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Protective role of health insurance coverage in reducing under-five mortality in Ethiopia: Gompertz inverse-Gaussian shared frailty modelling

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ABSTRACT

Objective To determine the association between health insurance coverage and under-five mortality in Ethiopia using data from the 2016 Ethiopia Demographic and Health Survey (EDHS).

Methods The current study used a total of 10 641 under-five children from the 2016 EDHS. To identify the predictors, the Gompertz inverse-Gaussian shared frailty model was fitted. The theta value, Akaike Information Criteria and Bayesian Information Criteria were applied for model evaluation, and variables with p values less than 0.2 were included in the multivariable analysis. The strength and statistical significance of the associations were demonstrated by reporting the adjusted HR (AHR) with a 95% CI in the multivariable Gompertz inverse-Gaussian shared frailty model.

Results According to the study's findings, 96.46% of the children were born to mothers not covered by health insurance. The study found that health insurance coverage was significantly associated with a lower risk of under-five mortality (not covered: AHR=0.13; 95% CI 0.02, 0.95). Other factors that showed significant associations with under-five mortality include place of residency, family size, twin status, place of delivery and preceding birth interval.

Conclusion The findings indicate that health insurance coverage in Ethiopia is significantly associated with a lower risk of mortality among children under five. However, coverage remains low among mothers of these children, highlighting an urgent need for policies and interventions aimed at expanding health insurance coverage and addressing key determinants of child health to reduce under-five mortality and improve child survival outcomes. Addressing gaps in health insurance and other contributing factors is vital for creating effective strategies to lower under-five mortality rates.

STRENGTHS AND LIMITATIONS OF THE STUDY

⇒ Uses a nationally representative survey, improving the generalisability to all children under five in Ethiopia and increasing statistical power.
⇒ Accounts for the effect of clustering, reflecting the correlation between data from the same cluster.
⇒ Mothers' recall of events over the past 5 years may be affected by recall bias.
⇒ Relies on secondary data, which exclude important variables that significantly predict under-five mortality.
⇒ Women's health insurance status may have differed between the time of the child's death and the time of the interview, which could introduce bias into the findings.

INTRODUCTION

Under-five mortality, which refers to the number of children aged 0–59 months who die before reaching the age of five,[1] serves as a crucial indicator of a country's overall health and population well-being. It reflects the combined impact of various health determinants, including maternal health, the quality and accessibility of healthcare services, socioeconomic factors and public health interventions.[2]

The leading causes of death among children under 5 years of age include preventable and treatable conditions such as respiratory infections, diarrhoeal diseases and malnutrition, along with neonatal issues such as prematurity, birth asphyxia and congenital anomalies.[3] Additionally, under-five mortality is influenced by factors such as limited access to healthcare, poverty and inadequate access to clean water and sanitation.[4 5] Socioeconomic conditions significantly impact these mortality rates, as families living in poverty often face challenges in accessing healthcare services, clean water and adequate nutrition. Moreover, educational levels, particularly maternal education, are crucial in shaping child health outcomes.[6]

The Sustainable Development Goals (SDGs) set by the United Nations include a critical target to end preventable deaths of newborns and children under five by 2030. The aim is for all countries to reduce under-five mortality to no more than 25 per 1000 live births.[7] Achieving this target requires a comprehensive approach that addresses both direct and indirect causes of child mortality.[8] Despite significant progress in reducing child mortality rates over the past few decades, the deaths of children under 5 years of age continue to account for a substantial portion of preventable deaths worldwide.[7] According to a WHO report, approximately 5 million children under the age of five died in 2022, with most of these deaths occurring in sub-Saharan Africa and southern Asia.[9] In Ethiopia, the under-five mortality rate decreased from 123 deaths per 1000 live births in 2005 to 88 deaths per 1000 live births in 2011 and further to 67 deaths per 1000 live births in 2016.[10] These figures highlight a significant decline in under-five mortality rates over the past decade, reflecting the country's progress in improving child health. This notable improvement can be attributed to several factors, including the expansion of immunisation programmes, enhancements in maternal and child health services and the implementation of the Health Extension Program, which has brought essential health services to remote and underserved areas.[11 12] Additionally, the government has made efforts to improve healthcare infrastructure and increase access to essential medications and treatments.[13]

