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Residential inequalities in child mortality in Ethiopia: Multilevel and decomposition analyses

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Abstract

Ethiopia is among the five countries which account for half of the global under-five deaths, with the under-five mortality rate of 67 deaths/1000 live births in 2016. Ethiopia had significant inequalities in child mortality between rural and urban areas where the risk of child mortality is largely higher in rural than urban areas. Inequalities in the distribution of factors influencing child mortality need to explain the gap between and within urban-rural areas. The study used the risk of child mortality as an outcome variable. Multilevel logistic regression was used as a standard model for assessing the effect of socioeconomic and contextual factors on child mortality. Furthermore, the Blinder-Oaxaca decomposition technique was used to explain the urban-rural, intra-rural, and intra-urban inequalities in child mortality. The birth order and sanitation type seem to be the most important explanatory factors, followed by wealth status in explaining the rural-urban inequality of 39 deaths/1000 children. Mean proportion indicates that there would be 47 deaths/1000 children for urban poor and 21 deaths/1000 children for urban non-poor, resulting in 26 deaths/1000 children change in urban poor when applying the urban non-poor coefficient and characteristics to urban poor behavior. The findings showed that some residential inequalities in child mortality occur at a level that could be addressed by targeting children, households, and some occurs at a community level that could be addressed by targeting regions. Therefore, any residential sensitive and specific interventions should consider child's and household's characteristics, and geographical location.

Keywords: Child mortality; Inequality; Residence; Intra-rural; Intra-urban; Rural-urban; Ethiopia

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1. Introduction

Inequality in child mortality is a global priority. Socioeconomic inequality in child mortality has been a concern of the United Nations since the adoption of the World Population Plan of Action in 1974 and its implementation agreed on at the International Conference on Population in 1984 (United Nations, 1991). The 1984 International Conference on Population strongly urged all governments, regardless of the mortality levels of their population to reduce mortality levels and socioeconomic and geographical differentials in their countries and to improve health among all population groups, especially among those groups where the mortality levels are the highest (United Nations.

Department of International Economic and Social Affairs, 1985). The 1994 International Conference on Population and Development also urged governments to reduce child mortality inequalities between and within developed and developing countries by promoting child health and survival, and eliminating preventable mortality among children (United Nations, 1995). Moreover, the United Nations had set a Millennium Development Goal (MDG4) to reduce the child mortality rate by two-thirds between 1990 and 2015 (UNICEF, 2015). Although MDG4 was targeted to reduce the under-five mortality rate (U5MR) by 67%, the target was not achieved and reduced by 53% reduction reached globally (United Nations Inter-agency Group for Child Mortality Estimation [UN IGME], 2020), from 91 deaths/1000 live births in 1990 to 43 deaths/1000 live births in 2015 (UNDP, 2016). Apart from the low reduction, there are inequalities across regions and countries.

Due to different efforts exerted by governments and development partners, the number of under-five deaths dropped from 12.5 million in 1990 to 5.2 million in 2019 globally. As a result, 14,000 children died before age 5 every day in 2019 compared to 34,000 in 1990 and 27,000 in 2000 (United Nations Inter-agency Group for Child Mortality Estimation [UN IGME], 2020). Despite the progress in child mortality, the 2019 figure is still large and alarming to the Sustainable Development Goal (SDG) targets and efforts to eliminate preventable child deaths between birth and age 5. In this regard, the SDG aims to reduce the under-five mortality rate to at least as low as 25 deaths/1000 live births by 2030 (WHO, 2015). However, Sub-Saharan Africa (SSA) remains the region with the highest under-five mortality rate in the world (United Nations Inter-agency Group for Child Mortality Estimation [UN IGME], 2020). In 2019, the region had an average under-five mortality rate of 76 deaths/1000 live births, which was 20 times higher than that of the region of Australia and New Zealand (United Nations Inter-agency Group for Child Mortality Estimation [UN IGME], 2020). Moreover, the SSA countries had high child mortality rates with significant urban-rural differences (Yaya *et al.*, 2019).

Ethiopia is one of the Sub-Saharan Africa countries with high burden of child mortality, ranking third in Africa (Dheresa *et al.*, 2022). Ethiopia was among the five countries which account for half of the global under-five deaths in 2019 (UN IGME, 2020). The child mortality was declined by 76% from 96 deaths/1000 live children in 1990 to 23/1000 live children in 2015 (Yohannes *et al.*, 2017). Ethiopia had significant inequalities in child mortality between rural and urban areas where the risk of child mortality is largely higher in rural than urban areas (Gebresilassie *et al.*, 2021). The overwhelming urban-rural inequality in child mortality can be explained by the individual, household, and community-level factors. The different approaches employed by various governments may make community-level factors influence under-five mortality differently. Therefore, this study attempts to answer the research question "*What are the key factors that explain the rural-urban, intra-rural, and intra-urban gaps in child mortality in Ethiopia?*" Answering this question is instrumental to explain the inequalities in child mortality between and within urban-rural areas. Thus, the objective of this paper was to examine the key factors that explain both between and within rural-urban inequalities in child mortality in Ethiopia.

