportional hazard models to analyze pooled data (N = 33,549 children) from the Demographic and Health Surveys of 28 SSA countries. Our study established that children of child brides faced heightened risks of infant mortality compared with children of women who married after the age of 18, although this relationship became insignificant after controlling for women's empowerment and other control variables. Therefore, the findings support the hypothesis that a certain extent of women's empowerment could moderate the relationship between early marriage and infant mortality in regions where early marriages occur due to the low socioeconomic status of women. We conclude that ensuring women empowerment and increasing their economic opportunities (such as involvement in the agriculture and formal employment sectors) will lead to decreases in child marriage, thereby reducing infant mortality in SSA.

Keywords: Child marriage; Child mortality; Infant mortality; Women's empowerment; Sub-Saharan Africa

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1. Introduction

Improving child health outcomes remains a key national and international priority. The world seeks to reduce the under-5 mortality rate to 25 deaths per 1000 live births by 2030, as enshrined in the international agenda, for instance, target 3.2 of the Sustainable Development Goals. To a large extent, considerable progress has been achieved in reducing global child mortality: 1 in 27 children died before the age of 5 in 2020 compared with 1 in 11 in 1990 (UNICEF *et al.*, 2020a). Notwithstanding this improvement, the global burden of child death remains high. Around 5 million children died before age 5

in 2020 alone, and more than half of these deaths occurred in sub-Saharan Africa (SSA; UNICEF *et al*., 2020b).

Prior studies have established many factors influencing child mortality in SSA. These determinants include low maternal education (Adedini *et al*., 2015b; Kravdal, 2004), sociocultural practices such as gender inequality and the desire for high fertility (Adedini *et al*., 2015a; Mobolaji *et al*., 2020), insufficient women's empowerment (Adedini *et al*., 2019; Akinyemi *et al*., 2017), low or non-use of contraception (Adedini *et al*., 2015c; Bitew & Nyarko, 2019), poor or limited access to health care interventions such as antenatal care and skilled delivery (Adedini *et al*., 2014; Vieira-Meyer *et al*., 2019), and biomedical causes (Breiman *et al*., 2021; Fottrell *et al*., 2015; Salzberg *et al*., 2019).

A significant gap exists in the literature; child marriage constitutes a conceivable risk factor for child mortality that remains inadequately explored. Several countries in SSA exhibit a high prevalence of child marriage (Adedini *et al*., 2022; Fatusi *et al*., 2021); however, the implications of child marriage for infant mortality have rarely been investigated. Child marriage is defined as matrimony involving at least one individual under the age of 18 years; this custom represents a key global public health concern because it adversely affects the sexual and reproductive health and rights of women and girls (Nour, 2006; Raj, 2010; Raj & Boehmer, 2013). Both boys and girls are involved in early marriage; however, girls are disproportionately affected (Nour, 2006; UNICEF, 2019; 2020). A recent overview of the available evidence indicated that an estimated 115 million boys and men were married as children compared with over 650 million girls and women. This statistic translates to around 765 million child grooms and brides globally (UNICEF, 2019). Approximately two-fifths of women aged 20 – 24 who were married before they were 18 years old live in SSA; therefore, a majority of global early marriages happen in SSA (Walker, 2012).

Women's empowerment is a critical factor in the promotion of child health, and the extant literature elucidates that child brides tend to belong to poorer socioeconomic strata compared with women who marry as adults (Ortigoza *et al*., 2021). For instance, a recent study found that girls who married as child brides are more likely to be unemployed, uneducated, poor, multiparous, rural residents, and engage in non-professional occupations in comparison with women who married as adults (Adedini *et al*., 2022). Furthermore, high education levels in women of reproductive age are linked with reduced infant mortality through decreases in adolescent birth rates and premature births and through improved caregiving skills (Gakidou *et al*., 2010). Similarly, women with more financial autonomy appear to allocate increased resources to the health of their children (Pratley, 2016). Births may occur in marital contexts or outside of marriage; however, literature clearly indicates that early marriage is strongly linked with younger ages of mothers at birth; meanwhile, while teenage pregnancy is viewed as a motivational factor for early marriage, as families evaluate the costs of their daughters raising children born out of wedlock (Schaffnit & Lawson, 2021).

The children of child brides may be predisposed to poor health outcomes such as childhood stunting, wasting, and being underweight due to the pressures of the mother raising children at a young age with little or no knowledge of childbearing and childrearing (Kidman, 2017). Moreover, giving birth before the body is fully mature is a major risk factor for poor maternal and child health and may result in stillbirths, miscarriages, or infant deaths. Furthermore, early marriage is associated with mistimed or unwanted pregnancies, susceptibility to domestic violence, poor participation in family decision-making, and poor agency (Godha *et al*., 2013; Santhya *et al*., 2010). Given that pregnancy among child brides places the mother as well as the fetus at a higher risk of adverse reproductive health outcomes, this study aimed to examine the influence of child marriage on infant mortality (and the impact of controlling for women's empowerment) in 28 selected countries in SSA.

1.1. Some theoretical perspectives on early marriage, women's agency, and child survival

The study was guided by the ecological model (EM) and the human behavioral ecology (HBE) theory to highlight the relationships among early marriage, women's empowerment, and child survival. EM emphasizes the multidimensionality of human behaviors and recognizes the role of structural and contextual factors (including socioeconomic issues and political environment) in determining individual behaviors. HBE uses the evolutionary approach to study human behaviors and posits that the patterns we observe in human behaviors are shaped by certain selective pressures present in the social and ecological environment in which individuals live. HBE has been widely applied in a range of domains including anthropology, archeology, and demographic transition (Winterhalder & Smith, 2000, 2017). A recent study conducted by Schaffnit & Lawson (2021) utilized HBE to offer perspectives on four alternative hypotheses sustaining the practice of child marriage in low- and middle-income countries.