Despite these efforts, Ethiopia's under-five mortality rate remains high compared with global standards, highlighting the complex interplay of challenges related to healthcare access, quality of care and socioeconomic factors. In 2019, Ethiopia ranked among the top 10 countries with the highest number of under-five deaths.[14] This poses a significant challenge to Ethiopia's progress toward achieving the SDGs, particularly Goal 3, which aims to ensure healthy lives and promote well-being for all at all ages, including children.[7]

Health insurance plays a crucial role in achieving universal health coverage (UHC) by pooling risks and resources, which helps reduce out-of-pocket (OOP) expenses for individuals.[15] This financial protection enables families to seek timely and adequate medical care for their children, which is critical in preventing and treating illnesses that contribute to child mortality. By reducing barriers to accessing essential health services, health insurance can significantly lower child mortality rates, leading to healthier, more resilient communities.[16] Additionally, it enhances maternal health service utilisation, such as antenatal care (ANC), institutional delivery and postnatal care, by reducing financial barriers and ensuring timely interventions.[17] However, in Ethiopia, these maternal health services are exempted and provided free of charge in public facilities, which may limit the direct impact of health insurance on their utilisation, though it can still contribute by improving service quality and reducing indirect costs.[18]

Previous studies have shown mixed results regarding the relationship between health insurance coverage and under-five mortality rates. Several studies conducted in Nigeria, Pakistan, Uganda, rural Ethiopia and Tanzania have demonstrated a significant association between health insurance coverage and under-five mortality, suggesting that comprehensive coverage can improve child health outcomes by enhancing access to essential medical services and preventive care.[19–23] This association is often attributed to increased utilisation of healthcare services and better management of childhood illnesses, both of which are critical for reducing mortality rates among young children.[24] However, a national study from Egypt reported no significant association between health insurance coverage and under-five mortality in urban areas, while a significant association was observed in rural settings, challenging the idea that insurance coverage alone can lead to substantial improvements in child health outcomes.[25] This inconsistency may be attributed to differences in healthcare infrastructure, service utilisation patterns and the quality of health services available in urban versus rural areas. In urban settings, the presence of a relatively better-developed healthcare system and higher baseline healthcare access may diminish the impact of health insurance on child mortality. Conversely, in rural areas, where healthcare access is more limited and OOP expenditures pose a greater financial burden, health insurance may play a more critical role in improving child survival outcomes.[26]

Ethiopia launched the Community-Based Health Insurance (CBHI) scheme in 2010 as part of the Ethiopian Health Sector Transformation Plan, which aimed to achieve UHC by ensuring all citizens have access to affordable, high-quality healthcare services. Initially, the programme was introduced as a pilot in 13 woredas across four regions (Amhara, Oromia, Southern Nations, Nationalities and Peoples' Region (SNNPR) and Tigray) with the goal of improving financial protection and increasing healthcare utilisation among informal sector workers and rural communities.[27] The programme was later expanded to more woredas due to its positive impact on healthcare access and financial risk protection.[28]

Evaluations of CBHI have shown that enrolment in the scheme is associated with increased utilisation of health services, reduced OOP expenditures and improved financial protection for households.[29] However, challenges such as sustainability, enrolment retention and service quality issues remain significant concerns.[30]

Despite these findings, there is still a considerable gap in understanding the relationship between health insurance coverage and under-five mortality rates. While previous research in Ethiopia has examined various determinants of under-five mortality, including maternal sociodemographic factors and household conditions, the specific role of health insurance coverage has not been a primary focus.[31 32]

To date, only one study has focused on health insurance as a predictor of under-five mortality in rural

Ethiopia.[19] Although CBHI in Ethiopia has primarily targeted rural areas, which comprise informal sector workers and agricultural communities, disparities persist in urban settings. Poorer urban households face greater challenges in CBHI enrolment and have lower healthcare utilisation compared with wealthier urban residents. Despite higher overall poverty levels, urban areas continue to experience significant health inequities, with the urban poor struggling to access affordable healthcare in contrast to their wealthier counterparts.[33 34]

Understanding the association between health insurance and under-five mortality is essential for formulating effective strategies that could optimise the benefits of health insurance to reduce under-five mortality, in line with achieving the SDG targets and ensuring that every child has a chance to survive. Therefore, the main objective of this study was to investigate the association between