1.2. Theoretical framework

This study is based on the two theoretical frameworks formulated to identify determinant factors and their relationships on child survival (Mosley & Chen, 1984; Schultz, 1984). Schultz (1984) is one of the pioneering researchers who developed the theoretical framework on child survival. Schultz's theoretical framework focused on the structural relationship between child survival and the individual's behavioral variables along with both observed socioeconomic (such as social, economic, community, and religious) and biomedical (breastfeeding patterns and hygiene), and unobserved biological factors. In Schultz's framework, biomedical factors are modeled as having direct effect on child mortality, while socioeconomic factors affect child survival indirectly as they work through the biomedical factors (Schultz, 1984). Likewise, Mosley and Chen (1984) classified the determinants of child survival as socioeconomic (such as social, economic, community, and regional determinants) and biomedical factors (such as maternal, environmental, nutrition, injuries, and personal illness). In Mosley and Chen's framework, socioeconomic factors are proposed to indirectly affect child survival as they pass through the proximate factors while proximate determinants affect child mortality directly (Mosley & Chen, 1984). Mosley and Chen categorized a set of proximate determinants into maternal factors (age, birth order, and birth intervals); environmental hygiene factors (source of water and type of sanitations); nutrient deficiency (calories, protein, and micronutrient deficiency); injury (related to physical, burn, and poisoning injury); and personal illness control (immunization, bed net, etc.). In addition, Mosley and Chen also classified the socioeconomic determinants of child survival into individual-, household-, and community-level variables (Mosley & Chen, 1984).

Several studies have applied hierarchical models that are rooted in Mosely and Chen (1984) to analyze how micro (i.e., individual and household level) and macro/contextual (community level) factors influence child mortality at different levels. For example, in South Asia, Zakaria *et al.* (2019) examined the effects of socioeconomic, demographic, and environmental variables on child mortality, and found that urbanization reduce child mortality. In South-Central Asia, Dendup *et al.* (2020) investigated the factors associated with child mortality in rural and urban Bhutan and the roles of the factors in explaining child mortality disparities using the 2012 National Health Survey. Logistic regression models were applied to investigate the determinants and the analysis revealed that children of younger mothers born in households without safe sanitation and electricity had increased odds of childhood mortality in the rural areas of the country. Larger number of births and smaller household sizes are associated with an increased odd of mortality irrespective of rural-urban residence (Dendup *et al.*, 2020).

In Bangladesh, Rahman & Alam (2021) examined the role of socioeconomic indicators on child mortality and found that urbanization had a positive effect on child mortality; whereas maternal education hurt child mortality rate. Noor & Udddin (2021) also found out that mother's education, higher birth order, and size of child at birth had a significant effect on child mortality in Bangladesh. Jayathilaka *et al.* (2021) explored socioeconomic and demographic factors associated with child mortality in Sri Lanka, and the improved source of drinking water had a lower risk of child mortality. In Afghanistan, place of residence, wealth index, age at first birth, and household size were found to be key determinants of child mortality (Shonazarova & Eshchanov, 2020). In Ghana, maternal age, mother's education, household wealth index, place of delivery, and birth order are found to be the most significant socioeconomic determinants that influence child mortality in rural-urban Ghana (Sarkodie, 2021).

In Ethiopia, Zewudie *et al.* (2020) examined determinants of child mortality and found that place of residence, mother's educational level, religion, breastfeeding status, sex of the child, birth order, and household size were found to be significant predictors of child mortality. Likewise, Fenta and Fenta (2020) in their study examined that individual-level factors, including maternal educational background and age of the mother at first birth, are associated with the small number of child death. On the other hand, higher birth order is associated with a higher number of child death (Fenta & Fenta, 2020).

More specifically, a few recent studies explored factors that determine child mortality including rural-urban inequalities (Adeyinka *et al.*, 2020; Dendup *et al.*, 2020; Gebresilassie *et al.*, 2021; Yaya *et al.*, 2019). In Sub-Saharan Africa, Yaya *et al.* (2019) examined the rural-urban gap in child mortality using the Demographic and Health Survey (DHS) in 35 SSA countries. The data were analyzed using Oaxaca-Blinder decomposition to depict urban-rural gap in the factors of under-five mortality. The results of the decomposition analysis revealed that the urban-rural differentials were due to demographic, socioeconomic, and proximate factors. Yaya *et al.* (2019) also explored that very young age at first birth, children of higher birth order, and those with small size at birth had a higher risk of child mortality. Children from the richest households and births from educated women had a lower risk of under-five mortality. Maternal age, maternal education, wealth index, total children ever born, and size of child at birth had contributed toward explaining urban-rural gap in child mortality (Yaya *et al.*, 2019). In Nigeria, a study conducted by Adeyinka *et al.* (2020) highlighted that children residing in different communities are likely to have different mortality risks. The study employed a multilevel multinomial logistic regression analysis method to identify the social determinants of age-specific childhood mortalities and to estimate the within- and between-community variations of mortality among under-five children. The multilevel analysis revealed that maternal education and household wealth index accounted for high variation in childhood mortalities across communities (Adeyinka *et al.*, 2020).