The prevalence of child marriage persists in developing countries despite its many negative consequences

including poor physical and mental well-being, poor sexual and reproductive health, and reduced educational and employment prospects for child brides. Its continued prevalence, despite its apparent adverse consequences, has inspired multiple disciplines including evolutionary and sociocultural anthropology and global health frameworks to elucidate why child marriages remain common. Scholars have argued that child marriage should not only be viewed as a forced union or a determinant of low socioeconomic status (Schaffnit *et al.*, 2021) but also as a viable response to poverty or poor socioeconomic status: girls marry early because it is the best available option for them in their community. Researchers have argued that early marriages tend to generate reproductive success and that parents benefit from child marriages at the expense of their daughters' best interests. Moreover, early marriages are viewed as the likely product of a conflict of interest between parents and their daughters because parents desire bride wealth at a cost to their daughters. Early marriages can also result from conflicts between men and women as girls are lured into early marriages against their desires or long-term relationship goals. Further, it has been posited that girls marry early to liberate themselves from intergenerational conflicts and escape unfavorable conditions in their native homes. Moreover, early marriages could be the best option for poor parents and their daughters due to the limited choices available. These hypotheses highlight the roles enacted by the autonomy and agency of women and reveal the complex determinants of transitioning through individual life courses. Thus, these studies emphasize the need for appropriate, context-specific policies to address the sociocultural framing of gender norms and attend to the practice of child marriage, and its negative concomitants (Mobolaji *et al.*, 2020).

This study hypothesized that a link exists between early marriage and adverse child health outcomes, including infant mortality. Girls who marry early suffer severe negative health and social consequences that result in poor status, low empowerment, and limited agency. Child brides lack the opportunities to enjoy their childhood and develop fully, which limits their empowerment. They do not get the opportunity to develop friendships and bonds. Their status in their households remains low because they are not granted the option of acquiring the education and skills needed for future employment prospects. Moreover, child brides cannot negotiate safer and protected sexual acts due to their low status or poor agency, which often leads to high-risk births. Kramer & Lancaster (2010) reported that negative pregnancy outcomes are associated with teen motherhood due to relative developmental maturity, limited knowledge about childrearing, and the psychological unpreparedness of young mothers for motherhood. Scholars have also shown that child bride pregnancies and births are often too early, too close (short inter-birth intervals), and even too late (Akinyemi *et al.*, 2015; Ibrahim *et al.*, 2019): such circumstances indicate higher mortality risks for the children of child brides than for the offspring of older women. Child marriage is also associated with low birth weights, preterm births, and risks of human immunodeficiency virus infection through mother-to-child transmissions. This jeopardizes the health of the next generation, making infant mortality/survival a relevant outcome for evolutionary models of human life history. The study also postulates that women's empowerment could reduce the risk of infant mortality for child brides who can subsequently acquire some measure of enfranchisement through education, employment, and participation in household decision-making.

2. Data and methods

2.1. Data source

The study used the most recent Demographics and Health Survey (DHS) data from 28 countries selected across the four regional blocs of SSA. The selected countries were located in four African subregions presenting sociocultural differences. The surveys were conducted in the selected countries between 2010 and 2020. Table 1 shows that the weighted samples of the children of the respondents range from 404 infants in Comoros to 3,817 babies in Nigeria. We employed a stratified two-stage cluster design sampling technique to select representative samples. Enumeration areas (EAs) served as the primary sampling units and a complete listing of households was compiled for selected EAs to derive representative samples for each country. The analysis for this study focused on young mothers aged 15 – 24 years, dividing them into three mutually exclusive strata: women who were first married at ages less than 15 years (<15 years), those who were first married between the ages of 15 and 17 (15 – 17), and those whose first marriage occurred at age 18 or older (18+ years). Categorizing early marriages in this manner according to the age the girls were first married allowed us to compare the risks of infant mortality between the three groups. We assumed that very early marriages of girls (before age 15) were probably associated with poorer child health outcomes compared to marriages at ages 15 – 17 (Kramer & Lancaster, 2010). We utilized the recode datasets pertaining to the children and restricted our analysis to children whose mothers were currently aged between 15 and 24 years and who were born within one calendar year before the survey. Our analysis focused on women aged 15 – 24 years to ensure that the sample was not biased due to the systematic exclusion of births to younger mothers. The existing literature indicates that maternal age at the birth of a child represents an

Table 1. Neonatal and infant mortality rates of countries included in the analysis

Countries	DHS year	N=33,549	Neonatal mortality rate (per 1000 live births)	Infant mortality rate (per 1000 live births)	% of infant deaths during the neonatal period
Angola	2015 – 2016	1,456	28.1	41	68.5
Benin	2017 – 2018	1,080	22.8	32	71.3
Burkina Faso	2010	1,876	21.8	48.7	44.8
Burundi	2016 – 2017	742	19	32.2	59.0
Cameroon	2018	1,404	25.5	38.9	65.6
Chad	2014 – 2015	1,544	38.5	60.2	64.0
Congo	2011 – 2012	789	22.2	34.8	63.8
Congo DR (CD)	2013 – 2014	1,494	45.3	64.4	70.3
Comoros	2012	404	35.3	53	66.6
Cote D'Ivoire	2011 – 2012	780	23.6	42.1	56.1
Gabon	2012	780	45.3	50.9	89.0
Ghana	2014	588	22.5	25.3	88.9
Guinea	2018	857	42.2	73.5	57.4
Kenya	2014	2,565	24.5	40.1	61.1
Lesotho	2014	646	30.2	41.2	73.3
Liberia	2019 – 2020	506	42.4	45.7	92.8
Malawi	2015 – 2016	1,582	33.8	40.7	83.0
Mali	2018	1,341	33.4	44.6	74.9
Mozambique	2015	878	29.4	48	61.3
Namibia	2013	680	18.9	34.5	54.8
Niger	2012	1,226	19.1	32.1	59.5
Nigeria	2018	3,817	41.3	59.5	69.4
Rwanda	2014 – 2015 (2019/20)	535	31.9	40.3	79.2
Sierra-Leone	2019	1,170	26.2	58.3	44.9
Tanzania	2015 – 2016	835	31.2	37.8	82.5
Uganda	2016	2,316	32.3	46	70.2
Zambia	2018	772	30.1	36.5	82.5
Zimbabwe	2015	886	25.2	37.8	66.7

important mediator between early marriage and infant mortality.