Table 1 List of confounding variables for the study on the protective role of health insurance coverage in reducing under-five mortality in Ethiopia

Variables	Description/category
Maternal-related variables	
Maternal age	The age of the mother was categorised as 15–24 years, 25–34 years and 35–49 years.
Age at first birth	Classified as less than 20 and 20 or above.
Maternal occupation	Categorised as having occupation/no occupation.
Marital status	Categorised as currently in union/not in union.
Educational status	Women's educational status was categorised as no education, primary, secondary and higher.
Parity	The number of children ever born is categorised as 3 or less and 4 or more.
Number of ANC visits	Classified as none, 1 to 3 and 4 or above.
Place of delivery	Categorised as home/health facility.
Media exposure	Women exposed to one of the media (reading newspapers/magazines, listening to the radio and watching television) were classified as yes/no.
Husband/partner education	Categorised as no education, primary, secondary and higher.
Husband/partner occupation	Categorised as having occupation/no occupation.
Household-related variables	
Family size	Classified as one to three, four to six and more than six.
Sex of the household head	Male/female
Wealth status	Categorised as poorest, poorer, middle, richer and richest.
Source of drinking water	Categorised as improved and unimproved.
Child-related variables	
Twin status	Categorised as single and multiple births.
Sex of the child	Male/female
Preceding birth interval	Measured in months and classified as less than 18 years, 18–36 years and above 36 years.
Breastfeeding experience	Categorised as never breastfed and ever breastfed/still breastfeeding.
Community-level variables	
Region	Categorised on the basis of geopolitical characteristics as 'small peripheral' areas (Afar, Somalia, Benishangul and Gambella), 'larger central' areas (Tigray, Amhara, Oromia and SNNPR) and 'metropolitan' regions (Harari, Dire-Dawa and Addis Ababa).[60]
Residence	The respondent's place of residence was urban/rural.
Community education level	The proportion of mothers in the cluster who were not educated. They were classified into two categories: a higher proportion of mothers with no formal education within the cluster and a lower proportion of mothers with no formal education.
Community poverty level	The proportion of children from the poorest households within a cluster. This measure aggregates the proportions of children from the poorest households to represent the overall poverty status within the cluster. Clusters were categorised into two groups based on the national median value: those with a higher proportion of children from the poorest households and those with a lower proportion.

ANC, antenatal care; SNNPR, Southern Nations, Nationalities and Peoples' Region.

health insurance coverage and under-five mortality in Ethiopia using survival analysis. The results provide evidence-based insights into how health insurance can play a role in reducing under-five mortality, supporting ongoing efforts to improve child survival rates.

METHODS

Study design and area

This study used data from the 2016 Ethiopia Demographic and Health Survey (EDHS), a nationally representative survey conducted by the Central Statistical Agency of Ethiopia. The 2016 EDHS is a cross-sectional survey which aims to provide data on health and related variables. The Measure DHS program granted permission to use the data.

Sampling technique and study population

The EDHS survey used a two-stage sampling process. In the first stage, regions were stratified, and then each region was separated into urban and rural areas, resulting in 21 sample strata. Enumeration areas (EAs) were then independently selected within each stratum in two stages. Detailed information about the DHS methodology can be found in the official database (https://dhsprogram.com/Methodology/index.cfm). This study used the survey's Children Recode file, which includes birth records for women aged 15–49 years who had given birth in the 5 years preceding the survey. The source population for this study consisted of all live births in Ethiopia within the 5 years preceding the survey period, while the study population was live births in the selected EAs within the same time period. For the analysis, a sample of 10 641 children under the age of five was used.

