Regional Disparities in Under-Five Mortality in Ethiopia: A Cross-Sectional Analysis of Nationally Representative Sample

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Abstract

Background: Reduction of inequalities has been the ultimate objective of the global social and health strategy. It is yet an internationally endorsed target stipulated among the 17 Sustainable Development Goals (SDGs) set to be achieved by 2030. Identifying the determinants and extent of perceived inequality in under-five children mortality amongst regions in Ethiopia is central in order to take appropriate policy actions and this requires an evidence based approach. This study evaluates the regional disparities for the risk of under-five mortality in Ethiopia. The study analyzed various biological, environmental and socio-economic factors explaining the regional disparities for the risk of under-five mortality using a nationally representative sample of women who gave birth during last five year preceding the survey.

Methods: A nationally representative cross-sectional data from the 2011 Ethiopia Demographic and Health Survey (EDHS) was used. Data comprised 11,184 children born within five years preceding the survey. Demographic information including maternal and child characteristics, socio-economic characteristics and environmental characteristics were measured from home interview. Cox proportional hazard regression analysis was used to calculate hazard ratios (HRs) and their 95% confidence interval (CI) for the regional disparities in under-five mortality.

Results: The prevalence of under-five mortality at national level was 7.2 deaths per 100 live births (N=809) with the highest mortality in Benishangul Gumuz region (9.2 deaths per 100 live births, adjusted HR 2.11, 95% CI 1.06 – 4.19) and lowest in Addis Ababa as the reference group (3.6 deaths per 100 live births). In multivariate analysis, contraceptive use (being not user), parity (having more than one child), size of the child at birth (being either large or very small), and sex of the child (being male) were significantly associated with under-five mortality. Environmental characteristics contributed relatively little to the under-five mortality.

Conclusions: The findings suggest that significant disparity on under-five children mortality exist among regions of Ethiopia. Child, environmental and socio-economic factors explain the relationship between region of residence and under-five mortality. Child survival interventions shall target on these factors to minimize inequality differentials and thereby reduction in the under-five mortality in the country.

Key words: Under-five mortality, regional disparity, child factors, socio-economic factors, environmental factors, maternal factors

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Reference to the original paper

This thesis is based on the original article:

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Abbreviations

AIDS	Acquired Immuno Deficiency Syndrom
ANC	Antenatal Care
ARI	Acute Respiratory Infection
CI	Confidence Interval
CSA	Central Statistical Agency
EA	Enumeration Area
EDHS	Ethiopian Demographic and Health Survey
FDRE	Federal Democratic Republic of Ethiopia
HEP	Health Extension Program
HH	House Hold
HR	Hazard Ratio
HIV	Human Immuno Deficiency Virus
MCH	Maternal and Child Health
MoFED	Ministry of Finance and Economic Development
PPP	Purchasing Power Parity
SDGs	Sustainable Development Goals
SNNP	Southern Nations and Nationalities and People
STI	Sexually Transmitted Infections
TT	Tetanus Toxoid
USA	United States of America
WHO	World Health Organization

Introduction

Under-five mortality rate has been one among most commonly used population health metrics in the assessment of child well-being as well as the health and economic development of a society (Chowdhury, 2013). The highest proportion (45%) of the under-five mortality accounts to the neonatal mortality, the death of newborns within 28 days (WHO, 2016a). Reducing the under-five mortality has long been an international target. However, the world is still facing high under-five mortality. In 2015 the global under-five mortality rate was 43 deaths per 1000 live births, still high, although it has reduced by 53% from the rate in 1990 (Gerland et al., 2015). Some 5.9 million children under the age of five died in 2015 worldwide of which half (49.6%) died in sub-Saharan Africa. Therefore, the global target for the reduction of under-five mortality by 2/3 by the year 2015 did not met at global level, even though there are countries that already met the target. Reducing the under-five mortality is yet a global health agenda, which is stipulated in the new framework, the SDGs. It aims to bring the under-five mortality down to at least 25 deaths per 1000 live births by 2030 (Gerland et al., 2015).