Despite the widely acknowledged rural-urban differential in child mortality, not all urban or all rural populations are homogenous. Living in socioeconomically disadvantaged urban areas might be associated with increased child mortality risks, as living in resource-rich and environmentally healthy rural areas might be associated with a lower risk of child mortality. In this regard, a few studies documented intra-urban differentials in child mortality in the developing countries (Antai & Moradi, 2010; Das, 2021; Touré *et al.*, 2020). For example, a study in Nigeria found that urban-area disadvantage was independently associated with the risk of child death even after controlling for individual child- and mother-level demographic and socioeconomic characteristics (Antai & Moradi, 2010). A study in Ghana also examined intra-urban spatial variation in child mortality rates and pointed out that non-traditional toilet types and water supply sources are associated with high rates of under-five mortality rates (Touré *et al.*, 2020). In India, Das (2021) showed that poverty, low female literacy, and unsafe delivery in the community are associated with a higher risk of child mortality in urban areas. The economic inequalities in child mortality are higher in urban poor than in rural but inequality is widened in urban poor in India (Das, 2021).

In Ethiopia, Gebresilassie *et al*. (2021) examined the factors behind the rural-urban differentials in under-five mortality using Fairlie's decomposition technique to analyze data from the three-round of the Ethiopian DHSs. The child size at birth, mother's education, and household size contributed to narrowing the disparity in child mortality rate (Gebresilassie *et al*., 2021).

To sum up, although the previous studies (Dendup *et al*., 2020; Ekholuenetale *et al*., 2020; Yaya *et al*., 2019), including the study conducted in Ethiopia (Gebresilassie *et al*., 2021), have examined the rural-urban inequalities in child mortality risks, the determinants contributing to intra-rural and intra-urban inequalities in child mortality were not covered. On the other hand, a few studies (Antai & Moradi, 2010; Das, 2021; Touré *et al*., 2020) assessed only intra-urban differentials in child mortality in the developing countries. However, the determinants contributing to intra-rural and intra-urban inequalities in child mortality have not been previously well documented in Ethiopia. Therefore, this paper seeks to contribute evidence on the major factors explaining the rural-urban inequalities in child mortality, including the intra-rural and intra-urban gap in Ethiopia.

2. Data and methods

This section highlights the data sources, study variables, and statistical methods used for the present study. Study context and design and data sources are presented under data source subsection. Description of study variables is explained under study variable subsection while the overall data diagnosis and analysis techniques are discussed in statistical methods subsection.

2.1. Data sources

We used data from the 2016 Ethiopia DHS (EDHS) which was collected from January 18, 2016, to June 27, 2016 (Central Statistical Agency [CSA] [Ethiopia] and ICF, 2016). The 2016 EDHS is a large-scale and cross-sectional survey conducted in a nationally representative sample of households from all regions of Ethiopia. Ethiopia is the second most populous country in Africa, after Nigeria and characterized by enormous diversity (FMOH-FDRE, 2016). The EDHS 2016 data were collected based on a two-stage stratified cluster sampling technique. In the first stage, 645 clusters (202 urban and 443 rural) were selected. In the second stage, a fixed number of 28 households per cluster were selected to gather the socioeconomic and health status of children below the age of 5 and their mothers of reproductive ages (15 – 49 years). The 2016 EDHS used standardized questionnaires to collect detailed information on birth histories, health, nutrition, and related information on mothers and children. Accordingly, a total of 10,641 under-five children born during the past 5 years preceding the survey date were included in the children's database. Of these, 8162 children (12 – 59 months of age) data were extracted from the children's dataset for this study.

2.2. Study variables

The outcome variable of the present study was the risk of child mortality. The outcome variable was measured in EDHS as the probability of dying between the exact age of 1 and the 5th birthday, and assigned a value of 1 if the child died between 12 and 59 months, and 0 if the child was alive at least until the age of 59 months. To explore the effects of individual, household, and community level characteristics on child mortality and to examine their influences and relationships between rural-urban effects, the explanatory variables were grouped into individual, household, and community-level factors.

The individual-level factors included in this paper are as follows: Sex of child; child size at birth as reported subjectively by mother; breastfeeding initiation; birth order; place of delivery; maternal education; maternal age at first birth; number of children ever born; and mother's religion. Please refer to the detailed categories in Table 1.

The household-level factors comprise of sex of household head; household size; source of drinking water; type of toilet facility; type of cooking fuel; and combined wealth status. In 2016 EDHS dataset, the urban/rural asset scores are standardized in relation to a standard normal distribution with a mean of zero and a standard deviation of one. Finally, the standardized urban/rural wealth index scores of the poorest, poorer, middle, richer, and richest levels are further regrouped into poor and non-poor for the analysis of intra-urban and intra-rural inequalities in child mortality.