Study variables and measurements

Dependent variable

The dependent variable was the time to death of children before the age of five. Children who died before reaching

Table 2 Schoenfeld residuals test for checking the proportional hazards assumption for the study on the protective role of health insurance coverage in reducing under-five mortality in Ethiopia

Variables	Rho	χ^2	Df	Prob>χ^2
Family size	0.12627	1.68	1	0.1949
Health insurance coverage	−0.18092	0.07	1	0.79
Source of drinking water	0.13297	1.58	1	0.209
Toilet facility	−0.23682	4.77	1	0.0289
Sex of household head	0.19373	3.63	1	0.0566
Media exposure	−0.10298	1.06	1	0.3026
Wealth index	0.0878	0.78	1	0.3761
Maternal age	0.24934	5.16	1	0.0231
Maternal education	0.14701	1.8	1	0.1792
Husband/partners' education	−0.20721	3.42	1	0.0644
Husband/partners' occupation	0.1647	2.39	1	0.1221
Maternal occupation	−0.28801	7.8	1	0.0052
Twin status	−0.01864	0.03	1	0.864
Sex of the child	0.2388	4.67	1	0.0308
ANC follow-up	0.07991	0.53	1	0.4662
Place of delivery	−0.09534	0.86	1	0.3545
Size of the child at birth	−0.22121	5.01	1	0.0252
Birth order	−0.04595	0.17	1	0.6787
Breastfeeding experience	−0.06247	0.33	1	0.5682
Preceding birth interval	−0.02568	0.05	1	0.8236
Residence	−0.05245	0.23	1	0.6344
Region	−0.07657	0.49	1	0.4841
Community poverty level	−0.04671	0.21	1	0.6496
Community education level	−0.11028	1.08	1	0.2982
Global test		**44.82**	**24**	**0.0061**

Note: The first and last rows are bolded for clarity, indicating the variable names and the overall result of the global test for the PH assumption, respectively.
ANC, antenatal care.

Table 3 Log-rank test for the study on the protective role of health insurance coverage in reducing under-five mortality in Ethiopia

Variables	P value	Variables	P value
Family size	<0.001	ANC	<0.001
Health insurance coverage	<0.001	Place of delivery	<0.001
Source of drinking water	0.009	Husband education	0.34
Toilet facility	0.19	Size of the child at birth	0.03
Sex of household head	0.13	Birth order	0.42
Media exposure	0.15	Breastfeeding	0.26
Household wealth status	<0.001	Preceding birth interval	<0.001
Maternal age	0.26	Residence	<0.001
Maternal education	<0.001	Region	<0.001
Husband occupation	0.02	Community poverty level	0.004
Maternal occupation	0.2	Community illiteracy level	<0.001
Twin status	<0.001		
Sex of the child	0.9		

ANC, antenatal care.

5 years of age were considered to have experienced the event and were coded as 1. Those who did not die were considered censored and were coded as 0. Data on child survival were gathered retrospectively through interviews with mothers, and the age at death was recorded in months.

Explanatory variables

The primary exposure variable in this study was health insurance coverage, defined as insurance that covers the medical expenses of mothers under social security insurance, employer-based insurance or mutual health organisation/community-based insurance. The confounding factors identified in the literature were categorised into household-related, maternal-related, child-related and community-level characteristics. Two community-level variables were created by aggregating individual-level data at the cluster level, as these variables were not directly available in the DHS dataset. The aggregates were calculated by determining the average proportions of women in each category of the respective variables. Median values were subsequently used to categorise these aggregated variables into groups, such as low levels and high levels of community poverty level and women's education (table 1).

Data management and analysis

Data extraction, coding and statistical analysis were conducted using Stata 17 software. The distribution of variables was presented using descriptive statistics, which included unweighted frequencies and weighted percentages. Since household selection probabilities vary across clusters in EDHS surveys, weighting was applied to ensure representativeness at both national and regional levels. The dataset was weighted using the v005 variable, which represents the women's individual sample weight, and was divided by 1 000 000 for analysis to accurately reflect the population structure. Missing values were identified in variables such as the number of ANC visits, child's size at birth, preceding birth interval and husband/partner's education and occupation. These missing data were addressed in accordance with the guidelines provided in the *Guide to DHS Statistics (DHS-7, Version 2)* to ensure methodological consistency and accuracy.[35] We assessed multicollinearity among independent variables using a correlation matrix. No variables had a correlation coefficient above 0.8, indicating that multicollinearity was not a major concern (online supplemental file 1).

