**EXPLAINING INTER-REGIONAL DIFFERENTIALS IN CHILD MORTALITY IN RURAL ETHIOPIA: A COUNT DATA DECOMPOSITION ANALYSIS**

Yibrah Hagos Gebresilassiea\* and Phocenah Nyatangab

aCollege of Business and Economics, Adigrat University, Ethiopia

\*Corresponding author: [yibhag@gmail.com](mailto:yibhag@gmail.com)

bCollege of Law and Management Studies, University of KwaZulu-Natal, South Africa

**Abstract**

*Using data from the Ethiopian Demographic and Health Survey, 2011 for a total of 1,295 number of under-five child deaths, this study examined the major determinants of inter-regional differentials in under-five child mortality in rural Ethiopia. An extended detailed Oaxaca-Blinder decomposition technique to negative binomial regression model was employed to examine the relative contribution of various factors to regional differentials in under-five child mortality. Findings of decomposition analysis indicated that large portion of the regional differentials remained unexplained, being the lowest between Tigrai and Benshangul-Gumuz (12 percent) and the highest in Tigrai-Gambella regions (37 percent). The explained regional gap was due to differences in the distributions of measured factors across regions mainly attributable to differences in short birth-spacing, higher birth-order, antenatal visits, women without education, home delivery, large household size, and poorest households’ economic status. Hence, understanding inter-regional differentials in under-five child mortality and developing appropriate policies and strategies could further reduce the rate of under-five child mortality. On top of strengthening the health extension program in rural Ethiopia, this study suggests that more sustained efforts focused on improving households’ economic status and women’s education should be a prior agenda of the country.*

Keywords: child, decomposition, determinant, Ethiopia, mortality, region, under-five

JEL Classification: D24, I14, J13, R23, R58

1. **Introduction**

Child mortality is one among the key indicators of the well-being of population and society, as measured by life expectancy and is considered as one of the Human Development Index’s (HDI) dimensions used by the “United Nations Development Program” (UNDP) (Aigbe & Zannu, 2012; MOFED, 2004; NIMS et al., 2012; Patel & Sharma, 2013; UN, 2010). Reducing child mortality can significantly increase the life expectancy and hence, human capital, which is highly required for the overall development of one’s nation (MOFED, 2004). The globe has made substantial improvement in overall under-five child mortality reduction. Overall, under-five child mortality rate (U5MR) has fallen dramatically from 12.7 million per year in 1990 to 5.9 million per year in 2015 (UNIGME, 2011, 2012, 2013, 2014, 2015). Despite the progress that the globe has made in reducing the overall child mortality, the rates of progress differ substantially across countries and regions (Shyama Kuruvilla et al., 2014). For example, East Asia and the Pacific have exceeded the “Millennium Development Goal” (MDG-IV) target of a two-thirds reduction in U5MR between 1990 and 2015, whereas sub-Saharan Africa has had only a 24 percent decline over the same period (UNIGME, 2015). Despite the progress the Sub-Saharan Africa made, the region remains with the highest in U5MR in the world (Demombynes & Trommlerová, 2012; UNIGME, 2011, 2012, 2013, 2014, 2015). Most of the global under-five child deaths still occur in this region, where one child in every twelve dies before reaching five years of age (UNIGME, 2015). Also, evidence indicates that there is a substantial difference in the rate of progress within sub-Saharan Africa (UNIGME, 2015), where one child in every nine dies before celebrating his or her fifth birthday when compared to the death of one under-five child in every 152 in developed countries (UNIGME, 2012).

Ethiopia is a sub-Saharan African country divided into nine administrative areas known as regions, namely Afar, Amhara, Benshangul-Gumuz, Gambella, Harari, Oromia, Somali, Southern Nations Nationalities and People (SNNP) and Tigrai. And two federal administrative cities (Addis Ababa and Dire-Dawa) (FMoH, 2010, 2014a; Yihunie Lakew et al., 2011). Ethiopia has experienced sizeable progress in under-five child mortality reduction at the national level, dropping from 211deaths in the 1990s to 88 deaths per thousand births in 2011 (CSA & ICFInternational, 2012), however, the country remains among the highest number of under-five child deaths in the world (UNICEF, 2015b). Although Ethiopia has already achieved its U5MR by two-thirds (68 deaths per thousand births) in 2012 (UNIGME, 2013, 2014) and dropped by 71 percent with average annual rate of reduction of 5 percent between 1990 and 2015 (UNICEF, 2015a), previous studies indicated the existence of substantial variations in the rate of progress across regions of the country (the regions are Afar, Amhara, Benshangul-Gumuz, Gambella, Harari, Oromia, Somali, Southern Nations Nationalities and People (SNNP) (Abebaw, 2013; CSA & ICFInternational, 2012; CSA & ORCMacro., 2006; Heins et al., 2001; UNDP, 2012). Oftentimes, the observed differences in the rate of progress across regions have been masked by the overall rate of reduction in under-five child mortality at the national average. Moreover, in Ethiopia, the inter-regional distribution of under-five child mortality indicate the marked regional disparities (Abebaw, 2013; CSA & ICFInternational, 2012; UNDP, 2012). In 2000, for example, the U5MR varied from as low as 169 deaths in Tigrai to as high as 233 death per thousand births in Gambella (CSA & ORCMacro., 2000). Similarly, in 2011, the U5MR also varied as low as 85 deaths in Tigrai to as high as 169 deaths per thousand births in Benshangul-Gumuz. The rates of decline in under-five mortality for all regions except Tigrai (85 deaths per thousand births) were significantly lower than the national average rate (88 deaths per thousand births) in 2011, indicating there was a disproportionate inter-regional gain in under-five child mortality rates across times (CSA & ICFInternational, 2012).

Furthermore, despite the overall rate of reduction in under-five child mortality, the magnitude of mortality rate inequalities has significantly varied between regions and over time. For example, the under-five mortality rate of the Ethiopian Somali and Benshangul-Gumuz regions have increased from 93 deaths in 2005 to 122 deaths per thousand births in 2011, and from 157 deaths in 2005 to 169 deaths per thousand births in 2011, respectively. Similarly, the U5MR for the Benshangul-Gumuz region has increased from 157 deaths in 2005 to 169 deaths per thousand births in 2011, a statistic (CSA & ICFInternational, 2012) even higher than for Angola with an under-five child mortality of 167 deaths per thousand, the highest in the world (UNICEF, 2014). This evidence shows that although most regions have reduced the under-five child mortality with different levels of reduction, some of them (Afar, Somali, and BG regions) have found to increase the U5MR instead from 2005 to 2011 (CSA & ICFInternational, 2012; CSA & ORCMacro., 2006). Moreover, compared to many other developing countries the improvement that Ethiopia has made in overall child mortality reduction remains very low. The country has been ranked 37th and is one among the ten top countries with highest absolute umber under-five children deaths (184 deaths per thousand). Hence, Ethiopia accounts for three percent of the share of global under-five child deaths in 2015 (UNICEF, 2015a; UNIGME, 2015). More importantly, about 59 of every one thousand children in Ethiopia are still dying before celebrating the age of five years (UNICEF, 2015a; UNIGME, 2015). Like in many developing countries, in Ethiopia mortality of under-five children in rural areas are considerably higher than in urban areas (CSA & ICFInternational, 2012; CSA & ORCMacro., 2006; Regassa, 2012). A child born in rural areas has 38 percent higher probability of dying than a child of urban counterparts (FMOH, 2014b). Previous studies have also noted that one child in every 11 Ethiopian children under-five dying before reaching the fifth births anniversary (CSA & ICFInternational, 2012; CSA & ORCMacro., 2006). Furthermore, most of the Ethiopian population is still primarily rural. Out of the total population (94 million), more than 15 percent (14.245 million) of them are under-five children (UNICEF, 2014). Since the share of rural population in Ethiopia is huge, combating under-five rural child mortality could further speed up the overall U5MR reduction both at the national and regional levels. The overall rate of progress that Ethiopia has made in U5MR (59) is considerably lower than infant mortality (41 deaths per thousand births) (UNIGME, 2015).

Furthermore, in Ethiopia, the regional disparities in under-five child mortality rates were twice higher than in infant mortality rates (UNDP, 2012). This suggests that the importance of addressing disparities in mortality of under-five children to further reduce the overall child mortality of the country. More importantly, much less is known about which factors explaining the regional variations in under-five mortality rates, while majority of previous studies have instead focused on factors influencing infant and under-five child mortality rates in Ethiopia (Amouzou et al., 2014; Dejene & Girma, 2013; Regassa, 2012; Tesfa & Jibat, 2014). These are the rationale as to why this study is carried out and focused on U5MR in rural areas of Ethiopia. This study, therefore, aims at identifying the major factors responsible for inter-regional differentials in under-five child mortality levels in rural Ethiopia.

The remaining of the paper is systematised as follows: review of previous studies is presented in section two. In section three, data source and methodologies are described followed by analysis of results in section four. Section five discusses the findings. The chapter concludes the study in section six.