The community-level factors consist of administrative regions and place of residence (urban vs. rural). For the sake of simplicity, the 11 administrative regions of Ethiopia are categorized into three regional categories: Emerging regions (Afar, Somali, Benishangul-Gumuz, and Gambella), developed regions (Amhara, Oromia, Harari, Southern Nations Nationalities, and People's Region [SNNPR], and Tigray) and fully urban (Addis Ababa and Dire Dawa City Administrations). Here, it is good to note that the emerging regions are drought-affected areas, pastoralists, and marginalized in terms of basic infrastructure as well as least developed as compared to developed and urban regional categories (Bareke *et al*., 2022). Moreover, to analyze the child mortality inequality gaps between and within rural-urban, the place of residence was assigned as a dummy variable.

2.3. Statistical methods

We used STATA version 15.1 for statistical data processing and analysis. We checked missing values, and there were no missing values for the outcome variable, but children with unknown birth places and children from not de jure residents were excluded from the analysis, which accounted for 3.2% of the cases. In this study, de jure residents refer to those residents who are usually living in a given area and who were counted as the resident of that area. We used a correlation matrix to test multicollinearity effect of the explanatory variables using a cutoff of 0.6 known to cause concern in multicollinearity (Senaviratna & Cooray, 2019). Due to high and strong collinearity with a place of residence (r = 0.8077) and sex of household head (r = 0.6236), the total children ever born variable was removed from the model. Place of residence cannot be removed since it is the key identifier in investigating residential inequality in child mortality. After removal of the total number of children ever born, an absolute correlation coefficient of <0.6 was observed among predictors indicating the absence of multicollinearity. Although the variable 'total children ever born' was removed from the model, the birth order was included in the model to explore the relative effects of fertility on child mortality.

Considering the hierarchical nature of the 2016 EDHS dataset into account, we used multilevel (i.e., three level: Community, household, and individual level) analysis technique to get unbiased estimates of standard errors and enable the modeling of between-level interactions by treating every effect at the appropriate level. A multilevel modeling explicitly accounts for the clustering of the units of analysis. Besides, the multilevel modeling provides a unified treatment for effects at individual, household, and community levels. Since the outcome variable is binary, a multilevel logistic regression (Balluerka *et al.*, 2010; Gelman & Hill, 2010) was used as a standard model for assessing the effect of socioeconomic and contextual factors on child mortality in this study. Accordingly, four models were fitted, including null model. The null model was fitted to determine whether the use of multilevel modeling was appropriate in the analysis. Further, all models were checked through interclass correlation (ICC) and criteria information tests (AIC and BIC) and their values were used to select the best model fitted for multilevel analysis. We used likelihood ratio (LR) test to test statistically significant difference between two models based on the ratio of their likelihoods.

We also used decomposition analysis to quantify the contribution of observed and unobserved heterogeneity at the individual, household, and community levels. The decomposition analysis helps understand variance estimates whether regressors are random or fixed, which is based on multiplying regression coefficients using regressors. And hence, to explain the urban-rural, intra-urban, and intra-rural inequalities in child mortality, we used the Blinder-Oaxaca decomposition technique for a non-linear variable. This technique allows for quantifying the gap between the advantaged and the disadvantaged groups (Ameyaw *et al.*, 2021; Bazen *et al.*, 2016; Fairlie, 2005; Jann, 2008; Bado & Appunni, 2015; Sinning *et al.*, 2008; Yaya *et al.*, 2019).

3. Results

3.1. Background characteristics of the study participants

Table 1 shows the background characteristics of the study population. Table 1 shows that 45.47% of children were born to mothers residing in emerging regions and almost the same proportion was born to mothers in developed regions, and 81.8% of children were born in rural areas. The majority (78.56%) of respondent women were from male-headed households; 83.09% of children were born to households that had unimproved sanitation facilities; only 5.28% of children were born to households that had clean cooking fuel; and 55.49% of households had six or more members. Table 1 also depicts that more than half (54.8%) of children were born to households grouped with poor wealth status; 45.5% of children were born to households that had improved sources of drinking water. Most (70.7%) children were born at home; a slightly higher proportion (52.1%) of children were female. Table 1 also illustrates that 19.7%, 43.9%, and 36.4% of children were born in the 1st, the 2nd – 4th birth order, and 5th and above birth order, respectively. More than 80% of mothers had initiated breastfeeding with their kids immediately after birth. About 6% of mothers had given birth before entering the age of 18 years. More than 66% of children were born to uneducated mothers. Nearly 29% of children were born to mothers of Orthodox religion and 51.2% were born to mothers of Muslim religion followers (Table 1).

3.2. Results from multilevel analyses

Table 2 presents results from the multilevel regression analysis. Here, it is crucial to understand that all individual and household level factors are nested within the community (place of residence), hence, it needs to explain the residential inequalities using multilevel analysis. With this understanding, four multilevel models were fitted using only variables with $P < 0.2$ (Heinze & Dunkler, 2017) from the bivariate analysis (not presented in this paper). The overall multilevel analysis was conducted with random intercept (only) model for both community and household levels. First, the null model (Model 0, i.e., a model without explanatory variables) was fitted and showed statistically