2.2. Variable measurements

2.2.1. Outcome variables

Infant mortality measured per 1000 live births among children of young mothers aged 20 – 24 years was set as the dependent variable for this study. Infant mortality was defined as death before age one (death before the first birthday). This variable was measured as the duration of survival since birth in months. This variable is an event history outcome; thus, infant mortality was modeled as the duration of survival from birth until the 11th month. The survival time for children who were alive was considered at their current age (in months) at the time of the survey. The survival time for dead children was recorded as their age at death in months.

2.2.2. Independent variables

Child marriage denoted the key explanatory variable in this study, and women's empowerment was considered as an intervening variable. Child marriage was measured and categorized as (i) first marriage before age 15, (ii) first marriage between ages 15 and 17, and (iii) first marriage at age 18 or older. In addition, we considered the women's education levels, occupation strata, and participation in household decision-making as proxy variables for women's empowerment. We utilized principal component analysis

to derive women's participation in household decision-making from responses to questions about who made decisions on visits to relatives, major purchases, husband's earnings, and the respondent's health care and earnings. The resultant composite scores were divided into (i) less empowerment and (ii) more empowerment. Other selected covariates were considered based on the reviewed literature. These variables included birth order, place of delivery, religion, wealth index, parity, place of residence, and number of antenatal visits. Antenatal care visits and place of delivery were included in the model based on the assumption that child brides are likely to have limited access to these life-saving measures for their infants due to their relatively low status in their families and communities. We also controlled for the country of residence to compare the estimated effects of child marriage on infant mortality across countries.

2.3. Statistical analysis

We performed three levels of statistical analyses. At the univariate level, the study samples were distributed according to the selected countries and the key independent variables. The bivariate analysis assessed the distribution according to the sample characteristics. Cox proportional hazard models were fitted at the multivariable level to determine the influence of child marriage on infant mortality while adjusting for the selected control variables. We employed the Cox proportional hazards model because it is appropriate for analyzing survival data and handling censored observations. Censoring occurs when the value of an observation is not comprehensively identified. Some children in our study sample were not completely exposed to mortality risk at the time of the survey. The probability of infant death was regarded as the hazard in using the Cox proportional hazards model.

A total of seven Cox proportional hazard models were fitted for the outcome variable. Model 1 represented an unadjusted model examining the relationship between age at marriage (as a continuous variable) and infant mortality. Model 2 had a similar objective but also adjusted for a proxy measure of women's empowerment (i.e., involvement in household decision-making). Model 3 was unadjusted with age at marriage as a categorical variable, whereas Model 4 included women's empowerment. Model 5 incorporated maternal characteristics, and Model 6 considered additional variables (i.e., characteristics of children). Model 7 represented the full model incorporating all the independent variables, including the country of residence. Multiple models were fitted to confirm rigorous analyses and to ensure that highly correlated predictors were not included in the same model. We applied weighting factors provided by the DHS program to account for the survey's complex nature ensuring the national representativeness of the data. We applied the sample size weight for the pooled data using the formula $1/(C\ [n_c/n_p])$, in which C denotes the number of countries involved in the analysis and n_c and n_p indicate the sample size for each studied country and the pooled data, respectively. Multivariable analyses of the pooled data were performed using the sample size weight. Measures of association were presented as hazard ratios (HRs) with a 95% confidence interval (CI) and at a significance level of $p < 0.05$. The normative and largest groups were chosen as the reference categories during the multivariable analysis. All statistical analyses were performed using Stata (version 16.0; StataCorp, USA).

2.4. Patient and public involvement

No patients were involved in the design or dissemination of this study.

3. Results

3.1. Infant mortality rate

Table 1 and Figure 1 present the infant mortality rates and the percentages of infant deaths occurring in the neonatal period in the selected countries. Table 1 clarifies that the neonatal mortality rate was found to be more than 30 per 1000 live births in 13 of the 28 selected countries. Moreover, the infant mortality rate was higher than 30 per 1000 live births in 27 of the 28 selected countries. At least, 45% of the total infant mortality occurred during the neonatal period in all 28 selected countries. The infant mortality rate was highest in Guinea (73.5 deaths/1000 live births) and lowest in Ghana (25.3 deaths/1000 live births).

3.2. Level of women's empowerment

Figure 2 illustrates the women's empowerment levels registered by the study participants in the selected countries. Women's empowerment levels were low across all selected countries except Burundi, the Democratic Republic of the Congo, Rwanda, Uganda, and Zimbabwe, where women were moderately (or intermediately) empowered.

3.3. Age at first marriage

Figure 3 presents the ages of the respondents in the selected countries at their first marriage. A high percentage of women married at age 18+ in Burundi, Gabon, the Democratic Republic of the Congo, Kenya, Lesotho, and Namibia. Meanwhile, the proportion of women who married before age 15 or at ages 15 – 17 was 50% or more in Burkina Faso, Guinea, Liberia, Mali, Mozambique, Niger, Tanzania, and Zambia.