1. **Review of previous literature**

A substantial number of previous studies have evaluated the factors affecting infant and under-five child mortality rates (Caldwell, 1979; Dejene & Girma, 2013; Kabir et al., 2001; Khadka et al., 2015; Shyama Kuruvilla et al., 2014; Srinivasan, 2000). However, despite the overall improvement in under-five child mortality rates across countries, the rate of progress was varied not only across countries or between developing and developed countries, but within a country. In Sub-Saharan Africa where Ethiopian is located, the marked disparities in the rate of under-five child mortality remain very high across the countries (UNIGME, 2012, 2013, 2014, 2015). Hence, within demographic and development economics literature, currently, substantial interest has been observed in identifying and quantifying the separate relative contribution of specific determinants on how each explains the observed regional under-five child mortality differentials across states or regions within a country and across countries. In developing countries, there have been substantial regional, provincial or cross- state differences in infant and under-five child mortality. Hence, reducing the variations in child mortality within and between countries could considerably contribute to the overall health of the population (Houweling & Kunst, 2010).

A study by Adedini et al. (2015) examined the sources of regional differentials in infant and under-five child mortality in Nigeria using 2008 demographic and health survey data. The study has applied Cox-proportional hazard regression model to identify the determinants of the regional differentials in child mortality (infant and under-five child mortality) in Nigeria. The findings simply indicated that differences in community infrastructure, households’ wealth index, households’ poverty status, place of delivery and residence distributions across the regions were the major factors of regional differentials in under-five child mortality while difference in birth-order, birth-spacing, mother’s level of education, and mother’s age at marriage distributions across regions were the most key factors explaining the regional disparities in infant mortality rate in Nigeria. The study concluded that to substantially reduce the overall child mortality of the country, much efforts should be exerted in addressing the sources of regional variations in these important health indicators by focusing on the disadvantageous regions of the country, however, the authors could not explain the percentage relative contribution of each covariate to the explained regional gap. A study by Jhamba (1999) indicated that despite the dramatic decline in child mortality among district of Zimbabwe, there have considerable disparities across districts. Hence, mother’s education, the percentage of households with access to improved water and toilet facility was among the major determinants of regional variation in child mortality in Zimbabwe. Other factors such as malaria epidemic, religious and cultural determinants were also explained the district differentials in child mortality rates in Zimbabwe. Similar regional differences in under-five child mortality have been reported in many other developing countries (references). For example, In Libya, a study by Ghaffar and Bhuyan (2000) examined the factors explaining the regional differentials in child mortality in North-eastern Libya. The study was based on the seven localities and then these localities have developed into three regions namely, Benghazi, Darna, and Tobruk, where five out of the seven localities are found in Benghazi.

In Nepal, the disparities in child mortality by ecological region was examined by Goli et al. (2015). To examine the determinants of regional variation in child mortality, they used an Oaxaca-blinder decomposition technique based on Cox-Proportional hazard regression model using demographic and health survey data. The results of Cox proportion regression indicated that children of Mountainous areas had the highest probability of dying than children of the same cohort living in the other two areas (Hill and Terai). The results of the decomposition analysis revealed that differences due to the proportional differences in children of four birth-order or higher, mother’s working status, place of residence, households’ economic status, and father’s level of education were reported to significantly explained the regional under-five child mortality disparities. The decomposed covariates altogether explained 40 percent of the regional variations in under-five child mortality between the mountain and the combined Hill and Terai regions while the larger 60 percent of the components of the gap remained an unexplained part. Findings of the decomposition analysis revealed that the differences in the proportional distribution of parental educational levels (mother’s and father’s education) contributed 34 percent of the regional variations in under-five child mortality. However, 30 percent of the explained gap by parental education was attributed to father’s level of education, the largest contributor to the ecological differentials in under-five child mortality. The results further indicated that households’ wealth status, households’ place of residence, higher birth-order along with short spacing (less than 24 moths), and mother’s employment status have contributed significantly to 25, 16, 11, and 5 percent of the explained ecological regional differences in under-five child mortality, respectively. In addition, mother’s religion and mother’s liberty on healthcare decision have contributed 3 percent each to the explained regional gap in under-five child mortality. Although its relative percentage contribution of the explained gap is very small, mother’s exposure to mass media has also contributed to under-five child mortality differences between the two ecological regions. Furthermore, the study indicated that female under-five children are in a les advantageous situation in terms of the survival rate in the country compared to male cohort counterparts. The study has concluded that though Nepal has made a remarkable progress and achieved the “Millennium Development Goal” four (MDG-IV) in under-five child mortality reduction by two-third, there has been variations in rate of progress in child mortality across its ecological regions. Hence, the disparities in rate of progress of under-five child mortality should be addressed from an ecological region outlook (Goli et al., 2015).

In Mozambique, the geographic disparities in child mortality have been examined using the Mozambican demographic and health survey data of 2003 (Macassa et al., 2012). The ten provinces have been geographically classified into three regions; North, Central and South regions. The study has applied Cox regression analysis to identify the factors explaining the regional differences in under-five child mortality. An under-five child whose mother was living in the North and the central regions had higher mortality risks than a child of a mother who was living in the South regions. The study has also indicated that there have been significant differences in levels of under-five child mortality within the regions (among provinces of the same region). However, although the authors have attempted to indicate why the regional variations occurred in child mortality in Mozambique through discussing the reviewed literature, empirically; the authors have nor explored which factors and how much each did contribute to explain the geographic-specific variations in under-five child mortality. Employing the Iranian demographic and health survey data of 2000, a study by Hosseinpoor et al. (2006) examined the contribution of determinants differentials in infant mortality. The analysis was made using the concentration index based on logistic regression to compute the contribution of specific socioeconomic determinants inequalities in infant mortality. The magnitude of differences in households’ economics status (36 percent), and mother’s education level (21 percent) were the largest contributors to the regional infant mortality differences in Iran. The paper further indicates that risky or short birth-spacing (13 percent), place of residence (14 percent) and access to improved toilet facilities (12 percent) contributed significantly to the regional disparities in infant mortality rates in Iran. The findings have finally noted that provinces had different levels of inequalities in infant mortality rates (Hosseinpoor et al., 2006).

Similarly, the study of Assi (2014) has attempted to assess the factors explaining regional variations in under-five child mortality in Cote d'Ivoire based on 2011-2012 Cote d'Ivoire demographic and health survey data using logistic regression model. Findings indicated there were considerable variations in child mortality across the region of Cote d'Ivoire. Mother’s education at least who completed secondary education was associated with under-five child mortality risk and was found to be statistically significant. However, the study failed to identify the sources of the observed regional variations in under-five child mortality in Cote d'Ivoire rather it has identified the factors affecting under-five child mortality not the regional variations in U5MR. More importantly, the study suggested further research be carried out explaining the sources of regional differences in child mortality. Similarly, a study by Akuma (2013) has evaluated regional differentials in infant mortality (IMR) using the 2009 Kenyan DHS. For analyses purpose, the author has examined the regional differences in infant mortality by classifying provinces of the country into two regions (groups) as low and high infant mortality regions based upon the magnitudes or levels of infant mortality that the provinces had and applied logistic regression model to analysis the data. Hence, the results of the regression analysis revealed that there were regional disparities in infant mortality across regions. The mother’s low level of educational attainment, poor socioeconomic status, and short birth spacings were the major determinants of infant mortality for the region of high mortality category that causes the regional variations in infant mortality between the mortality regions (high and low mortality regions). Finally, the author has concluded that the sources of infant mortality differentials across provinces of Kenya are due to differences in households’ economic status and social development. However, the study did not consider other important demographic and other socioeconomic factors while examining the regional differentials in infant mortality that. More importantly, findings of the study might not really indicate the sources the regional differentials in infant mortality in Kenya Akuma (2013).

In Asia, a study by Khosravi et al. (2007) evaluated the mortality differentials among the Iranian provinces. Child mortality rates varied among the provinces from 25 to 47 per thousand births. The findings indicated that important sources of variations in child mortality among the Iranian provinces. These are the GDP per capita, life expectancy, and health care accessibility. Provinces having a high GDP per capita and a high life expectancy had the lowest rate of child mortality. The Iranian study concluded that variations in child mortality were worse in the rural areas than the urban areas of the country. However, in Iran, the extent of variations in child mortality is lower than the child mortality differentials for other developing countries. Another study evaluating “inter-district variations in infant mortality in Sri Lanka” indicated that access to health care services, (33 percent); safe drinking water, (16 percent); low childbirth weight, (13 percent); and health care utilization (8 percent) explained infant mortality differences across districts of the country. Findings of the study noted that a unit increment in health care service accessibility and utilization reduces infant mortality rate by 4.3 and 7.1 percent, respectively (Chaudhury et al., 2006).