Table 1. Background characteristics of study participants in Ethiopia, 2016

Variable (N=8,162)	Category	N	%
Regional category	Emerging	3,703	45.47
	Developed	3,706	45.41
	Urban	753	9.23
Place of residence	Rural	6,680	81.8
	Urban	1,482	18.2
Sex of household head	Male	6,412	78.56
	Female	1,750	21.44
Household size	<6	3,633	44.51
	6+	4,529	55.49
Combined wealth status	Poor	4,473	54.8
	Non-poor	3,689	45.2
Source of drinking water	Improved	3,550	45.5
	Unimproved	4,612	56.5
Type of sanitation facility	Unimproved	6,782	83.09
	Improved	1,380	16.91
Type of cooking fuel	Solid fuel	7,731	94.72
	Clean fuel	431	5.28
Place of birth	Home	5,770	70.7
	Health facility	2,392	29.3
Sex of child	Male	3,910	47.9
	Female	4,252	52.1
Breastfeeding initiation (N=6911)	Delayed	1,331	19.26.
	Immediately	5,580	80.74
Size of a child at birth	Large	2,592	31.8
	Average	3,403	41.7
	Small	2,167	26.5
Birth order	First	1,609	19.7
	2 – 4	3,579	43.9
	5th and above	2,974	36.4
Age at child birth	<18	459	5.62
	18 and above	7,703	94.38
Maternal education	No education	5,399	66.2
	Primary or above	2,763	33.8
Total children ever born	1 – 4	4,665	57.16
	5 and above	3,497	42.84
Religion	Orthodox	2,342	28.7
	Muslim	4,181	51.2
	Others	1,639	20.1

significant variation in child mortality across individual and household levels by place of residence justifying the applicability of multilevel models for analysis.

Second, Model I was fitted after including community-level predictors in the null model. Significant mortality differentials were observed by place of residence and regional category in Model I. Statistically significant ($P < 0.001$) lower risks of death were found among children born in the urban areas relative to children in the rural areas. Children from the emerging regions had higher risks of death compared with their counterparts in the developed regions of the country.

Third, Model II was fitted after including household-level predictors into the Model I. Similar to Model I, children born in urban areas had statistically significant ($P < 0.001$) lower risks of death than those children in the rural areas. Children living in the emerging regions had statistically significant ($P < 0.001$) higher risks of death as compared with their counterparts in the developed regions of the country. Children living within small household size (<6 members) had a significantly ($P < 0.001$) higher risk of death as compared to those from households of large size (six and above members). Children from households with improved sanitation facilities had significantly lower ($P < 0.001$) risk of death than their counterparts living in households with unimproved sanitation facilities.

Finally, the full model (Model III) with all proposed explanatory variables including individual-level predictors was fitted to examine the effect of residential location on child mortality. Significant mortality differentials were observed at community-, household-, and individual-level attributes. In Model III, we found that children from the emerging regions had higher risks of death compared with their counterparts in the developed regions of the country. Similarly, the lower risks of death were found among children born in the urban areas as compared with children in the rural areas as observed in Models I and II.

As we found in Model II, children from the small household size (<6 members) had a significantly ($P < 0.001$) higher risk of death as compared to those from households of large size (six and above members). Likewise, children from households with improved sanitation facilities had significantly lower ($P < 0.001$) risk of death than their counterparts living in households with unimproved sanitation facilities. Children born with large and medium size at birth had a significantly ($P < 0.001$) lower risk of death as compared to small size at birth. This study also revealed that children born at health facilities had a lower risk of death as compared to their counterparts born at home. Children born to Orthodox Christianity follower women had a statistically significant lower risk of death than children born from Muslim

Table 2. Binary mixed effects multilevel regression model (N=8162), EDHS, 2016

Attributes	Model 0	Model I	Model II	Model III
	Coef. [CI]	Coef. [CI]	Coef. [CI]	Coef. [CI]
Constant	−3.015 [−0.60, −2.43]***	−2.84 [−3.001, −2.0681]***	−3.081 [3.30, −2.87]***	−2.457 [−2.94, −1.97]***
Community-level attributes				
Place of residence (rural)				
Urban		−0.883 [−1.216, −0.549] ***	−0.768 [−0.045, −0.006]***	−0.543 [−0.929, −0.156]***
Region: Emerging (ref)				
Developed		0.4261 [0.237,0.615] ***	0.472 [0.272,0.672]***	0.3381 [0.112,0.565]***
Urban		0.230 [−0.188,0.649]	0.353 [−0.074,0.780]	0.329 [0.110,0.769]
Household-level attributes				
Household size (+6) (ref)				
< 6			0.482 [0.301, 0.663]***	0.853 [0.622, 1.083]***
Type of sanitation (unimproved)				
Improved			−0.535 [−0.894, −0.175]***	−0.498 [−0.857, −0.139]***
Wealth status: Poor (ref)				
Non-poor			0.0616 [−0.150,0.272]	0.008 [−0.051, 0.390]
Individual-level attributes				
Child sex: (Male)				
Female				0.2515 [0.068,0.434]***
Birth weight: (Small)				
Large				−0.168 [−0.402,0.064]
Average				−0.232 [−0.452, -0.015]**
Birth order (5th & above)				
First				−0.626 [−0.96, -0.29]***
2nd – 4th				−0.624 [−0.866, −0.382]***
Place of birth: Home (ref.)				
Health facility				0.195 [0.452, 0.063]
Religion: Muslim (ref)				
Orthodox				0.346 [0.613, −0.079]**
Others				0.048 [0.297, 0.200]
Education: No education (ref)				
Primary or above				−0.121 [−0.358, 0.114]
Age at first birth (<18+)				
18 and above				−0.269 [−0.655, 0.117]
Random effect				
Community-level variance	161 [0.020,01.334]	$9.74e^{36}$	$4.21e^{35}$	$3.58e^{35}$
Household-level variance	104 [0.025,0,434]	0.111 [0.028,432]	0.101 [0.023,0.444]	0.102 [0.023,0.455]
ICC	0.074	0.033	0.030	0.30
AIC	3857.55	3833.27	3801.94	3766.10
BIC	3878.57	3868.31	3857.99	3829.21
LR test (χ2)	-	28.27***	37,34***	55.86***