The proportional hazards (PH) assumption was assessed using the Schoenfeld residuals test. The global p value was found to be less than 0.05, indicating a violation of the PH assumption, which suggests that using the Cox PH model is not appropriate for analysing these data (table 2). In contrast, parametric survival models do not rely on the PH assumption, as they define a specific distribution for survival times. This allows them to handle a variety of hazard functions, making them more flexible and effective in cases where the HR varies over time, thus providing a more accurate representation of survival data when the PH assumption is violated. The log-rank test was used to compare survival distributions between population groups. The null hypothesis for this test states that there are no differences in the probability of an event (in this case, death) occurring at any given time point across the groups (table 3). Survival time and comparison of survival rates, stratified by health insurance coverage, were analysed using the Kaplan-Meier estimation method.

Since the DHS data structure was hierarchical, we employed a frailty model (a random effect survival model) to assess clustering within the data. The presence of unobserved heterogeneity or shared frailty was

confirmed by a significant theta in the null model (likelihood ratio (LR) test of theta=0: χ^2 = 125.76, p<0.001). This finding indicates that children within a cluster tend to be more closely correlated with each other than with children in other clusters.

Cluster-specific EAs were used as a random effect in a shared frailty model with baseline distributions (Weibull, Gompertz and exponential) and frailty distributions (gamma and inverse Gaussian). It was determined that the Gompertz inverse-Gaussian shared frailty model best suited the data because it had the lowest values of Akaike Information Criteria and Bayesian Information Criteria. Variables with p values below 0.2 in the bivariable Gompertz inverse-Gaussian shared frailty analysis were selected for inclusion in the multivariable analysis. To evaluate the robustness of the analysis results, a sensitivity analysis was performed by excluding multiple births. However, no significant changes were observed in the HRs or CIs. Therefore, the original model was retained. The significance and strength of the association between under-five mortality and the independent variables in the multivariable Gompertz inverse-Gaussian shared frailty model were assessed using the adjusted HR (AHR) and 95% CI.

RESULTS

Distribution of the study population

A total of 10 641 under-five children were included in the study. The majority of the children (88.96%) were from rural areas. A vast majority of children (96.46%) reside in households not covered by health insurance, indicating extremely low coverage. Two-thirds (66.08%) of the children were born to mothers who had no formal education. 37 (37.20%) children were born to mothers who had no ANC follow-up (online supplemental file 2).

Comparison of failure functions

The Kaplan-Meier failure curve was used to assess the probability for mortality across categorical explanatory variables graphically and the log-rank test statistically. The overall Kaplan-Meier failure curve showed an increase in the likelihood of under-five mortality over time (figure 1). Additionally, the Kaplan-Meier failure curve stratified by health insurance coverage revealed that children of uninsured mothers had a higher probability of death compared with those with health insurance (figure 2). There was a statistically significant variation in under-five mortality across health insurance coverage, family size, source of drinking water, household wealth status, maternal education, husband occupation, birth type, ANC visit, place of delivery, size of the child at birth, preceding birth interval, residence, region, community poverty level and community illiteracy level (log-rank, p<0.05) (table 3).

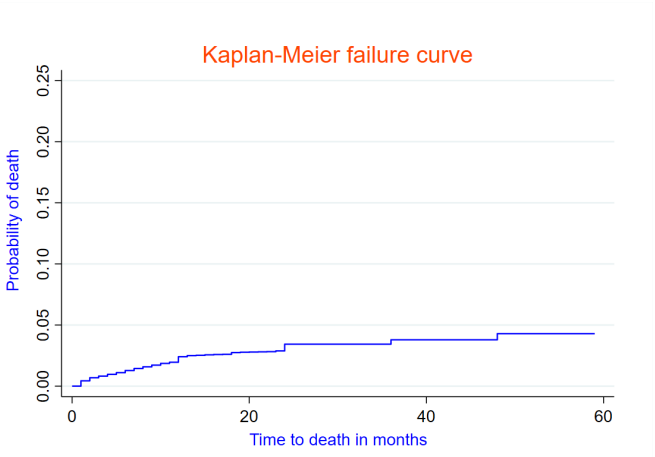

Figure 1 The Kaplan-Meier failure curve of under-five mortality for the study on the protective role of health insurance coverage in reducing under-five mortality in Ethiopia.

Association between health insurance coverage and under-five mortality

The study revealed that children born to mothers who had health insurance coverage were significantly less likely to die than those whose mothers were not insured. Specifically, these children had an 87% lower risk of death (AHR=0.13, 95% CI 0.02, 0.95) than those who did not (online supplemental file 3). This suggests a strong protective influence of maternal health insurance on child survival.