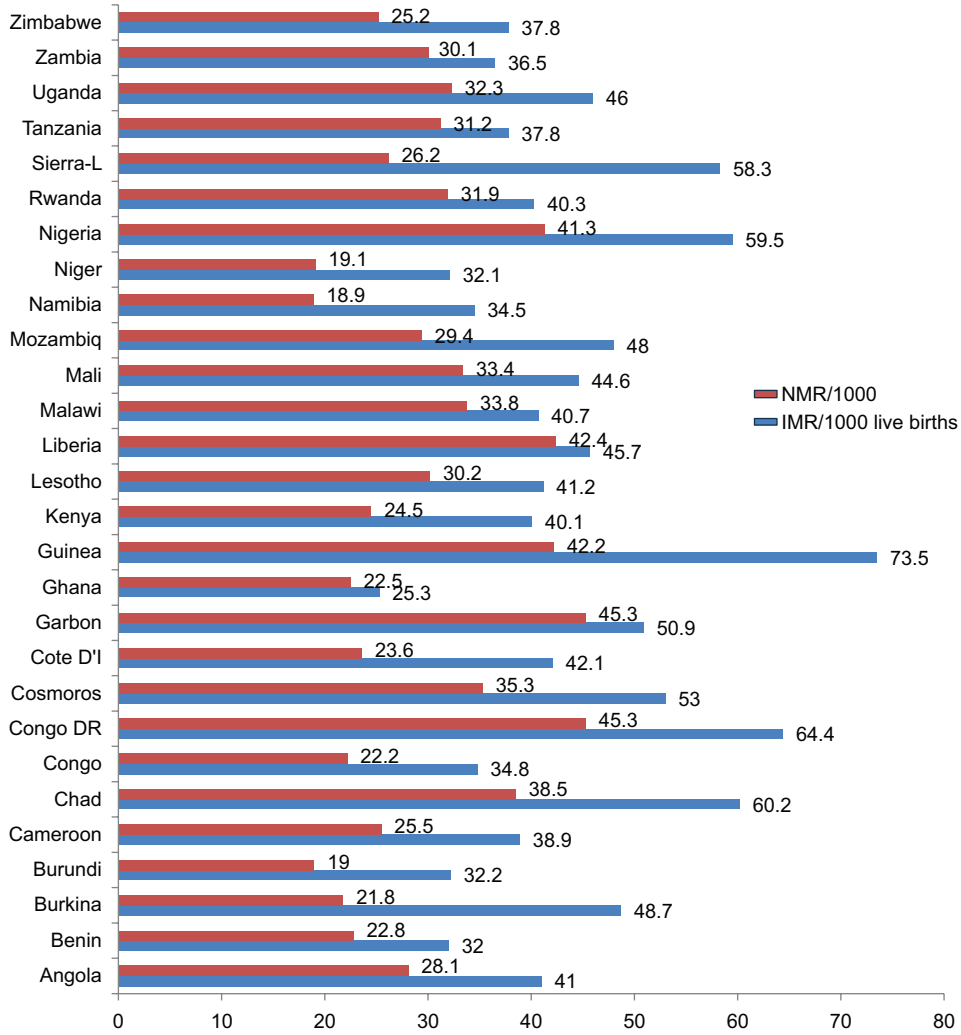


Figure 1. Infant and neonatal mortality rates (per 1000 live births). Cote D'I = Cote D'Iviore; Sierra L = Sierra Leone
Abbreviations: IMR: Infant mortality rate; NMR: Neonatal mortality rate.

3.4. Child marriage, women's empowerment, and infant mortality

Table 2 displays the relationships between child marriage, women's empowerment, selected maternal characteristics, and infant mortality. Compared with the other categories, infant mortality was higher among male children (χ^2 = 10.26, p < 0.05), children who are in first birth order (χ^2 = 41.94, p < 0.001), children of less empowered women (χ^2 = 15.21, p < 0.01), children of 15 – 19-old mothers (χ^2 = 51.07, p < 0.001), children of uneducated mothers (χ^2 = 16.28, p < 0.01), multiple-birth children (χ^2 = 346.10, p < 0.001), children of Muslim mothers (χ^2 = 13.17, p < 0.05), children of mothers who married at age 15 – 17 (χ^2 = 3.68, p < 0.05), children delivered at home (χ^2 = 45.51, p < 0.001), and children whose mothers had <4 antenatal care visits (χ^2 = 89.65, p < 0.001).

The results of the multivariable analysis are presented in Table 3. Model 1 shows the unadjusted HRs indicating the independent effects of age at first marriage (continuous variable) on infant mortality. The findings reveal significantly elevated hazards of infant death among children whose mothers married at ages 15 (HR: 1.65, CI: 1.18 – 2.31, p < 0.01) and 16 (HR: 1.40 CI: 1.04 – 1.90, p < 0.05) compared with those whose mothers married at ages 18+. The outcomes obtained after adjusting for the proxy measure for women's empowerment in Model 2 divulged similar patterns.

The unadjusted Model 3 is shown in Table 4, revealing that children whose mothers married before age 15 (HR: 1.34, CI: 1.01 – 1.89, p < 0.05) and at the age span of 15 – 17 (HR: 1.38, CI: 1.06 – 1.80, p < 0.05) were at significantly higher risk of dying during infancy than children whose