In the case of Ethiopia, usually previous studies focused on determinates of infant and under-five child mortality both at national and regional levels, however, almost none of these studies have identified and quantified the drivers of inter-regional differentials in these health indicators at the national level. For example, the most recently published study in Ethiopia by Negera et al. (2013); Bedane et al. (2016); Regassa (2012) have attempted to analyses regional disparities in infant and under-five child mortality. However, the partial regression coefficients of the regressed variables in these study analyses are areal units, i.e. regions, measures (indicates) the rate of infant and under-five child mortality differ across regions rather than identifying the sources of differences among regions in infant and under-five child mortality. These studies have attempted to analyses the factors influencing infant and under-five child mortality in Ethiopia indicated infant and under-five child mortality substantially vary across regions, but most of the studies have indicated that infant and under-five child mortality rates varied substantially between urban and rural areas and across regions of the country. Most importantly, the goals of these studies were completely different from the present study. The present study, on the other hand, focused on identifying factors responsible for such disparities in child mortality levels across regions of Ethiopia. However, the overall child mortality differentials by various determinants might tend to mirror the inter-regional differentials and thus, almost none have analysed the sources of inter-regional differentials in a child or under-five child mortality. Although Ethiopia has shown remarkable progress in reducing the overall child mortality rates at the national level, there has been considerable differences in rates of reduction in infant and under-five child mortality across regions of the country. Some regions have been observed to reduce infant and under-five child mortality steadily with different degree of rate of reduction. On the contrary, some other regions of the country have been observed to increase the rates of under-five child mortality (CSA & ICFInternational, 2012; CSA & ORCMacro., 2006).

The contribution of this study to the literature is to decompose the determinants into explained part (covariates effect) and unexplained part (coefficients effects) and provides new insights. This empirical study is the first to decompose inter-regional differentials in under-five child mortality in Ethiopia. Therefore, the present study contributes to the emerging literature on the factors responsible for explaining the within country differentials in U5MR by presenting comparable inter-regional results relevant to sources of differentials in under-five child mortality levels as benchmark information for other developing countries. For example, the findings of this study could provide an evidence-based knowledge on the determinants of the observed inter-regional differentials in under-five child mortality in rural Ethiopia as cornerstones for planning national strategies, policies, and intervention on child health to further speed up the rate of reduction both at national and regional levels. Allowing for such regional disparities in child mortality, by using count data model regression-based detailed decomposition method, a recently developed method by Power et al (2011), the authors examined the determinants of inter-regional variations in under-five child mortality.

The reviewed literature revealed that there have been several factors affecting regional differentials in infant and under-five child mortality such as households’ economic status, maternal education, parental education, birth order, birth spacing, birth size, place of delivery, contraceptive use, access to improved toilet facility and access to electricity facility are among the others however, prior studies available on this domain in Ethiopia have not given due emphasis on examining determinants of regional disparities in infant and under-five child mortality. Therefore, given the lack of empirical evidence on the relative individual contribution of determinants to regional differentials in under-five child mortality, there is a need to systematically examine the major drivers of inter-regional differences in under-five child mortality in rural Ethiopia. The present study, therefore, aims at quantifying and identifying the major factors responsible for inter-regional differentials in under-five child mortality levels in rural Ethiopia.

1. **Data and Methods**
2. **Data source**

The study uses data from the Ethiopian “Demographic and Health Survey” 2011. The data are a cross-sectional and large-scale health survey carried out in nationally representative sample households across all regions of the country. The survey employed a multistage cluster sampling procedure to select sample households that are nationally representative. Altogether, a total 8,881 households were selected. However, the present study was delimited to a total of 5,481 households from nine administrative regions of rural Ethiopia. There was a total of 5,437 under-five children ever born at the national level. In this study, about 1,295 number of rural under-five deaths were considered for further analysis after excluding those missing values for the variables included in the regression analysis. Details of sampling procedure, data collection tools, and sample design are available in the report of the CSA and ICFInternational (2012).

**Outcome variable**

Analysis of this study was limited to rural children whose age is between 0-59 months as a primary health outcome variable (dependent variable), defined as the probability of a child dying by age under-five years per thousand births (CSA & ICFInternational, 2012). While examining the association between under-five child mortality and explanatory variables, the unit of analysis was number of under-five child deaths.

**Explanatory variables (covariates)**

Several previous studies have indicated that the importance of various determinants (socioeconomic, proximate, demographic and environmental factors) that affects infant and under-five child mortality across various countries (Akuma, 2013; Caldwell, 1979; CSA & ICFInternational, 2012; CSA & Macro, 2006; Dev et al., 2016; Gupta, 1997; Hong et al., 2009; Khadka et al., 2015; Mosley & Chen, 1984; Negera et al., 2013; Regassa, 2012; Trussell & Hammerslough, 1983). Hence, the inclusion of a set of explanatory variables in the analyses was mainly guided by these previous studies and availability of data on these potential explanatory variables. In the analytical framework employed in the study analysis, these covariates are grouped into three distinct classifications: I) proximate determinants such as the age of the child, gender of the child, multiplicity of birth, birth-order, birth size, birth spacing, and mother’s age at birth. II) socioeconomic determinants such as mother’s use of modern contraceptives, antenatal visits, mother’s working status, mother’s and father’s education level, sex and age of household head, household size, and household’s wealth index as a proxy measure for household’s economic status. III) environmental determinants such as place of delivery, access to toilet facilities, electricity facility, safe drinking water and household’s region of residence (see Table 1).

1. **An Oaxaca-Blinder decomposition model**

Since the response variable is a count data variable, application of linear regression models based O-B decomposition could not be an appropriate technique of decomposition (Bauer et al., 2006). Thus, this warrant to use an extended nonlinear decomposition technique to count data modeling approach (Bauer & Sinning, 2008; Park & Lohr, 2010; Yun, 2004). The differences in the average rate of under-five child mortality for any two groups (regions is in the present context) can be explained by a set of independent variables (O‘Donnell et al., 2008) and then are decomposed into two components. Namely, i) the “explained component” is the part of the outcome measure disparity due to differences in the magnitude of observable determinants across the two regions (characteristics or covariates effect), labeled as EC). ii) the “unexplained component” is the part of the outcome measure due to differences in estimated effects of theses determinants across the two regions (coefficients effect), labelled as UC) (Blinder, 1973; Fairlie, 2005; Oaxaca, 1973; Powers et al., 2011; Sen, 2014; Wagstaff et al., 2007).

Assume there are N number of under-five child deaths () (indexed, = 1., ,., ) belonging to household (h=1,. ,. ,. H) in R mutually exclusive and collectively exhaustive regions, = 1,.,.,R, each region containing , is a vector of j observable explanatory variables (as explained above), represents a vector of regression parameters to be estimated, and denotes the error term. Thus, following Bauer et al. (2006); Bauer and Sinning (2008); Park and Lohr (2010); Yun (2004) and Sinning et al. (2008), the O-B decomposition of two regions, continuing with TG as a reference category and HR as a comparison regions for example is computed by:

[01]

A detailed O-B decomposition is not only decomposing the overall mean outcome variable difference into “explained and unexplained components”, but also it measures the detailed separate contribution of individual explanatory variables to the overall differentials in across groups (Jann, 2008; Kaiser, 2016; Park & Lohr, 2010; Powers et al., 2011). Using the latest available estimates of the 2011 EDHS, the under-five child mortality rates for Tigrai region was relatively lower with 85 death per thousand births compared to other comparisons regions (Afar, Amhara, Oromia, Harari, Gambella, Benshangul-Gumuz, Somali, and SNNP) (CSA & ICFInternational, 2012). Alternatively, inter-regional differential in U5MR between these two regions using average weights of a detailed Oaxaca-Blinder decomposition technique for each of the j explanatory variable for each component (EC and UC) can be decomposed as follows:

[02]

The weights for the j explanatory variables for each “explained (EC) and unexplained (UC) components” in the detailed decomposition technique are defined, respectively as follows (Park & Lohr, 2010; Powers et al., 2011; Yun, 2004): ; and . These weights ( are computed using coefficient estimates obtained from negative binomial regression at average values of the regressed explanatory variables and the sum of each weight category are equal to one. The first bracketed segment on the right-hand side of equations [01-02] represents the “explained component”, the differences in U5MR due to differences in the magnitude of observable characteristics across the two regions (“characteristics effect or covariates effect”). The second bracketed segment represents the “unexplained component”, the regional differences in under-five child mortality rates due to effects of the estimated coefficient of the observable attributes across the two regions (“coefficients effect”).

A separate decomposition analysis was performed for the nine regions continuing with Tigrai region as a reference category to examine how much of the overall regional disparity or the relative regional differentials specific to one of the covariates () is attributable to differences in covariates (covariates effect) and differences in returns of these covariates (coefficients effect). the present discussion focused only on explained part of the components gap (covariates effect) because influencing the behavioral responses to the characteristics (captured by the coefficient effects) is more complicated (Jann, 2008; O'Donnell et al., 2009; Oaxaca & Ransom, 1999). The statistical analyses are computed using Stata version 14 by adopting the “user-written mvdcmp Stata command” on nonlinear regression-based detailed decomposition technique of average outcome differentials proposed by Powers et al. (2011) and O‘Donnell et al. (2008).