Other predictors of under-five mortality in Ethiopia

In the multivariable Gompertz inverse-Gaussian shared frailty model, in addition to health insurance coverage, factors such as residence, family size, birth type, place of delivery, preceding birth interval and region were found to be significant predictors of time to under-five mortality

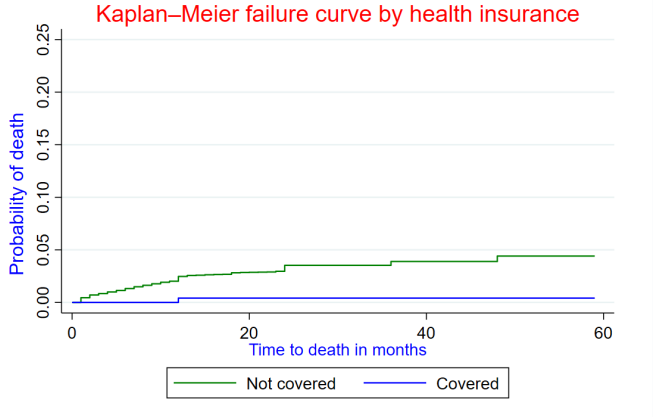

Figure 2 The Kaplan-Meier failure curve of under-five mortality by health insurance coverage for the study on the protective role of health insurance coverage in reducing under-five mortality in Ethiopia.

in Ethiopia. Compared with their counterparts, children born to mothers who lived in urban areas had a 58% (AHR=0.42, 95% CI 0.18, 0.94) lower risk of death. Children born 18–36 months or more than 36 months after the previous birth had a 43% (AHR=0.57, 95% CI 0.41, 0.79) and an 82% (AHR=0.27, 95% CI 0.18, 0.42) lower mortality risk, respectively, than those born less than 18 months apart (online supplemental file 2).

Additionally, children in households with a family size of four to six members and those with more than six members were at a 72% (AHR=0.28, 95% CI 0.18, 0.44) and 81% (AHR=0.19, 95% CI 0.12 to 0.31) reduced risk of death, respectively, compared with those in smaller families of one to three members. Compared with those born at home, children who were delivered in healthcare facilities had a 61% lower risk of mortality (AHR=0.59, 95% CI 0.38, 0.93). However, children born as part of a multiple birth were 3.35 times more likely to die (AHR=3.35, 95% CI 1.86 to 6.02) than those from single births. Finally, children born to mothers in small peripheral regions faced a 1.48 times greater risk of death (AHR=1.48, 95% CI 1.01, 2.18) than those whose mothers lived in larger central regions (online supplemental file 2).

DISCUSSION

The primary objective of this study was to examine the association between health insurance coverage and the risk of mortality among Ethiopian children under the age of five.

The findings revealed a significant association, indicating that children whose mothers had health insurance were at a lower risk of death compared with those whose mothers did not have coverage. This finding aligns with previous research, which has shown that maternal health insurance coverage acts as a protective factor against under-five mortality. [19 20 36]This can be explained by the fact that health insurance is useful since it reduces financial constraints associated with medical expenses and provides access to services that would otherwise be prohibitively expensive.[37] However, this study indicated that the coverage of health insurance was extremely low. These findings suggest that the government should enhance insurance coverage for the necessary services to promote the use of healthcare services and, as a result, increase the survival of children under the age of five through efficient service utilisation. Additionally, it is important to adjust and increase coverage and capability levels to make medical services more accessible to households with insured children because investing in children's health affects not only their own well-being but also the health of the entire society and the future of the nation as a whole.

This study provides an interesting insight into the relationship between family size and child mortality, revealing that children living in households with a family size of four or more were less likely to die than those in less than four households. In the absence of a universally accepted definition for 'large' family size, we referred to households with four or more members as 'larger' relative to those with fewer than four members. This terminology was guided by previous studies, including the study by Stamoulis and Pierrakos, which highlights varying definitions across contexts.[38] This finding contrasts with previous studies conducted in the Awi zone, SNNPR, rural parts of Ethiopia and sub-Saharan Africa, which suggested that children in households with fewer than four members were associated with a lower risk of mortality compared with those in families with four or more members.[39–42]

One possible explanation for this finding could be the dynamics within relatively larger families. A relatively larger household may benefit from shared resources and a support network among family members, which can contribute to the overall well-being of children. For instance, in larger families, older siblings might play a role in helping with caregiving responsibilities, which could lighten the burden on parents, allowing them to manage household tasks and healthcare needs more effectively.