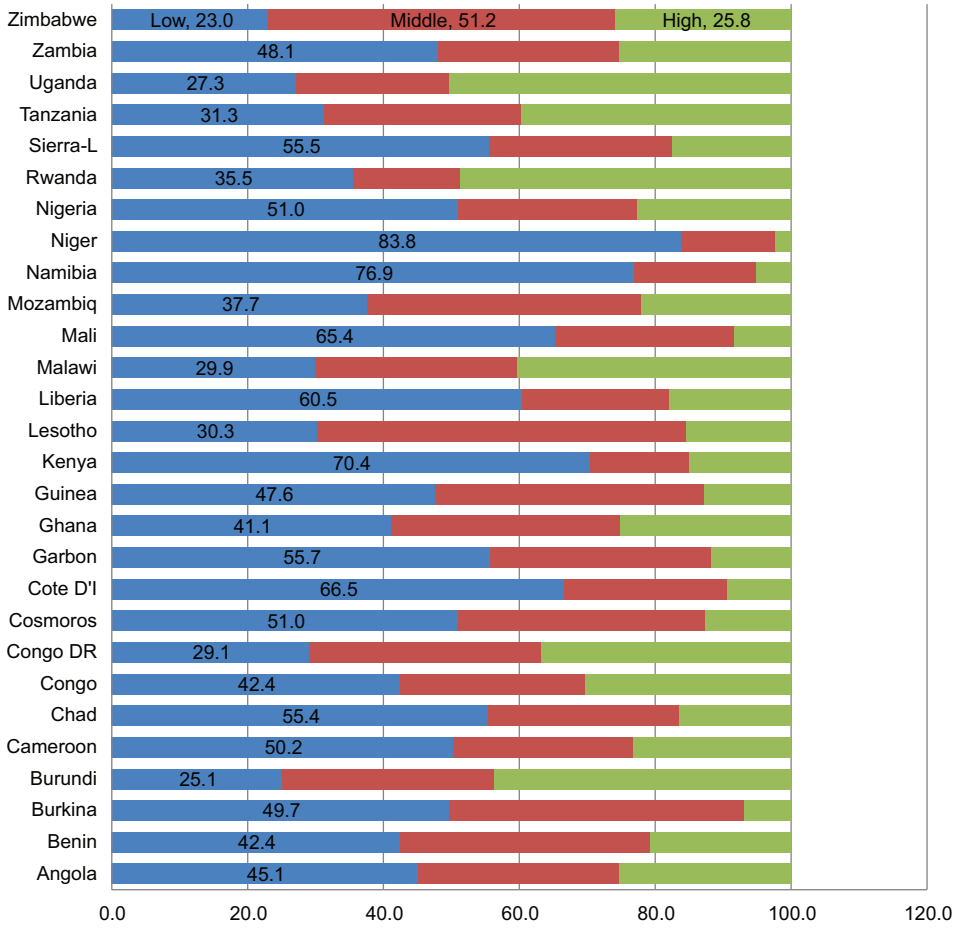


Figure 2. Level of women's empowerment in selected countries

mothers were first married at age 18 or older. These results were reaffirmed after adjusting for women's empowerment in Model 4 because children of respondents who were married at age 15 – 17 (HR: 1.33, CI: 1.02 – 1.74, $p < 0.05$) were significantly at higher risk of infant mortality than babies whose mothers were age 18 or older when they were first married. The findings obtained from Model 4 further revealed that children whose mothers were less empowered (HR: 1.41, CI: 1.10 – 1.84, $p < 0.01$) were significantly more at risk of infant mortality compared to children of women who were more empowered. The risks of infant death were significant for the offspring of child brides aged 15 – 17 in both Model 3 (HR: 1.38, CI: 1.06 – 1.80, $p < 0.05$) and Model 4 (HR: 1.33, CI: 1.02 – 1.74, $p < 0.05$). However, the risk of death during infancy was significant for children whose mothers were married before age 15 in Model 3 (HR: 1.34, CI: 1.01 – 1.89, $p < 0.05$) but was insignificant for the same group in Model 4. The results obtained from Model 4 further evinced that children of less empowered women (HR: 1.41, CI: 1.10 – 1.84, $p < 0.01$) were significantly more at risk of infant death than children whose mothers were more empowered. The relationship between child marriage and infant mortality became insignificant after controlling for the selected variables noted in Model 5. Some control variables included in Model 5 were significantly associated with infant mortality. For instance, children of women with secondary or higher education (HR: 0.80, CI: 0.58 – 0.96, $p < 0.05$) were significantly more at risk of infant mortality than children in the reference groups. Model 6 clarified that birth order, birth type, and antenatal care visits were significantly associated with infant mortality. For example, children with a 4+ birth order (HR: 0.76, CI: 0.46 – 0.95, $p < 0.05$) and children with multiple births (HR: 3.93, CI: 2.43 – 6.35, $p < 0.001$) had significantly higher risks of dying during infancy than children in the reference groups. Meanwhile, children whose mothers attended up to four or more antenatal visits (HR: 0.75, CI: 0.58 – 0.97, $p < 0.05$) had significantly lower risks of dying during infancy than children whose mothers who attended less than four antenatal visits. Like Model 6, the last model (Model 7) established some predictors of infant mortality, including birth order, birth type, antenatal visits, and country of