Table 1: Definition, description, and categorization of variables

|  |  |  |  |
| --- | --- | --- | --- |
| Dependent variable () | | is defined as the number of deaths of under-five children of the household living in the rural region expressed per thousand live births | |
|  | Variables | | Description and categorizations of variables |
| Proximate factors | Child’s age | | Age of child at death measured in years |
| Child’s age squared | | Age of the child squared |
| Male child | | 1 if sex of the child is male, 0 otherwise |
| Birth order | | Order in which a baby (child) is born. 1 if child’s birth-order is greater than 4, 0 otherwise |
| Birth size | | Three categories used: 1 if child’s size at birth is smaller than average, 2 if it is an average, and 3 if it is larger than average (used as reference) |
| Multiplicity of births | | 1 if child is multiple births, 0 otherwise |
| Short birth spacing | | An indicator of mother’s birth spacing between the child’s birth and the birth of the previous child. 1 if mother’s birth spacing is less than 24 months after preceding birth, 0 otherwise |
| Age of mother at birth | | Three categories used: 1 if mother’s age at first birth is less than 20 years, 2 if it is between 20-34 years (as reference), and 3 if mother’s age at first birth is greater than 35 years. |
| Socioeconomic factors | Contraceptive | | 1 if the mother has ever utilized modern contraceptive (like condom, pill, IUD, injection, etc.), 0 otherwise |
| At least four antenatal visits | | 1 if mother received or visited antenatal healthcare service at least four times prior to birth by health professionals (such health extension workers, midwifery, nurse, etc), 0 otherwise. |
| Mother’s education level | | 1 if mother has not yet completed primary school, 0 otherwise |
| Mother’s work status | | 1 if mother present occupational status is working, 0 otherwise |
| Female household head | | 1 if sex of the household head is female, 0 otherwise |
| Age of household head | | The present age of household head in years |
| Father’s education level | | 1 if father has not yet completed primary school, 0 otherwise |
| Household wealth index | | An indicator for a household wealth status was computed, but excluding toilet, electricity, and water sources facilities related variables. Hence, three categories used: 1 for poorest third indicating household’s poorest economic status, 2 for middle third and 3 for richest third (used as reference). |
|  | Household size | | The number of household members per a household |
| Environment factors | Toilet facility | | 1 if household has any improved toilet facilities, 0 otherwise |
| Electricity facility | | 1 if household has access to use of electricity facilities, 0 otherwise |
| Place of delivery | | 1 if mother’s place of delivery is home, 0 otherwise |
| Safe drinking water | | 1 if household’s uses safe or protected drinking water (such as piped/protected well), 0 otherwise (such as river, stream rainwater or unprotected well) |
| Region | | Region in which a household is living: TigraiRC=1, Afar=2, Amhara=3, Oromia=4, Somali=5, Benshangul-Gumuz (BG)=6, Southern Nations, Nationalities and People (SNNP)=7, Gambella=8, and Harari=9. |

Note: RC indicates the reference category used in the decomposition analysis

1. **Empirical result****s**
2. **Descriptive** **analysis**

The statistical analysis was based on 1,295 number of under-five child deaths (51 percent female and 49 percent male). Of all births, about 23 percent of children were died before celebrating the fifth birthdays. About 56 percent were birth-order four or more and 15 percent were born with less than 24 months of birth spacing. The highest number of deaths under-five children were observed in SNNP, Amhara and Oromia regions each 16 percent followed by Afar, Benshangul-Gumuz and Tigrai regions each 10 percent. About 8 percent of deaths children were reported by each Somali and Gambella regions while 4 percent of several deaths of children were reported from Harari region. At the national level, the average age of a child at the time of death was less than one year with slight differences in the magnitude of the average age of a child across regions. About 34 percent of mothers were reported that they were below the age of 20 years at the time of the first birth while less than one percent of them were between the age of 20 and 35 years. The overall literacy rate was very small, with a female and male illiteracy rate of over 90 percent.

1. **Inferential statistics:** The results of detailed decomposition analysis

As indicated in Figure 1, there have been significant regional differentials in U5MR due to differences in the distribution of effect of determinants (covariate effects), due to differences in returns of these determinants. The results of decomposition analysis indicated the over-dominance of coefficients effect across groups of regions. The aggregate regional gaps due to differences in the distribution of effect of determinants and differences in returns of these determinants yield the aggregate effect (total gaps). Hence, to make the estimated results more convenient for analysis, estimates of aggregate, explained, and unexplained components of the gap are reported in terms of percentage. Accordingly, the highest covariates effect (9.2 percent) was observed by Tigrai-Gambella regions while the lowest was shown between Tigrai-Somali regions (-2.6). Similarly, the highest aggregate coefficients effect was observed between Tigrai-Amhara regions (6 percent) followed by Tigrai-Afar regions (5.8 percent) while the lowest was observed between Tigrai-Somali regions (-5.8 percent). Likewise, results further indicated that the highest aggregate effect was found between Tigrai-Afar regions (8.5 percent) followed by Tigrai-Amhara regions (8.3 percent) while the lowest was reported by Tigrai-Somali regions (-8.3 percent).

Source: Own computation using data from 2011 EDHS

Figure 1: Aggregate decomposition gap in U5MR between Tigrai and the comparison regions

Furthermore, the results of decomposition analysis show that of the regions being compared with a benchmark of Tigrai region, Somali region seems exceptional in that its aggregate, characteristics, and coefficients effects were significantly smaller than in the case of the other regions. The results of detailed decomposition analysis indicated that the relative contribution of determinants to the regional differentials in under-five child mortality rates differ significantly across groups of regional comparisons of Ethiopia (Table 2). The relative contribution of a determinant (factor) reflects the differences between the groups of regional comparisons distributions of that covariate (variable) and the differences in the magnitude of the association of the variable with under-five child mortality (Van de Poel et al., 2009). Therefore, among the socioeconomic determinants, the most important relative contributions come from antenatal health care visits, maternal education, households’ economic status, household size, and use of modern contraceptive. The differences in the proportion of children born to mothers have received antenatal healthcare services contributed a substantial 12, 9, 26, 55, 13, 37, and 32 percent to the explained Tigrai-BG, Tigrai-Harari, Tigrai-Amhara, Tigrai-Oromia, Tigrai-Somali, Tigrai-Afar, and Tigrai-SNNP regional gaps in under-five child mortality, respectively. On the contrary, the antenatal visit has been found to reduce 8 percent of Tigrai-Gambella regional under-five child mortality difference. Similarly, results of decomposition analysis revealed that the differences in under-five child mortality for Tigrai-BG, Tigrai-Somali, Tigrai-Afar, and Tigrai- Gambella regions were explained by the proportional differences in children to mothers with no education, which accounts for 3, 23, 6, and 21 percent of the total explained regional differences. However, this covariate contributed significantly to a 79, and 3 percent reduction of the Tigrai-Oromia and Tigrai- SNNP regional differentials in under-five child mortality, respectively. In the present study, households’ economic status measured in households’ wealth index was the most important socioeconomic determinants of the regional gap. The differences in the proportion of children to households in the poorest third index category contributed significantly to a 4, 12, 3, and 10 percent of the explained Tigrai-Harari, Tigrai-Amhara, Tigrai-Oromia and Tigrai-SNNP regional gaps in under-five child mortality, respectively. However, this factor has also been found to significantly reduce 8 percent of the explained Tigrai-Gambella regional gap.

Furthermore, results indicated that the proportion of children to larger household size explained significantly the Tigrai-BG, Tigrai-SNNP, and Tigrai-Amhara regional gaps in under-five child mortality by about 9, 4 and 9 percent, respectively. On the contrary, differences in the proportion of children to households with relative larger household size were found to significantly narrow down by about 10, 8 and one percent, respectively of the covariates effect of Tigrai-Harari, Tigrai-Afar, and Tigrai-Gambella regional differences. The regional gaps were also partly explained by differences in proximate factors. The differences in the proportion of children of four or higher between regions contributed a substantial 9, 4, 29 and 12 percent, respectively to the explained Tigrai-Harari, Tigrai-Oromia, Tigrai-SNNP and Tigrai-Gambella regional gap in under-five child mortality. However, its relative effect was the reverse for the other groups of regional comparisons and was found to significantly reduce 13, 10, 8 and one percent of the explained Tigrai-Amhara, Tigrai-Somali, Tigrai-Afar and Tigrai-BG regional differences U5MR, respectively. Similarly, the differences in the proportion of children whose birth size are less than average constituted significantly 36 percent of the Tigrai-Gambella regional gap while it has significantly reduced by less than one percent of the explained Tigrai-Amhara and Tigrai-Somali regional gaps in under-five child mortality rates. Interestingly, differences in children who had an average birth size contributed significantly 15 percent of the explained Tigrai-Gambella regional gaps in U5MR while it has also been found to significantly reduce the Tigrai-BG regional gap by less than one percent. As to the relative contribution of short birth spacing (birth spacing less than 24 moths), differences in proportional distributions of children of short birth spacing contributed 17, 5, 53, 2, 39, and 3 percent, respectively of the covariates effect in under-five child mortality for Tigrai-BG, Tigrai-Amhara, Tigrai-Oromia, Tigrai-Somali, Tigrai-Afar and Tigrai-SNNP regions, and the differences were statistically significant. However, unlike to the other groups of regional comparisons, short birth spacing significantly narrow down by 34 percent of the Tigrai-Harari regional child mortality differences. More importantly, children born to mothers with less than 20 years age at first birth contributed significantly 6 and .78 percent, respectively to the Tigrai-Amhara and Tigrai-Somali regional gaps while it has also been found to reduce 8 percent of the Tigrai-Gambella regional differences in under-five child mortality. Also, the differences in the proportion of children who have been delivered at home (out of health facilities) contributed significantly 3, 9, 10 and 3 percent of the Tigrai-Harari, Tigrai-Amhara, Tigrai-Somali, and Tigrai-Gambella regional differences in under-five child mortality, respectively. More importantly, results of decomposition analysis revealed that the negative relative contribution of the male under-five child shows that female of the same cohort was in a less advantageous situation in terms of survival rate in the other comparison regions except for Harari and Somali regions. Likewise, the negative contribution of age of the child at the time of death in explaining regional gaps in under-five child mortality indicated that children of the comparison regions were relatively younger than children of the same cohort of the references category (Tigrai) except for Harari and Amhara comparison regions. However, results of decomposition analysis further indicated that no statistically significant regional differences were observed due to differences in the proportional distribution of access to improved toilet facility, electricity facility and safe drinking water across the regional comparisons (Table 2).