In many areas of the world child mortality or disability due to debilitating infectious disease decreased during the last few decades (Maurice & Davey, 2009). This is supposedly following improvement in health service delivery notably, after the introduction of immunization programs. Moreover, improvements in socio-economic circumstances such as per capita income and literacy level have contributed for the dropping of the under-five mortality in particular to the sub-Saharan African region (Amouzou & Hill, 2004). Nevertheless, mortality differences between population groups have not disappeared, for example, parents' level of education, remoteness of place of residence and poor household are associated with the child's risk of death in all socio-economic setting including in high income countries (You, Hug, & Chen, 2014).

The mortality rate for under-five children in Ethiopia continues to decline. In 2015, it dropped to 59.2 deaths per 1000 live births (95% CI: 40.6 - 83.0) (WHO, 2015b). It reduced by 59.3% since the beginning of the millennium and by 71.2% since the rate in 1990 (Gerland et al., 2015). Among other strategies, the fruitful implementation of the Health Extension Program (HEP) has been credited for the change (Dejene & Girma, 2013) (Ambel et al., 2015). On the other hand, some evidences indicate huge disparity on under-five mortality prevail between Ethiopia's administrative regions (CSA Ethiopia and ICF International & CSA Ethiopia, 2012; WHO, 2014; Bwalya & Alebachew, 2012).

Despite recent developments in health, disparities in life expectancy and various key health outcomes become a common feature of all societies, even in developed countries. In 2015 children in low income countries die 10.8 times higher than their counterparts in high income countries (Gerland et al., 2015). Differences in under-five mortality between communities or regions are evident indicators of health disparity (WHO, 2014). Theoretical and empirical evidence suggest various maternal and child factors mostly related with pregnancy and birth, environmental conditions, demographic and socio-economic factors relate with these phenomena. The influence of these factors claimed to have contributed for health outcome differentials among children (Mosley & Chen, 2003; Houweling & Kunst, 2010).

The extent of Ethiopia's regional disparity in under-five mortality is poorly understood, albeit various studies has been conducted on child mortality determinants. These studies mostly indicate among other factors, the role of communicable diseases, nutritional deficiencies and poor socio-economic conditions related with poor child health outcomes. However, research in particular to health disparities is generally limited. Therefore, an empirical approach was required to determine the significance of inequality differentials and the factors associated with it. Reduction of inequalities is one among the 17 targets in SDGs set to be achieved by 2030 (Pisano, Lange, Berger, & Hametner, 2015).

This study aims to investigate the regional disparities in risk of under-five mortality in Ethiopia; the study also analyzed various biological, environmental and socio-economic factors explaining the regional disparities for the risk of under-five mortality using a nationally representative sample of women who gave birth during last five year preceding the survey.

Review of Literature

This study is laid on the conceptual framework that brings up range of various health determinants responsible for disparities in under-five children mortality. It encompasses a review on relevant literature pertaining to child survival disparities as a result of biological, environmental and socio-economic determinants. The aim was to assess factors that were learned in earlier studies that implicate vulnerability of the child thereby contribute for disparities in child survival and to examine the theoretical basis for their influencing mechanism. The section begins summarizing the study conceptual framework. Following this a brief overview of relevant summaries pertaining to health disparities and health determinants in general and in particular to under-five children follow in a row.

2.1 Study conceptual framework

The study's conceptual framework was set based on the assumption that disparities in child survival emanated as a result of differences in the distribution of various health determinants. The determinants pertaining to child survival were thematically organized and include: the region of residence, maternal factors, child factors, environmental contaminants, and socio-economic factors. Region of residence is a key variable used independently and also to assess regional differences. The components of thematically organized determinants were clustered through fitting similar attributes grouping together. Region of residence was also used to assess disparities by disaggregating summary of the components of other thematically organized determinants by

region. These components were partly adopted from Mosley and Chen framework and from other relevant studies in the field.