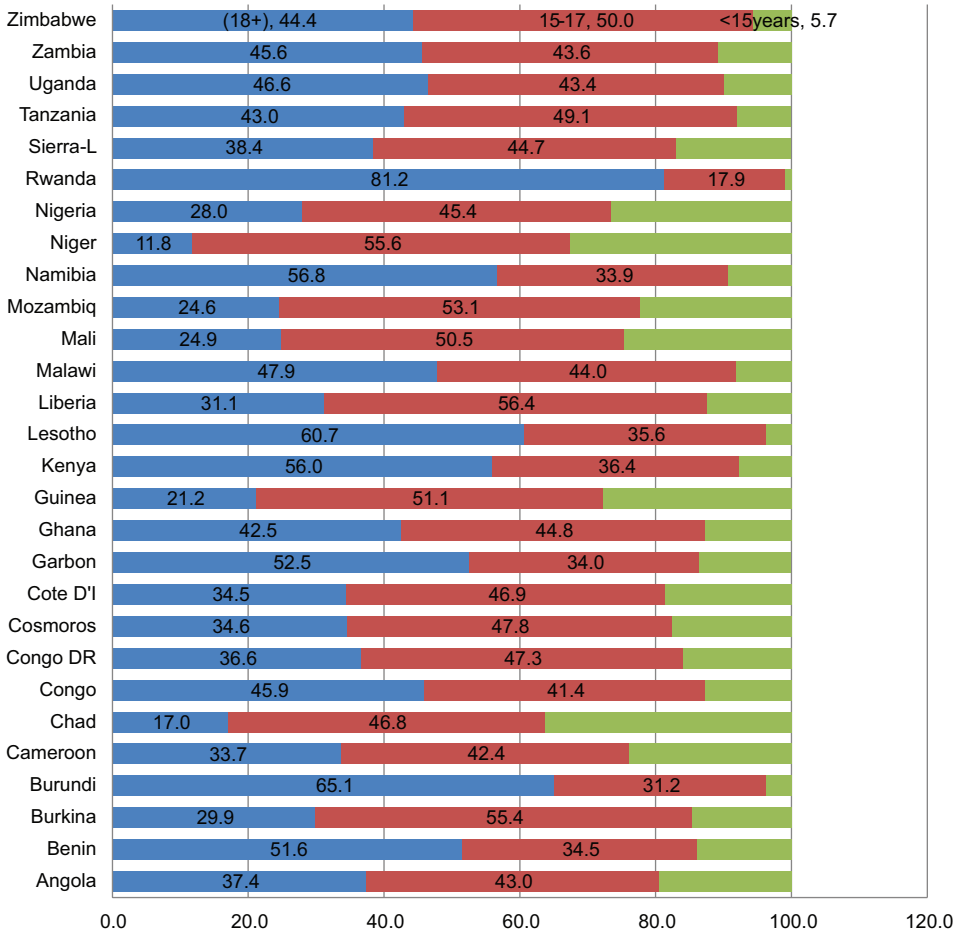


Figure 3. Age at first marriage by selected countries

residence. For instance, children born in Burkina Faso (HR: 1.79, CI: 1.00 – 3.22, $p < 0.05$), Guinea (HR: 2.21, CI: 1.09 – 4.48, $p < 0.05$), and Sierra-Leone (HR: 2.93, CI: 1.43 – 5.83, $p < 0.01$) confronted significantly higher risks of dying during infancy than children born in Nigeria.

4. Discussion

This study evidenced the influence of child marriage on infant mortality (while controlling for women's empowerment) in countries in SSA where it is still commonplace for girls to be married before the age of 18. The study represents one of the few scholarly investigations conducted on this subject and is valuable given the prevalence of child marriage and the huge burden of child death observed in many parts of SSA (Adedini *et al.*, 2022; Adedini & Akinyemi, 2022; Simmons *et al.*, 2021; UNICEF *et al.*, 2019). The findings of this study could aid policy framing and guide future actions toward improving child health outcomes in SSA.

The previous studies have primarily established variances in child mortality between high- and low/middle-income countries (Adedini & Akinyemi, 2022; UNICEF *et al.*, 2020a). However, our analysis established substantial intra- and inter-regional variations in infant mortality across SSA. The intra-regional pattern divulged that among the selected countries, Ghana, a West African country, reported the lowest infant mortality rate (per 1,000 live births), whereas Guinea, another West African country, registered the highest infant mortality rate. The previous studies have advocated for (Adedini & Akinyemi, 2022; Macassa *et al.*, 2011) context-specific programs and interventions to address the high burden of childhood deaths in countries exhibiting high incidences of infant mortality. Such actions are essential given the immense intra- and inter-regional variations in infant mortality in SSA. Such efforts will accelerate the global progression toward achieving target 3.2 of the SDGs. Our study also found that approximately half the total infant mortality in all 28 countries occurred during the neonatal period. This

Table 2. Percentage distribution of infant mortality by child marriage, women's empowerment, and selected characteristics

Characteristics	Infant mortality (% who died before age 1)		χ^2
	Dead	Alive	
Age at first marriage			3.68*
18+	4.3	95.7	
15 – 17	4.8	95.2	
<15	4.3	95.7	
Maternal age			51.07***
15 – 19	5.9	94.1	
20 – 24	4.1	95.9	
Women's empowerment			15.21**
Less empowerment	4.9	95.1	
More empowerment	3.0	96.0	
Educational attainment			16.28**
No formal education	5.2	94.8	
Primary	4.8	95.2	
Secondary or higher	4.0	96.0	
Occupation			9.84
Not working	4.3	95.7	
Professional/technical/managerial work	5.8	94.2	
Clerical/sales/agriculture/service	5.0	95.0	
Manual labor	4.4	95.6	
Child's sex			10.26*
Male	5.0	95.0	
Female	4.3	95.7	
Birth order			41.94***
First	5.4	94.6	
2 – 3	3.9	96.1	
4+	4.9	95.6	
Number of births			346.10***
Singleton	4.3	95.7	
Multiple births	18.5	81.5	
Religion			13.17*
Christianity	4.6	95.4	
Islam	5.5	94.5	
Others	4.3	95.7	
Wealth quartile			18.05*
Poorest	4.6	95.4	
Poorer	5.1	94.9	
Middle	4.5	95.5	
Richer	4.6	95.4	
Richest	4.1	95.9	
Place of residence			2.86
Rural	4.3	95.7	
Urban	4.8	95.2	
Family structure			2.04
Monogamous	4.6	95.4	
Polygamous	5.1	94.9	
Place of delivery			45.51***
Home	5.6	94.4	
Facility-based	4.1	95.9	
Other	5.9	94.1	
Antenatal care visits			89.65***
<4	5.7	94.3	
4+	3.6	96.4	

(Cont'd...)

Table 2. ***(Continued)***

Note: *p<0.05, **p<0.01, ***p<0.001.