**Table 2:** Detailed decomposition of inter-regional differentials in under-five child mortality (between TigraiRC and other regions)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Tigrai and BG regions** | | | **Tigrai and Harari regions** | | | | **Tigrai and Amhara regions** | | | | **Tigrai and Oromia regions** | | |
| Covariates effect | Estimates | Std. Err | Sharea | | Estimates | Std.Err | Sharea | | Estimates | Std.Err | Sharea | Estimates | Std.Err | Sharea |
| .0186 | -.0189 | 12.32 | | .0041 | .0059 | 21.29 | | .0229 | .0179 | 27.61 | .0119 | .0255 | 28.84 |
| Child’s age | -.0017 | -.0061 | -1.15 | | .0005 | -.0014 | 2.64 | | .0023 | -.0059 | 2.72 | -.0047 | -.0167 | -11.3 |
| Child’s age squared | -.0010 | -.0059 | -.64 | | .0013 | -.0163 | 6.84 | | .0003 | -.0062 | .39 | -.0009 | -.0126 | -2.07 |
| Child =Female | -.0001 | -.0006 | -.05 | | .0003 | -.0199 | .51 | | -.00001 | -.0002 | -.01 | -.0001 | -.0014 | -.12 |
| Birth order>4 | -.0011\*\*\* | -.0001 | -.68 | | .0017\*\*\* | -.0002 | 8.63 | | -.0108\*\*\* | -.0021 | -13 | .0018\*\*\* | -.0004 | 4.47 |
| Birth size < average | -.00013 | -.0002 | -.08 | | .0029 | -.0051 | 14.73 | | -.0004\*\* | -.0008 | -.53 | -.0003 | -.0005 | -.76 |
| Birth size = average | -.0009\*\* | -.0004 | -.62 | | -.0008 | -.0026 | -4.31 | | .0005 | -.0011 | .57 | .0003 | -.0009 | .61 |
| Multiple birth | .0002 | -.0003 | .11 | | .0006 | -.0012 | 2.85 | | -.0009 | -.0021 | -1.07 | -.0006 | -.0015 | -1.52 |
| Short birth interval/spacing | .0251\*\*\* | -.0075 | 16.68 | | -.0066\*\*\* | -.0014 | -33.8 | | .0042\*\*\* | -.0013 | 5.06 | .0219\*\*\* | -.0076 | 53.15 |
| Maternal age at birth <20 | -.0001 | -.0003 | -.05 | | .0007 | -.0007 | 3.52 | | .0048\*\* | -.0024 | 5.78 | -0.0021 | -.0024 | -5.11 |
| Maternal age at birth >35 | .0001 | -.0001 | .09 | | .0050 | -.0089 | 25.92 | | -.0142\*\*\* | -.0040 | -17.1 | -.0039 | -.0067 | -9.34 |
| Contraceptive use | -.0007 | -.0005 | -.46 | | .0018 | -.0015 | 9.22 | | -.0071\* | -.0059 | -8.57 | -.0001 | -.0006 | -.24 |
| Antenatal visits | .0177\* | -.0107 | 11.72 | | .0017\* | -.0009 | 8.53 | | .02210\*\* | -.0126 | 26.62 | .02287\* | -.0128 | 55.48 |
| Mother’s education | .00431\*\* | -.0021 | 2.85 | | .0006 | -.0012 | 3.08 | | -.0008 | -.0018 | -.9 | -.0328\*\* | -.0114 | -79.5 |
| Mother’s work status | -.0085 | -.0101 | -5.63 | | .0019 | -.0027 | 9.53 | | -.0003 | -.0005 | -.4 | -.0067 | -.0090 | -16.31 |
| Female HH head | .0001 | -.0019 | .04 | | -.0006 | -.0086 | -2.96 | | -.0002 | -.0039 | -.21 | -.0002 | -.0038 | -.55 |
| Age of HH head | -.0317 | -.0078 | -21 | | -.0029 | -.0023 | -14.7 | | .0012 | -.0011 | 1.46 | -.0007 | -.0017 | -1.74 |
| Father’s education | -.0008 | -.001 | -.54 | | -.0017 | -.0274 | -8.57 | | -.0002 | -.0006 | -.28 | -.0006 | -.0076 | -1.54 |
| Poorest third | .0063 | -.0031 | 4.15 | | .0009\*\* | -.0004 | 4.44 | | .0104\* | -.0058 | 12.51 | .0012\* | -.0006 | 2.92 |
| Middle third | .0001 | -.0046 | .09 | | -.0012\* | -.0007 | -6.28 | | .0001 | -.0024 | .07 | .0071 | -.0040 | 17.29 |
| Household size | .0134\*\*\* | -.0044 | 8.84 | | -.0019\*\*\* | -.0006 | -9.99 | | .0077\*\*\* | -.0025 | 9.26 | .0028 | -.0010 | 6.69 |
| Toilet facility | -.0005 | -.0012 | -.33 | | -.0006 | -.0015 | -3.14 | | -.0005 | -.0011 | -.61 | -.0013 | -.0022 | -3.05 |
| Electricity facility | -.0020 | -.0018 | -1.34 | | -.0006 | -.0063 | -3.2 | | -.0018 | -.0016 | -2.21 | .0005 | -.0006 | 1.32 |
| Home delivery | -.0017 | -.0012 | -1.12 | | .0005\*\*\* | -.0001 | 2.7 | | .0018\*\*\* | -.0095 | 9.17 | .0099 | -.0013 | 24.1 |
| Safe drinking water | .0026 | -.0028 | 1.74 | | .0008 | -.0009 | 3.84 | | -.0009 | -.0007 | -1.12 | -.0017 | -.0014 | -4 |
|  | **Tigrai and Somali regions** | | | | **Tigrai and Afar regions** | | | | **Tigrai and SNNP regions** | | | **Tigrai and Harari regions** | | |
| Covariates effect | Estimates | Std. Er | Sharea | | Estimates | Std.Err | Sharea | | Estimates | Std.Err | Sharea | Estimates | Std.Err | Sharea |
| -.0255 | .0142 | 30.65 | | .0274 | .0312 | 32.23 | | .0209 | .0228 | 35.58 | .0925 | .0299 | 37.12 |
| Child’s age | -.0025 | .0037 | 3.03 | | -.0016 | -.0060 | -1.89 | | -.0021 | -.0066 | -3.5 | -.0073 | -.0015 | -2.93 |
| Child’s age squared | .0017 | .0064 | -2.04 | | -.0012 | -.0685 | -1.44 | | -.0005 | -.0036 | -.83 | .0000 | -.0006 | -2.53 |
| Child =Female | -.0003\*\*\* | .0000 | .03 | | -.0001 | -.0008 | -0.06 | | -.0002 | -.0014 | -.39 | -.0063\*\*\* | -.0008 | -.01 |
| Birth order>4 | .0083\*\*\* | .0028 | -9.96 | | -.0065\*\*\* | -.0008 | -7.6 | | .0171\*\*\* | -.0021 | 29.14 | .0310\*\* | -.0158 | 12.45 |
| Birth size < average | .0002\*\* | .0001 | -.28 | | .0033 | -.0029 | 3.9 | | -.0004 | -.0010 | -.6 | .0901\*\*\* | -.0217 | 36.17 |
| Birth size = average | -.0003 | .0061 | .36 | | -.0038 | -.0138 | -4.44 | | -.0005 | -.0011 | -.89 | .0037\*\* | -.0016 | 14.71 |
| Multiple birth | .0003\*\* | .0001 | -.33 | | -.0003 | -.0006 | -0.31 | | -.0003 | -.0009 | -.47 | .0003 | -.0009 | .13 |
| Short birth spacing | -.0020\*\* | .0009 | 2.4 | | .0330\*\*\* | -.0010 | 38.88 | | .0184\*\*\* | -.0054 | 31.27 | -.0041\*\*\* | -.0032 | -1.63 |
| Mother’s age at birth <20 | -.0007\*\* | .0003 | .79 | | .0107 | -.0151 | 12.63 | | -.0069 | -.0071 | -11.7 | .0286 | -.0235 | 11.49 |
| Mother’s age at birth >35 | .0019 | .0037 | -2.26 | | -.0051 | -.0059 | -6.04 | | -.0009 | -.0021 | -1.6 | -.0206\*\*\* | -.0051 | -8.31 |
| Contraceptive use | .0084\* | .0049 | -10.2 | | .0125 | -.0098 | 14.66 | | -.0031 | -.0025 | -5.19 | .0017 | -0.002 | .68 |
| Antenatal visits | -.0107\* | .0056 | 12.89 | | .0313\* | -.0182 | 36.83 | | .0189\* | -.0106 | 32.21 | -.0202\* | -.0113 | -8.12 |
| Mother’s education | -.0191\*\*\* | .0060 | 22.97 | | .0052\*\* | -.0025 | 6.15 | | -.0021\*\* | -.0010 | -3.52 | .0598\*\*\* | -.0118 | 21.42 |
| Mother’s work status | .0001 | .0006 | -.17 | | .0007 | -.0193 | 0.78 | | -.0059 | -.0083 | -9.98 | -0.0303 | -.0051 | -12.15 |
| Female HH head | -.0006 | .0012 | .69 | | -.0006 | -.0097 | -0.66 | | .0000 | -.0006 | .01 | -.0157 | -.0288 | -6.31 |
| Age of HH head | .0008 | .0015 | -.96 | | -.0058 | -.0046 | -6.85 | | -.0235\*\*\* | -.0059 | -40 | -.0366 | -.0514 | -6.27 |
| Father’s education | -.0054 | .0042 | 6.31 | | -.0140 | -.0301 | -17.6 | | .0004 | -.0006 | .67 | -.0013\*\* | -.0065 | -.54 |
| Poorest third | -.0063\*\*\* | .0021 | -7.6 | | .0063 | -.0086 | 7.37 | | .0058\* | -.0032 | 9.98 | 0.009 | -.0068 | 3.9 |
| Middle third | .0009 | .0007 | -1.04 | | -.0183 | -.0099 | -21.5 | | .0003 | -.0046 | .52 | -.0454\*\* | -.0211 | -18.21 |
| Household size | -.0043 | .0044 | 5.2 | | -.007\*\*\* | -.0023 | -8.45 | | .0025\*\*\* | -.0008 | 4.33 | -.0020\*\*\* | -.0066 | -.81 |
| Toilet facility | .0004 | .0018 | -.5 | | -.0273 | -.0500 | -32.1 | | -.0014 | -.0032 | -2.37 | -.0004 | -.0007 | -.16 |
| Electricity facility | .0014 | .0026 | -1.69 | | -.0003 | -.0030 | -.37 | | .0000 | .00002 | .04 | .0077 | -.0032 | 3.08 |
| Home delivery | -.008\*\*\* | .0027 | 9.6 | | .0211 | -.0051 | 24.86 | | -.0034 | -.0025 | -5.79 | .0085\* | -.0048 | 3.41 |
| Safe drinking water | -.0024 | .0079 | 2.86 | | -.0039 | -.0036 | -4.58 | | .0084 | -.0112 | 14.32 | -.0052 | -.0074 | -2.09 |