Note: ****P* < 0.01, ***P* < 0.05, **P* < 0.1.

mothers ($P < 0.05$). In this study, maternal education, maternal age at birth, and wealth status had no statistically significant difference to explain child mortality inequality by place of residence (Table 2).

3.3. Results from decomposition analyses

The multilevel analyses have provided evidence for the existence of a statistically significant higher risk of child death in rural areas as compared to those living in the urban areas in Ethiopia. However, the rural-urban residential gap and the intra-rural and intra-urban gaps are not known yet. For this purpose, the present study employed Blinder-Oaxaca decomposition analysis based on the place of residence and urban/rural wealth status, separately. Table 3 presents the decomposition of the rural-urban inequalities in child mortality grouped by place of residence. The rural-urban decomposition analysis showed the mean predictions by groups and their difference. For the sake of understanding, we converted mean prediction into proportion per 1000. The decomposition result showed that the mean proportion of the child death was 71 deaths/1000 children for rural and 32 deaths/1000 children for urban areas, resulting in rural-urban differential of 39 deaths/1000 children. There would be 39 deaths/1000 children change in rural areas when applying the urban areas coefficient and characteristics to rural areas' behavior/characteristics. In the rural-urban decomposition analysis, child size at birth, birth order, type of sanitation facilities, and wealth status contributed to explaining the rural-urban gap in child mortality. On the other hand, child sex, religion, household size, and regional categories contributed to widening the child mortality gap.

Table 4 depicts the decomposition of the intra-rural inequalities in child death grouped by rural wealth status. The intra-rural decomposition analysis revealed that the mean proportion of child death was 76 and 64 deaths/1000 children for rural poor and rural non-poor, respectively. As a result, there would be 12 deaths/1000 children change in rural poor when applying the rural non-poor coefficient and characteristics to rural poor characteristics. The intra-

Table 3. Blinder-Oaxaca decomposition of rural-urban in risk of child death, EDHS, 2016

Child mortality	Coefficient	Standard error	z statistic	*P*-value	95% confident	Interval
Overall						
Rural	0.071	0.003	22.750	0.000	0.065	0.077
Urban	0.032	0.005	7.080	0.000	0.023	0.041
Difference	0.039	0.006	6.970	0.000	0.028	0.049
Explained	0.017	0.060	0.280	0.777	−0.100	0.134
Unexplained	0.022	0.060	0.360	0.716	−0.095	0.139
Explained						
Child sex	−0.000	0.000	−0.750	0.451	−0.000	0.000
Child size	0.008	0.007	1.110	0.267	−0.006	0.022
Birth order	0.047	0.034	1.380	0.167	−0.020	0.114
Religion	−0.009	0.009	−1.010	0.314	−0.027	0.009
Household size	−0.032	0.022	−1.460	0.144	−0.074	0.011
Toilet type	0.027	0.038	0.700	0.481	−0.048	0.101
Wealth status	0.018	0.051	0.350	0.725	−0.081	0.117
Regional cat.	−0.042	0.029	−1.430	0.154	−0.099	0.016
Unexplained						
Child sex	0.000	0.005	0.100	0.923	−0.010	0.011
Birth weight	0.019	0.041	0.460	0.644	−0.061	0.098
Birth order	0.027	0.060	0.460	0.646	−0.090	0.145
Religion	−0.020	0.044	−0.460	0.646	−0.106	0.066
Household size	−0.033	0.072	−0.450	0.652	0.174	0.109
Toilet type	0.001	0.015	0.090	0.927	−0.027	0.030
Wealth status	−0.015	0.023	−0.680	0.495	−0.060	0.029
Regional cat	0.019	0.051	0.370	0.709	−0.081	0.119
_cons	0.023	0.047	0.490	0.627	−0.070	0.115

Note: The models were based on 8,162 observations using logistic regressions, with 6,680 observations from rural samples and 1,482 observations from urban samples.