Additionally, larger families may also have more diverse social and economic resources, such as access to extended family networks, which can provide emotional, financial and material support in times of crisis.[43] This support system could contribute to better health outcomes for children in these households, including reducing the likelihood of mortality.

On the other hand, smaller families, although often associated with more individualised care, may face financial constraints, with fewer income earners to provide for the household. This can impact the family's ability to access adequate healthcare, nutritious food and other resources essential for child survival. Additionally, smaller families may experience higher levels of stress, as parents may not have the same level of external support found in larger family structures.[44]

In contrast to people who were born less than 18 months after the previous birth, the current study showed that being born over 18 months after the previous birth was proven to be a protective factor against under-five mortality. This finding is consistent with prior studies.[45 46] This may be the result of siblings born with short intervals and sharing the same limited maternal resources, which may lead to an increase in morbidity from inadequate maternal care and a higher mortality rate from neglecting sick children. Short intervals preceding birth can therefore be particularly unfavourable to a child's survival.[47] The other explanation for this finding is that women who experience pregnancies quickly are less able to nurture their second pregnancy because their bodies have not had the time to recover from the first pregnancy, which may result in greater child mortality rates.[48]

The present study found that children born in a health facility had a reduced mortality risk compared with those born at home, which was consistent with the findings of previous studies.[49–52] This might be because health facilities often offer a clean environment and medically skilled delivery services that could enhance the care given to mothers during childbirth because it directly affects the

avoidance of infection and birth trauma, which can affect the survival of the child.[53]

When compared with their counterparts, the likelihood of mortality among children with multiple births was higher. This result is in line with studies previously conducted in Nigeria and Ghana.[49 54] The lack of proper breastfeeding, low birth weight and competition for nourishment, which affect children of multiple births more frequently than those of single births, may be a possible explanation for this.[55]

The current study discovered that children delivered to mothers who resided in urban areas had a lower risk of dying than their counterparts. This result is in line with earlier studies.[42 56 57] This can be attributed to Ethiopia's rural areas' dispersed settlements, poor sanitation, lack of access to safe drinking water, inadequate public services, strong traditional beliefs, poor socioeconomic and environmental conditions and poor health infrastructure. Due to these factors, the risk of morbidity among rural inhabitants is significantly higher, especially among children.[58]

The analysis results also showed that there was a higher risk of mortality for children born to mothers who lived in small peripheral regions compared with mothers who lived in large central regions. This finding is consistent with a prior Ethiopian study that revealed regional variance in under-five child mortality.[59] This can be attributed to regional disparities in economic development and variations in basic infrastructure, such as healthcare access and workforce distribution.

One limitation of the study is the potential for recall bias, as mothers were asked to report events from the past 5 years. The retrospective nature of the data may lead to inaccuracies in recalling the exact date of death, potentially affecting the reliability of the findings. This could result in either overestimation or underestimation of under-five mortality rates in our study.

Additionally, the study relies on secondary data, which limits the scope of analysis due to the unavailability of critical variables that may significantly influence child survival. Key factors such as maternal nutritional status, access to emergency obstetric care and cultural practices related to child healthcare, while potentially important, are not captured in the dataset. The exclusion of these variables restricts our ability to fully assess the complex interplay of determinants affecting under-five mortality. Finally, women's health insurance status may have differed between the time of the child's death and the time of the interview, which could introduce bias into the findings.

Despite these limitations, the use of a robust Gompertz inverse-Gaussian shared frailty model enhances the study's analytical rigour by accounting for unobserved heterogeneity across clusters, thereby improving the reliability of the estimates within the constraints of the available data.

CONCLUSION

In conclusion, the study found that health insurance coverage significantly reduced the risk of under-five mortality. However, households with children under the age of five had notably low levels of insurance coverage. Other key predictors of under-five mortality included the place of delivery, birth interval and place of residence. These findings highlight the need to scale up health programmes focused on expanding universal health service coverage, aiming to improve both access and coverage. This would enable insured households to access essential health services more effectively.

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