Source: Own computation, 2011 EDHS

Notes: a The share of the percentage contribution of each covariate (characteristics) has been computed by dividing estimates of each covariate reported in columns two and five of Table 2 to estimates of the total gap reported in the fourth rows of same tables. **RC** indicates the reference category. The relative contributions of individual covariates can be positive (>0 percent) or negative (<0 percent) and can exceed 100 percent. A positive value (sign) shows the component contributes to the greater differentials of U5MR between Tigrai and the other regional comparisons whereas a negative contribution designates the opposite.

Asterisks denote the level of significance: \*\*\* p<0.01, \*\* p<0.05, and \* p<0.1. HH represents household

1. **Discussions**

While Ethiopia has made a remarkable improvement in reducing the overall child mortality at the national level, evidence indicated that there were variations in rates of progress across its administrative regions (Abebaw, 2013; CSA & ICFInternational, 2012; CSA & ORCMacro., 2006; UNDP, 2012). To author’ best knowledge, this study is the first to decompose the major determinants of inter-regional differentials in under-five child mortality into components gap (explained and unexplained parts). The results of the negative binomial regression analysis indicated that most determinants have the expected associations with the under-five child mortality rates and supported by previous studies (Dejene & Girma, 2013; Khadka et al., 2015; Regassa, 2012). The results of regression analysis show that there have been substantial differences in estimated coefficients of all regressed determinants on under-five child mortality, indicating substantial variations in degree of effects on under-five child mortality across regions.

Identifying the factors that explain most inter-regional differentials in under-five child mortality rates could help in minimizing the regional gaps and to speed up the rate of reduction in under-five child mortality both at regional and national levels of Ethiopia. The results of O-B decomposition analysis indicated that there have been substantial regional variations in under-five child mortality across regional comparisons. Only small part of regional gaps in under-five child mortality was explained (28 percent), being the lowest in Tigrai and Benshangul-Gumuz regions (12 percent) and the highest in Tigrai-Gambella regional comparisons (37 percent). However, the substantial part of the regional differentials in under-five child mortality remained unexplained (72 percent), range from 62 percent (for Tigrai- Gambella regions) to 88 percent (for Tigrai-BG regions) which entails due attention. The results of decomposition analysis also indicated the substantial differences in socioeconomic, proximate and environmental determinants in explaining the regional gaps with socioeconomic factors being the major determinants of regional differentials in under-five child mortality followed by proximate factors. More specifically, results of the detailed decomposition analysis reported the specific relative contribution of determinants to the regional gaps in under-five child mortality. The differences in the proportion of children born to mothers who have received antenatal healthcare services contributed a substantial to the explained regional gaps in under-five child mortality with different magnitude of effect and significance levels across regions. Evidence indicated that though the trends in antenatal health care coverage shows increasing rate, there has been wide disparities observed across regions of Ethiopia, ranging from the lowest 41 percent in Somali to the highest 100 percent in SNNP, Harari, Oromia and Tigrai regions (FMoH, 2014a). In low and middle-income countries, the socioeconomic disparities in child mortality are the key public health problem (Houweling & Kunst, 2010). Women education was considered as a major determinant factor of reducing under-five child mortality (Caldwell, 1979). Likewise, the contribution of the proportion of children to women with no education constituted to regional gaps in under-five child mortality for most regional comparisons. Comparable regional disparities in child mortality was reported in other developing countries. For example, in Iran, mother’s level of education contributed 21 percent of the regional differences in infant mortality rates (Hosseinpoor et al., 2006), in Nepal, 4 percent of the explained regional differentials in under-five child mortality was attributed to mother’s level of education (Goli et al., 2015). Also, in Nigeria, there have been regional child mortality differentials due to differences in women’s education level (Adedini et al., 2015). Moreover, Jhamba (1999) and Akuma (2013) indicated that maternal education was the major determinants of regional variation in child mortality in Zimbabwe and Kenya, respectively.

The most striking regional differentials almost across the groups of regional comparisons occurred due to differences in the proportion of children from the poorest third index households. In line with present study, significant difference in child mortality was observed due the major difference in households’ wealth index in Nigeria (Adedini et al., 2015), Nepal (Goli et al., 2015), Kenya (Akuma, 2013), and in Iran (Hosseinpoor et al., 2006). A mother who gave a birth at less than 20 years old could face delivery and pregnancy related problems due to the mother’s biological immaturity. Also, the mother could not have basic knowledge on how to care babies (Pandey et al., 1998) and as a result, a child born to this mother could have more likely to significantly die than a child of a mother whose age is above 20 years (Babson & Clarke, 1983). In the present study, the differences in distribution of maternal age at first birth less than 20 years was among the major determinants of regional differentials in under-five child mortality with different magnitude of effects and level of significant. In line with the present findings, it was also evident that the proportional differences in children of mothers whose age at first birth less than 20 years across regions explained the regional variations in child mortality significantly in Nepal (Goli et al., 2015), and in Nigeria (Adedini et al., 2015).