Table 3. Cox proportional hazard model examining the effects of child marriage and women's empowerment on infant mortality

Variables	Model 1	Model 2
Age at first marriage		
10	0.56 (0.13 – 2.29)	0.55 (0.13 – 2.28)
11	0.75 (0.23 – 2.14)	0.76 (0.24 – 2.41)
12	1.19 (0.60 – 2.32)	1.18 (0.60 – 2.31)
13	1.74 (0.93 – 3.26)	1.72 (1.00 – 3.23)*
14	1.39 (0.95 – 2.32)	1.38 (0.94 – 2.03)
15	1.65 (1.18 – 2.31)**	1.66 (1.19 – 2.32)**
16	1.40 (1.04 – 1.90)*	1.42 (1.05 – 1.93)*
17	1.30 (0.93 – 1.83)	1.34 (0.95 – 1.88)
18+ (RC)	1.00	1.00
Women's decision-making		
Less empowerment		1.34 (1.05 – 1.71)*
More empowerment		1.00

Note. *p<0.05, **p<0.01.
Abbreviation: RC: Reference category.

outcome calls for more concerted efforts and interventions to bolster child survival rates during the 1st month after birth.

Table 4. Cox proportional hazard model examining the effects of child marriage, women's empowerment, and selected control variables on infant mortality

Variables	Model 3	Model 4	Model 5	Model 6	Model 7
Age at first marriage					
18+years (RC)	1.00	1.00		1.00	1.00
15 – 17	1.38 (1.06 – 1.80)*	1.33 (1.02 – 1.74)*	1.07 (.81 – 1.39)	1.09 (.81 – 1.44)	1.05 (0.78 – 1.39)
<15 years	1.34 (1.01 – 1.89)*	1.26 (0.89 – 1.79)	0.91 (.63 – 1.32)	0.94 (.62 – 1.40)	0.90 (0.60 – 1.36)
Women's decision-making					
Less empowerment		1.41 (1.10 – 1.84)**	1.31 (1.01 – 1.69)*	1.28 (.98 – 1.65)	1.23 (0.94 – 1.61)
More empowerment		1.00	1.00	1.00	1.00
Maternal educational attainment					
No formal education			1.00	1.00	1.00
Primary			1.06 (0.79 – 1.42)	1.14 (0.85 – 1.52)	1.30 (0.94 – 1.79)
Secondary or higher			0.8 (0.58 – 0.96)*	0.89 (0.64 – 1.23)	1.00 (0.70 – 1.44)
Maternal occupation					
Not working			1.00	1.00	1.00
Professional/technical/managerial work			0.92 (0.23 – 3.79)	0.99 (.24 – 3.97)	1.01 (0.23 – 4.21)
Clerical/sales/agriculture/service			1.08 (0.83 – 1.39)	1.14 (0.88 – 1.47)	1.04 (0.77 – 1.41)
Manual labor			0.81 (0.52 – 1.25)	0.86 (0.55 – 1.33)	0.89 (0.55 – 1.43)
Religion					
Christianity			1.00	1.00	1.00
Islam			1.14 (0.84 – 1.55)	1.08 (0.79 – 1.45)	1.37 (0.87 – 2.14)
Others			0.88 (0.66 – 1.17)	0.89 (0.66 – 1.18)	1.18 (0.81 – 1.71)
Wealth quartile					
Poorest (RC)			1.00	1.00	1.00
Poorer			0.86 (0.63 – 1.18)	0.89 (0.65 – 1.22)	0.88 (0.64 – 1.21)
Middle			0.72 (0.51 – 1.02)	0.75 (0.53 – 1.06)	0.73 (0.51 – 1.04)
Richer			0.87 (0.61 – 1.25)	0.95 (0.66 – 1.36)	0.91 (0.61 – 1.34)
Richest			0.79 (0.48 – 1.31)	0.85 (0.50 – 1.42)	0.79 (0.44 – 1.42)
Family structure					
Monogamous			1.00	1.00	1.00
Polygamous			1.27 (0.95 – 1.70)	1.26 (0.94 – 1.67)	1.20 (0.89 – 1.61)
Place of residence					
Rural			1.18 (0.85 – 1.64)	1.10 (0.79 – 1.52)	1.11 (0.79 – 1.56)
Urban			1.00	1.00	1.00
Child's sex					
Male				1.00	1.00
Female				1.08 (0.85 – 1.36)	1.05 (0.85 – 1.35)
Birth order					
First				1.00	1.00
2 – 3				0.82 (0.61 – 1.08)	0.81 (0.61 – 1.08)
4+				0.76 (0.46 – 0.95)*	0.76 (0.45 – 0.97)*
Birth type					
Single				1.00	1.00

(Cont'd...)

Table 4. ***(Continued)***

Variables	Model 3	Model 4	Model 5	Model 6	Model 7
Multiple				3.93 (2.43 – 6.35)***	3.97 (2.44 – 6.47)***
Antenatal care visits					
<4				1.00	1.00
4+				0.75 (.58 – 0.97)*	0.75 (0.58 – 0.98)*
Place of delivery					
Facility-based				1.00	1.00
Home				1.31 (1.01 – 1.69)	1.35 (.096 – 1.89)
Other				0.78 (0.33 – 1.81)	0.90 (0.37 – 2.17)
Country					
Nigeria (RC)					1.00
Angola					1.06 (0.42 – 2.69)
Benin					0.80 (0.37 – 1.73)
Burkina Faso					1.79 (1.00 – 3.22)*
Burundi					1.33 (0.54 – 3.29)
Cameroon					0.71 (0.34 – 1.49)
Chad					1.47 (0.78 – 2.43)
Congo					1.59 (0.61 – 4.14)
Congo DR					1.77 (0.77 – 4.07)
Comoros					1.30 (0.44 – 3.78)
Cote D'Ivoire					1.68 (0.67 – 4.15)
Gabon					0.36 (0.09 – 1.38)
Ghana					0.06 (0.01 – 0.51)**
Guinea					2.21 (1.09 – 4.48)*
Kenya					1.20 (0.57 – 2.52)
Lesotho					0.58 (0.21 – 1.59)
Liberia					0.52 (0.12 – 2.18)
Malawi					0.60 (0.24 – 1.47)
Mali					0.83 (0.40 – 1.74)
Mozambique					1.31 (0.49 – 3.48)
Namibia					1.31 (0.28 – 6.00)
Niger					0.82 (0.35 – 1.94)
Rwanda					0.93 (0.30 – 2.89)
South Africa					1.20 (0.24 – 5.92)
Sierra-Leone					2.93 (1.43 – 5.83)**
Tanzania					0.48 (0.15 – 1.52)
Uganda					0.95 (0.52 – 1.72)
Zambia					1.09 (0.32 – 3.68)
Zimbabwe					1.09 (0.41 – 2.85)

Note: *p<0.05, **p<0.01, ***p<0.001.
Abbreviation: RC: Reference category.