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Table 4. Blinder-Oaxaca decomposition of intra-rural in risk of child death, EDHS, 2016, rural

Child mortality	Coefficient	Standard error	z statistic	*P*-value	95% Conf.	Interval
Overall						
Rural poor	0.076	0.004	18.330	0.000	0.068	0.084
Rural non-poor	0.064	0.005	13.500	0.000	0.054	0.073
Difference	0.012	0.006	1.900	0.058	−0.000	0.024
Explained	0.013	0.009	1.360	0.175	−0.006	0.031
Unexplained	−0.001	0.010	−0.080	0.939	−0.021	0.020
Explained						
Child sex	−0.000	0.000	0.580	0.562	−0.000	0.000
Child size	0.001	0.002	0.390	0.699	−0.003	0.005
Birth order	0.000	0.001	0.640	0.521	−0.001	0.001
Religion	−0.001	0.001	−0.720	0.473	−0.003	0.001
Household size	−0.001	0.001	−2.160	0.031	−0.002	0.000
Toilet type	−0.002	0.003	−0.830	0.405	−0.007	0.003
Regional cat	0.016	0.008	2.000	0.045	0.000	0.031
Unexplained						
Child sex	−0.301	115.735	0.000	0.998	−227.138	226.535
Birth weight	−0.117	44.892	0.000	0.998	−88.103	87.870
Birth order	−0.685	263.195	0.000	0.998	−516.537	515.167
Religion	−0.550	211.166	0.000	0.998	−414.427	413.327
Household size	−0.056	21.473	0.000	0.998	−42.143	42.030
Toilet type	0.202	77.716	0.000	0.998	−152.118	152.523
Regional cat	0.429	164.569	0.000	0.998	−322.121	322.979
_cons	1.077	414.172	0.000	0.998	−810.685	812.840

Note: The models were based on rural 6,680 observations using logistic regressions, with 4,045 observations from poor families and 2,635 observations from non-poor families.

rural decomposition analysis revealed that child size at birth and regional category contributed to explaining the intra-rural gap in child mortality. On the other hand, child sex, religion, household size, and type of sanitation facilities contributed to widening the intra-rural child mortality disparity.

Table 5 presents the decomposition result of the intra-urban inequalities in child mortality grouped by urban wealth status. The intra-urban decomposition illustrated the mean proportion of urban child death by poverty difference. On average, there would be 47 deaths/1000 children for urban poor and 21 deaths/1000 children for urban non-poor, resulting in 26 deaths/1000 children change in urban poor when applying the urban non-poor coefficient and characteristics to urban poor behavior. In intra-urban decomposition analysis, birth order and type of sanitation facilities contributed to widening the intra-urban gap in child mortality. On the other hand, household size and regional categories contributed to explaining the intra-urban child mortality gap.

4. Discussion

To the best of our knowledge, this is the first paper that examined residential inequalities in child mortality taking intra-urban and intra-rural inequalities into account in Ethiopia. We employed multilevel and decomposition analyses techniques to explore the key factors that widen the rural-urban, intra-rural, and intra-urban gaps in child mortality in the country. We found statistically significant higher child mortality in rural areas than in urban areas which are also consistent with the previous studies (Adeyinka *et al.*, 2020; Dendup *et al.*, 2020; Gebresilassie *et al.*, 2021; Yaya *et al.*, 2019). This might be due to difference in access and distance to public health service, population living standards, health conditions, child healthcare-seeking behavior, and exposure to media by place of residence in Ethiopia.

Our findings also provided the confirmatory evidence that the largest part of the rural-urban inequality in child mortality was attributable to individual, household, and community

Table 5. Blinder-Oaxaca decomposition of intra-urban in risk of child death, EDHS, 2016, urban

Child mortality	Coef.	Std. Err.	z statistic	*P*-value	95% Conf.	Interval
Overall						
Urban poor	0.047	0.008	5.640	0.000	0.030	0.063
Urban non-poor	0.021	0.005	4.330	0.000	0.012	0.031
Difference	0.026	0.010	2.620	0.009	0.006	0.044
Explained	−0.082	0.074	−1.110	0.266	−0.227	0.063
Unexplained	0.107	0.077	1.390	0.164	−0.044	0.258
Explained						
Child sex	−0.003	0.003	−1.190	0.235	−0.008	0.002
Child size	−0.000	0.000	−0.010	0.990	−0.001	0.001
Birth order	−0.060	0.034	−1.770	0.077	−0.126	0.006
Religion	−0.007	0.030	−0.240	0.813	−0.067	0.052
Household size	0.019	0.016	1.230	0.218	−0.011	0.050
Toilet type	−0.041	0.048	−0.840	0.400	−0.135	0.054
Regional cat.	0.009	0.034	0.260	0.792	−0.057	0.075
Unexplained						
Child sex	−0.031	0.022	−1.420	0.154	−0.074	0.012
Birth weight	0.018	0.047	0.380	0.707	−0.075	0.110
Birth order	−0.070	0.051	−1.380	0.169	−0.169	0.030
Religion	−0.028	0.033	−0.840	0.399	−0.093	0.037
Household size	0.078	0.060	1.300	0.192	−0.039	0.195
Toilet type	0.059	0.059	1.000	0.317	−0.056	0.174
Regional cat.	−0.049	0.073	−0.660	0.507	−0.193	0.095
_cons	0.130	0.125	1.040	0.298	−0.115	0.376

Note: The models were based on urban 1,482 observations using logistic regressions, with 643 observations from poor families and 839 observations from non-poor families.

level factors. At individual level, child's size at birth and birth order contributed to explaining the rural-urban gap in child mortality similar to other studies (Gebresilassie *et al.*, 2021; Yaya *et al.*, 2019). This could be due to relatively high prevalence of home delivery in rural settings where the child size at birth may not be recorded. Another potential reason might be due to high prevalence of early marriage in rural area that could lead to teenage delivery with a lower physical preparedness for pregnancy, and difference in access to public health services including family planning, antenatal care, childhood immunization, and health education services provided in rural and urban areas of Ethiopia.