How a child birth order determines child mortality and explains regional gaps in child mortality? A child of the first order is most probably to born from a young woman who is not biologically ready to accept and care for a baby. On top of this, the young woman has very limited basic knowledge on how to care for a baby (NIMS et al., 2012; Pandey et al., 1998). A child of higher birth-order, in contrast, is most probably to born to an older woman and is likely to be influenced by competition from older siblings in terms of resources (NIMS et al., 2012). Hence, in the present study, higher birth-order was among the major proximate determinants of under-five child mortality. The differences in the proportional distribution of children of birth-order of four or higher across the regions explained the regional gaps in under-five child mortality with different magnitude of effects and levels of significant. The present finding was consistent with some previous studies from Nepal (Goli et al., 2015), and in Nigeria (Adedini et al., 2015). Prior studies have indicated that birth spacing and child mortality has a direct relationship (Srinivasan, 2000; Sweemer, 1984). A woman who experienced a short birth spacing may not recover instantly her health and then can deter baby’s growth. Therefore, a child born to less than 24 moths birth spacing (short birth spacing) have more likely to die than a child born to a birth spacing of more 24 months (Hobcraft et al., 1983; NIMS et al., 2012). Likewise, a child born to less than 24 months birth spacing had more likely to die. The differences in the proportional distribution of children of short birth spacing across regions explained the regional differences in U5MR for most regional comparisons with different degree of effects and levels of significant. Findings on short birth spacing were in line with some of the existing literature in Iran (Hosseinpoor et al., 2006), Nigeria (Adedini et al., 2015) and in Nepal (Goli et al., 2015).

Findings of this study further indicated that birth size less than average (2500g) affects under-five child mortality across regions. The differences in the distribution of birth size less than average explained significantly to 39 percent of the regional variations in under-five child mortality for Tigrai-Gambella regions. In Sri Lanka, low birth-weight explained the inter-district disparity in infant mortality rate (Chaudhury et al., 2006). However, the present findings revealed that for most regions child size at birth less than average contributed to reducing the regional differentials in under-five child mortality with small size effect. Furthermore, the unequal distributions of children who have been delivered at home (out of health facilities) attributed significantly to the explained regional gap in under-five child mortality, however, the relative percentage contribution of this variable was small. This result was in line with previous empirical studies from Nigeria (Adedini et al., 2015).

1. **Conclusions**

The present study has identified the inter-regional differentials in under-five child mortality in rural Ethiopia was due to different levels of determinants that are often associated with under-five child mortality. The results of decomposition analysis indicated that households’ economic status, mothers’ levels of education, birth-order, birth-spacing, antenatal visits, household size, and place of delivery attributed were the key determinants of regional disparities in under-five child mortality. The under-five child mortality disparities were largely due to the reflection of the wide regional differentials of these determinants. The findings of this study can help to draw a critical attention in developing specific national and regional policy based on the relative contribution of individual covariates to explained regional gaps that help in reducing child mortality disparities among regions of the country. Hence, on top of strengthening the Ethiopian health extension program across regions, this study suggests that addressing those identified potential determinants focusing on improving households’ economic status and women’s education could help to minimize regional disparities in under-five child mortality and ensure universal health care coverage of the country. Also, further sustained effort is needed to speed up the rate of reduction in under-five child mortality both at the national and regional levels against a certain target set, for example, 75 percent disparity reduction goal in under-five child mortality among regions in 2025.

**Acknowledgements**

The authors thank the office of the Central Statistics Authority, the Federal Democratic Republic of Ethiopian, for the provision of available data for study purpose.

**Funding and Conflicts of Interest:** None declared.

**Ethics approval:** A letter of ethical approval of this study was obtained from the “Humanities and Social Science Research Ethics Committee” with a protocol reference number: HSS/0981/015D at the University of KwaZulu-Natal (UKZN), South Africa.

**References**

Abebaw, D. (2013). Infant and child health in Ethiopia: Reflections on regional patterns and changes. *Journal of International Development,* 25, 536 - 548.

Adedini, S. A. , Odimegwu, C. , Imasiku, E. N. , Ononokpono, D. N. , & Ibisomi, L. (2015). Regional variations in infant and child mortality in Nigeria: a multilevel analysis. *Journal of biosocial science,* 47, 165-187. doi:10.1017/S0021932013000734

Aigbe, G. o. , & Zannu, A. E. (2012). Differentials in infant and child mortality rates in Nigeria: Evidence from the six Geopolitical Zones. *International Journal of Humanities and Social Sciences,* 2, 206-214.

Akuma, J. M. (2013). Regional Variations of Infant Mortality in Kenya: Evidence from 2009 KDHS Data. *Mediterranean Journal of Social Sciences,* 4, 425 - 433 doi:10.5901/mjss.2013.v4n9p425

Amouzou, A. , Kozuki, N. , & Gwatkin, D. R. (2014). Where is the gap?: the contribution of disparities within developing countries to global inequalities in under-five mortality. *BMC public health,* 14, 216 - 220.

Assi, K. P. (2014). *Determinants of Regional Disparities in Under Age five Mortality in Cote d'Ivoire.* (Mster of Public Health), Georgia State University, Atlanta, Georgia, USA. (30303)

Babson, S. G. , & Clarke, N. G. (1983). Relationship between infant death and maternal age: comparison of sudden infant death incidence with other causes of infant mortality. *The Journal of pediatrics,* 103, 391-393.

Bauer, T. , Göhlmann, S. , & Sinning, M. (2006). Gender Differences in Smoking Behavior.

Bauer, T. K. , & Sinning, M. (2008). An extension of the Blinder–Oaxaca decomposition to nonlinear models. *AStA Advances in Statistical Analysis,* 92, 197-206. doi:10.1007/s10182-008-0056-3

Bedane, A. S. , A., T. F. , Shamenna, A. T. , & Abshoko, A. D. (2016). Variations in Under-five Child Mortality among Regional States of Ethiopia: A Multi-level Modelling Approach. *British Journal of Applied Science & Technology,* 15, 1-16. doi:10.9734/BJAST/2016/24448

Blinder, A. S. (1973). Wage Discrimination: Reduced Form and Structural Estimates. *Journal of Human Resources,* 8, 436 - 455.

Caldwell, J. C. (1979). Education as a factor in mortality decline an examination of Nigerian data. *Population studies*, 33, 395-413.

Chaudhury, R. H. , Gunasekera, P. , & Gunasekera, D. (2006). Child Health. *World Health Day Message from the Regional Director,* 10, 96 - 103.

CSA , & ICFInternational. (2012). Ethiopia Demographic and Health Survey 2011. Addis Ababa, Ethiopia and Calverton, Maryland, USA: Central Statistical Agency and ICF International.

CSA , & Macro, O. (2006). *Ethiopia Demographic and Health Survey 2005. Addis Ababa, Ethiopia and Calverton, Maryland, USA: Central Statistical Agency and ORC Macro*.

\_\_\_\_\_\_. (2000). Ethiopia Demographic and Health Survey 2000. Addis Ababa, Ethiopia and Calverton, Maryland, USA: Central Statistical Authority and ORC Macro.

Dejene, T. , & Girma, E. (2013). Social determinants of under-five mortality in Ethiopia: Event history analysis using evidence from Ethiopian Demographic and Health Survey (EDHS). *Health* 5, 879 - 884.

Demombynes, G. , & Trommlerová, S. K. (2012). What has driven the decline of infant mortality in Kenya?

Dev, R. , Williams, M. F. , Fitzpatrick, A. L. , & Connell, F. A. (2016). Topographical Differences of Infant Mortality in Nepal. *Kathmandu University medical journal (KUMJ),* 14, 96 - 102.

Fairlie, R. W. (2005). An extension of the Blinder-Oaxaca decomposition technique to logit and probit models. *Journal of economic and social measurement,* 30, 305-316.

FMoH. (2010). *Health Sector Development Plan IV 2010/11 – 2014/15. Addis Abba 2010. Federal Democratic Republic of Ethiopia Ministry of Health.* .

\_\_\_\_\_\_. (2014a). *Ethiopia's Fifth National Health Accounts 2010/2011*. Addis Ababa, Ethiopia.

\_\_\_\_\_\_. (2014b). *Ethiopia Ministry of Health, Ethiopian Public Health Institute, United Nations Children’s Fund, Countdown to 2015: Ethiopia's progress towards reduction in under-fve mortality. UNICEF Ethiopia, Addis Ababa.*

Ghaffar, A. , & Bhuyan, K. C. (2000). Regional variations in child mortality in north-eastern Libya. *Journal of Family Welfare,* 46, 47-56.

Goli, S. , Bhandari, P. , Atla, U. M. R. , & Chattopadhayay, A. (2015). Childhood Mortality Differentials by Ecological Region in Nepal. *Population, Space and Place,* 23, 1 - 13. doi:10.1002/psp.1977

Gupta, M. D. (1997). Socio-economic status and clustering of child deaths in rural Punjab. *Population studies,* 51, 191-202.

Heins, F. , Mekonen Tesfaye , & Valente, P. (2001). "Infant and Child Morality in Urban Ethiopia: with Special Refrence to Socio-Demographic and Housing Condition in Urban Areas and Addis Ababa.".

Hobcraft, J. , McDonald, J. W. , & Rutstein, S. (1983). Child-spacing effects on infant and early child mortality. *Population Index,* 49(4), 585-618.