Our multivariable analysis explored the independent effects of child marriage on infant mortality and its results established an association between the two variables: children of women who were first married before age 15 and at the age range of 15 – 17 were found to confront elevated danger of dying in the 1st year of their life. The

association between early marriage and infant mortality was similar in magnitude in the unadjusted models for women who married before age 15 and those who married at the age span of 15 – 17 years. It was hypothesized that girls who are married before age 15 would bear children with worse health outcomes than those who married in later adolescence (Kramer & Lancaster, 2010); however, our results indicated a somewhat similar pattern in the risks of infant mortality of both groups. Nevertheless, our findings were congruent with Kramer's (2008) report that children whose mothers got married before age 18 (at <15 or 15-17) exhibited a higher risk of death compared with those whose mothers were married as adults (aged 18+). The model that considered age at marriage as a continuous variable also indicates slight variations in the estimated effects of child marriage on infant mortality by the mother's age at marriage.

Numerous plausible reasons could be posited for the high risk of death of children of child brides. Child brides have a limited capacity for healthy childbearing and childrearing (Parsons *et al*., 2015; Raj, 2010). Scholars have argued that the risks of malnutrition, underweight, stunting, and wasting are generally high among children of child brides (Kidman, 2017; Nour, 2006; Raj *et al*., 2010). Furthermore, children of child brides tend to have poor access to adequate health care due to limited resources (Atuoye *et al*., 2015; Rutherford *et al*., 2010). The previous studies have also asserted that child marriage should not always be viewed as a forced marital dyad; it is sometimes a viable option for poor parents and their daughters due to the limited choices limited (Mobolaji *et al*., 2020; Schaffnit *et al*., 2019; Schaffnit *et al*., 2021). Therefore, we controlled for proxy measures of women's empowerment in this study. An analysis was conducted to compare the estimated effects of child marriage on infant mortality with and without the inclusion of controls for women's empowerment. We assumed that controlling for women's empowerment would result in an insignificant association between the outcome and exposure variables if early marriage is explained as the best available option due to women's low social status. A significant relationship was established between child marriage and infant mortality in Models 1 – 4; however, the relevant values became insignificant in Models 5 – 7 after adjusting for proxy measures of women's empowerment, education, occupation, and other control variables. These outcomes lend credence to the findings of previous studies that emphasize the crucial function of the agency and autonomy of women in decision-making related to their reproductive health (Budu *et al*., 2020; Sougou *et al*., 2020; Wado, 2018). The outcomes of our study suggest that age at marriage is of little relevance to infant mortality once women's empowerment and other selected covariates are considered in the analysis. The results also indicate that efforts to improve infant mortality must include strategies to improve the socioeconomic status of women by encouraging the education of girls, enhancing their employment prospects, and encouraging their participation in decision-making processes.

Furthermore, we found that some of the selected demographic and socioeconomic characteristics influencing child marriage are also predictors of infant mortality. Poor socioeconomic status (SES) makes early marriage an attractive option to parents, and their daughters could also predispose the children of child brides to unfavorable socioeconomic and health conditions. For instance, if the hypothesis that girls could opt for early marriages in the attempt to liberate themselves from the unfavorable conditions in their natal households is correct, it is expected that children of child brides would also be somewhat disadvantaged by the poverty and poor socioeconomic status that pushed their psychologically unprepared and young mothers into early marriage.

This study has some drawbacks. First, this study used cross-sectional datasets, precluding a cause–effect analysis. A longitudinal study design could offer the opportunity to explore causality; however, such datasets are rarely available across SSA. Second, the studied datasets were not compiled in the same year in all the selected countries. However, our findings cannot be invalidated by this limitation because the changes in key reproductive health variables across SSA were non-significant during the study period. Our study presents several strengths notwithstanding its limitations. First, our study utilized nationally representative data. Second, the DHS program utilized a similar data collection methodology across countries, allowing us to effect cross-country comparisons.

5. Conclusions

This study established a higher risk of infant deaths in children of child brides than in those of adult brides. However, this relationship became insignificant after controlling for indicators of women's empowerment and other control variables. The study thus indicates that high socioeconomic status (improved education, employment, and enhanced wealth status for girl children) helps ameliorate poor health outcomes and mitigate vulnerabilities in children of child brides. Therefore, policies directed toward raising the educational status of girl children are a crucial strategy for improving child survival rates in SSA. We conclude that enhancing women's empowerment and increasing economic opportunities for women (such as their participation in the agriculture and formal employment sectors) will contribute to the reduction of infant mortality in SSA.

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Conflict of interest

Authors declare no conflicts of interest.

Author contributions

Conceptualization: Sunday A. Adedini
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Writing – review & editing: Sunday A. Adedini

Ethics approval and consent to participate

This study utilized secondary data from DHS with all identifier information removed. The MEASURE Demographic and Health Surveys project was reviewed and approved by the Institutional Review Board (IRB) of Inner City Fund (ICF), United States. All study participants gave written informed consent and the projects were implemented following relevant guidelines and regulations.

Consent for publication

Not applicable.

Availability of data

Datasets for this study were obtained from the Demographic and Health Survey (DHS) program. These are publicly available data that can be accessed on request at https://dhsprogram.com/Data/.

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