At the household level, the household wealth status and type of sanitation facilities were found to be the key factors in explaining rural-urban inequality in child mortality in line with the previous studies (Dendup *et al.*, 2020; Touré *et al.*, 2020). This could be due to the child mortality in urban areas which can be influenced by relatively higher education attainment and income as compared to rural settings in the country.

At a community level, our analysis revealed significant mortality inequalities by regional category and place of residence. Children from the emerging regions (Afar, Somali, Benishangul-Gumuz, and Gambella) had higher risks of death compared to children in the developed regions (Amhara, Oromia, Harari, Southern Nations Nationalities, and People's Region (SNNPR) and Tigray) of the country (Gebresilassie *et al.*, 2021). This might be due to the reason that the emerging regions are drought-affected areas, pastoralists, and marginalized in terms of basic infrastructure development (Bareke *et al.*, 2022).

Moreover, this study revealed that child size at birth, birth order, and regional category by wealth status are key factors to explaining intra-rural inequalities in child mortality. This might be due to difference in socioeconomic status of the poor and non-poor rural residents, where the rich (non-poor) could have access to improved water and sanitation facilities that affect the risk of child mortality in Ethiopia. This study also found that the intra-urban inequality in child mortality was explained by the household and community level factors. For example, the household size was found to explaining intra-urban inequalities in child mortality by wealth status. This might be linked to having larger household size may reduce access to clean water and improved sanitation facilities and childhood nutrition status within poor urban households as compared to non-poor, which, in turn, affects child survival in Ethiopia. Regional categories by wealth status were another contributing factor to explain intra-urban inequality in child mortality in this study. One of the potential reasons for this could be existence of urban slums with environmentally and economically poor dwellers in emerging and developed regions as well as urban regional categories, including Addis Ababa, the capital of Ethiopia. And hence, the present paper suggests that substantial efforts to reduce residential inequalities in child mortality shall focus more on child's birth size, birth order, sanitation facility, and socioeconomic status of different population subgroups of the country.

The present paper is not free from any limitations. For example, we focused on well-known and extensively reported determinants of child mortality in the literature, whereas others such as childhood nutrition status (including exclusive breastfeeding for the first 6 months and appropriate complementary feeding) as well as the households' affordability and accessibility to care and the food insecurity and distance to the nearest health facility remain unexplored. In this regard, the necessity of assessing the factors related to the urban and rural disparity in child mortality may not be well explained. And hence, the authors agree that the present work may represent just an early attempt to a much more integrated investigation of the determinants of child mortality in Ethiopia. More studies are needed in the near future to disentangle the complex relationships among the factors contributing to urban and rural inequalities in child mortality in Ethiopia.

5. Conclusions

This study attempted to answer the research question that inquires the key factors that explain both between and within rural-urban inequalities in child mortality. The findings suggest that there is statistically significant residential inequality in child mortality in rural than urban settings. The findings also showed that some residential inequalities in child mortality occur at a level that could be addressed by targeting children, households, and some occurs at a community level that could be addressed by targeting regions. Following the findings of decomposition analysis, critical multifaceted regionally specific interventions are suggested to be a potentially better approach for addressing the intra-rural and intra-urban differential in child mortality with policies tailored to the disadvantageous specific condition in emerging regions, that is, Afar, Somali, Benishangul-Gumuz, and Gambella. Furthermore, the present paper suggests that substantial efforts to reduce intra-urban inequalities in child mortality shall focus more on household size. Finally, the importance of the finding, if taken into cognizance and extended to cover the entire country, will not only reduce inequality in child mortality but also will bring the country close to achieving SDG targets by 2030.

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Conflict of interest

The authors declare that they have no competing interests.

Author contributions

Conceptualization: Negussie Shiferaw Tessema
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Writing – review & editing: Chalachew Getahun Desta, Nigatu Regassa Geda, and Terefe Degefa Boshera

Ethics approval and consent to participate

For the original conduct of the 2016 Ethiopia Demographic and Health Survey (DHS), ethical approval was obtained from the ethical committee of the ICF. The enumerators obtained informed consent and authorization to anonymously use the data from all survey participants. In our study, we obtained permission to use the data from the DHS program. No further ethical approval was required, as our study solely involved secondary data analysis of publicly available data that do not contain any identifiable information that links to the actual survey participants. Authors also confirm that all methods were carried out in accordance with relevant guidelines and regulations.

Consent for publication

Not applicable.

Availability of data

The dataset can be accessed at https://dhsprogram.com/data/available-datasets.cfm.

Further disclosure

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