Hong, R. , Ayad, M. , Rutstein, S. , & Ren, R. L. (2009). Childhood mortality in Rwanda: levels, trends, and differentials. *DHS Further Analysis Report*(66).

Hosseinpoor, A. R. , Van Doorslaer, E. , Speybroeck, N. , Naghavi, M. , Mohammad, K. , Majdzadeh, R., Vega, J. (2006). Decomposing socioeconomic inequality in infant mortality in Iran. *International Journal of Eepidemiology,* 35(5), 1211-1219. doi:10.1093/ije/dyl164

Houweling, T. A. J. , & Kunst, A. E. (2010). Socio-economic inequalities in childhood mortality in low-and middle-income countries: a review of the international evidence. *British medical bulletin,* 93(1), 7-26.

Jann, B. (2008). The Blinder-Oaxaca decomposition for linear regression models. *The Stata Journal,* 8(4), 453-479.

Jhamba, T. (1999). Regional variations in childhood mortality in Zimbabwe. *Geography,* 84(4), 319-330.

Kabir, A. , Islam, M. S. , Ahmed, S. M. S. , & Barbhuiya, K. (2001). Factors influencing infant and child mortality in Bangladesh. *J Med Sci, 5*, 292-295.

Kaiser, B. (2016). Decomposing differences in arithmetic means: a doubly robust estimation approach. *Empirical Economics, 50*(3), 873-899.

Khadka, K. B. , Lieberman, L. S. , Giedraitis, V. , Bhatta, L. , & Pandey, G. (2015). The socio-economic determinants of infant mortality in Nepal: analysis of Nepal Demographic Health Survey, 2011. *BMC pediatrics,* 15(1), 152.

Khosravi, A. , Taylor, R. , Naghavi, M. , & Lopez, A. D. (2007). Differential mortality in Iran. *Population health metrics, 5*(7), 478 - 493.

Macassa, G. , Ghilagaber, G. , Charsmar, H. , Walander, A. , Sundin, Ö. , & Soares, J. (2012). Geographic differentials in mortality of children in Mozambique: their implications for achievement of Millennium Development Goal 4. *Journal of Health, Population and Nutrition,* 30(3), 331-345.

MOFED. (2004). *Millennium Developement Goals Report: Challenges and Prospects for Ethiopia*.

Mosley, W. H. , & Chen, L. C. (1984). An analytical framework for the study of child survival in developing countries. *Population and development review, 10*, 25-45.

Negera, A. , Abelti, G. , Bogale, T. , Gebreselassie, T. , & Pearson, R. (2013). An analysis of the trends, differentials and key proximate determinants of infant and under-five mortality in Ethiopia. ICF International: Calverton, Maryland USA.

NIMS , ICMR , & UNICE. (2012). *Infant and Child Mortality in India: Levels, Trends and Determinants, National Institute of Medical Statistics (NIMS), India Council of Medical Research (ICMR), and UNICEF India Country Office, New Delhi, India*. Retrieved from

O'Donnell, O. , Nicolás, Á. L. , & Van Doorslaer, E. (2009). Growing richer and taller: Explaining change in the distribution of child nutritional status during Vietnam's economic boom. *Journal of Development Economics,* 88(1), 45-58.

O‘Donnell, O. , Doorslaer, E. V. , Wagstaff, A. , & Lindelow, M. (2008). *Analysing Health Equity Using Household Survey Data: A Guide to Techniques and Their Implementation. Washington, DC: World Bank Institute Learning Resource Series, the World Bank*.

Oaxaca, R. (1973). Male-Female Wage Differentials in Urban Labor Markets. *International economic review, 14*(3), 693 - 709.

Oaxaca, R. L. , & Ransom, M. R. (1999). Identification in detailed wage decompositions. *Review of Economics and Statistics, 81*(1), 154-157.

Pandey, A. , Choe, M. K. , Luther, N. Y. , Sahu, D. , & Chand, J. (1998). Infant and child mortality in India. National Family Health Survey Subject Reports No. 11. *International Institute for Population, Mumbai*.

Park, T. A. , & Lohr, L. (2010). A Oaxaca–Blinder decomposition for count data models. *Applied Economics Letters, 17*(5), 451-455. doi:10.1080/13504850801964307

Patel, T. A. , & Sharma, D. B. (2013). Inter-state variation in Neonatal Mortality Rate among Indian states. *Community Med, 4*(1), 54-58.

Powers, D. A. , Yoshioka, H. , & Yun, M. (2011). mvdcmp: Multivariate decomposition for nonlinear response models. *The Stata Journal,* 11(4), 556-576.

Regassa, N. (2012). Infant Mortality in the Rural Sidama Zone, Southern Ethiopia: Examining the Contribution of Key Pregnancy and Postnatal Health Care Services. *Journal of Nursing, Social Studies, Public Health and Rehabilitation 1*(2), 51 – 61.

Sen, B. (2014). Using the Oaxaca-Blinder Decomposition and Empirical Tool to Analyze Racial Disparities Obesity. *EPIDEMIOLOGY/GENETICS, 22*(7), 1750–1755.

Shyama Kuruvilla , Julian Schweitzer , David Bishai , Sadia Chowdhury , Daniele Caramani, e. L. F. , Rafael Cortez, Bustreoh, F. (2014). Success factors for reducing maternal and child mortality. 533 - 544.

Sinning, M. , Hahn, M. , & Bauer, T. K. (2008). The Blinder-Oaxaca decomposition for nonlinear regression models. *Stata Journal, 8*(4), 480 - 492.

Srinivasan, S. (2000). Determinants of infant and child mortality in Tamil Nadu and Uttar Pradesh. *International Institute for Population, Mumbai*, 18-23.

Sweemer, C. D. (1984). The influence of child spacing on child survival. *Population studies, 38*(1), 47-72.

Tesfa, B. , & Jibat, N. (2014). Tesfa, B., & Jibat, N. (2014). Health extension program as innovative health care service: The socio-cultural factors affecting its implementation in Jimma Zone, South Western Oromia. *International Journal of Sociology and Anthropology,* 6(8), 235-245.

Trussell, J. , & Hammerslough, C. (1983). A hazards-model analysis of the covariates of infant and child mortality in Sri Lanka. *Demography, 20*(1), 1-26.

UN. (2010). *The Millennium Development Goals Report, 2010.*

UNDP. (2012). *Analyzing Regional Performance and Disparities in Health Outcomes in Ethiopia: Development Brief, UNDP, Ethiopia*.

UNICEF. (2014). The State of the World’s Children 2015: Reimagine the Future: Innovation for Every Child.

\_\_\_\_\_\_. (2015a). *Committing to Child Survival: A Promise Renewed. Progress Report 2015, UNICEF New York*.

\_\_\_\_\_\_. (2015b). *Committing to Child Survival: A Promise Renewed. United Nations Children’s Fund (UNICEF) Progreess Report*.

UNIGME. (2011). *Levels and Trends in Child Mortality, Report 2011, Estimates Developed by the UN Inter-agency Group for Child Mortality Estimation (UNIGME), UNICEF, World Health Organization, World Bank Group, and United Nations, New York*.

\_\_\_\_\_\_. (2012). *Levels and Trends in Child Mortality, Report 2012, Estimates Developed by the UN Inter-agency Group for Child Mortality Estimation (UNIGME), UNICEF, World Health Organization, World Bank Group, and United Nations, New York*.

\_\_\_\_\_\_. (2013). *Levels and Trends in Child Mortality, Report 2013, Estimates Developed by the UN Inter-agency Group for Child Mortality Estimation (UNIGME), UNICEF, World Health Organization, World Bank Group, and United Nations, New York*.

\_\_\_\_\_\_. (2014). *Levels and Trends in Child Mortality, Report 2014, Estimates Developed by the UN Inter-agency Group for Child Mortality Estimation (UNIGME), UNICEF, World Health Organization, World Bank Group, and United Nations, New York*.

\_\_\_\_\_\_. (2015). *Levels and Trends in Child Mortality, Report 2014, Estimates Developed by the UN Inter-agency Group for Child Mortality Estimation (UNIGME), UNICEF, World Health Organization, World Bank Group, and United Nations, New York*.

Van de Poel, E. , O'donnell, O. , & Van Doorslaer, E. (2009). What explains the rural-urban gap in infant mortality: household or community characteristics? *Demography, 46*(4), 827-850.

Wagstaff, A. , O'Donnell, O. , Van Doorslaer, E. , & Lindelow, M. (2007). *Analyzing health equity using household survey data: a guide to techniques and their implementation. World Bank Publications*.

Yihunie Lakew, A. A. , Tamene, H. , Benedict, S. , & Deribe, K. (2011). Geographical variation and factors influencing modern contraceptive use among married women in Ethiopia: evidence from a national population based survey. *women,* 10(1), 1 - 10.

Yun, M. (2004). Decomposing differences in the first moment. *Economics Letters, 82*(2), 275-280. doi:<http://hdl.handle.net/10419/20112>