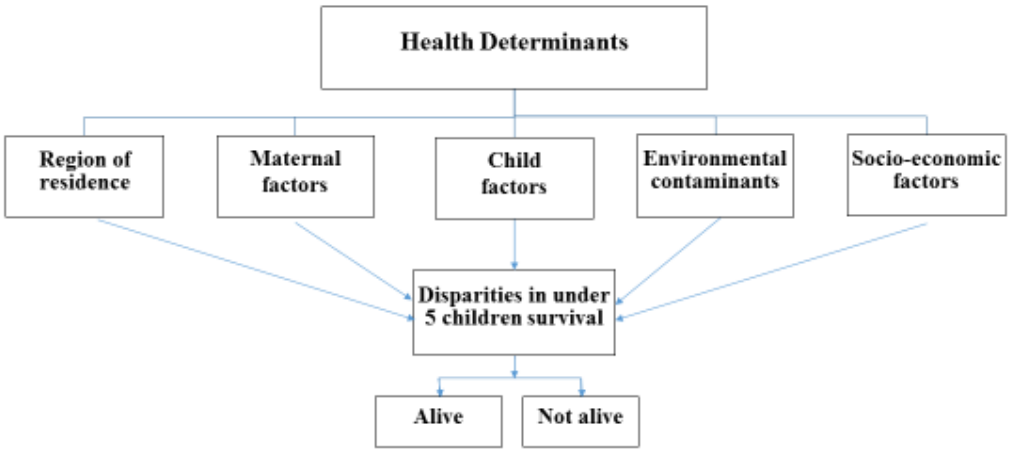

Figure 1: Study conceptual framework

2.2 Health Disparities

Health disparities between populations are a global health concern in the 21st century (Gerland et al., 2015). Despite recent developments in health, disparities in life expectancy and various key health outcomes, however become a common feature of all societies, even in developed countries. In Ethiopia huge disparity prevail in the under-five mortality rate between regions where regions such as Benishangul Gumuz were disadvantageous (Negera et al., 2013). In the United States, health disparity as a result of race, sex, socioeconomic status, and geographical location were well known factors where women for instance live longer than men (Grimm, Moore, & Scanlon, 2013). Olshansky et al., (2012) argued educated people live longer than not educated ones; likewise, white race has a longer healthy life expectancy than a black race. Disparities in mortality are also evident

with differences in geographical locations (Grimm et al., 2013). Such same trend of the phenomenon in different areas has elicited for research in health disparities in recent years.

2.3 Health Determinants

The understanding of health determinants has evolved with time and the current understanding is multifaceted. The miasmic theory was popular since the ancient times until the germ theory was introduced in 1880. It considers, the cause of illness arising from toxic vapor or mist coming from decomposed substance. Following the germ theory was introduced, the focus was given on the study of infectious diseases until 1940's. The current understanding of health determinants encompasses social aspects of life besides biology. Many areas of personal life are redefined as health related. (Peterson & Lupton, 1996)

Following the seminal framework of Mosley and Chen in 1984, an increasing attention was given for the theories that stipulates on the dynamics between biology and social factors that impact the survival of the child. The key theme of that framework lies on the premise that not only biology, a primary or proximal determinant, but also parental socio-economic factors in the background also play part in the path of child survival. Proximal determinants involve the child's or the mother's attributes; or circumstances which affect their health such as nutrition, injury or preventive/treatment measures; or environmental contamination. The influencing pathway for proximal determinants is principally biological. Socio-economic factors on the other hand impact indirectly through knowledge/skill gains, economical competence, or through availability and utility of various household assets or accessibility to services. It generally constitutes educational, economic, and ecological settings. (Mosley & Chen, 2003)

The interaction of various health determinants give rise to the widening of health differences. In particular to socio-economic related factors, Marmot (2003) argued, the theory of social gradient in health and illness partially explain the differences in health. The theory illustrates that there

exist a social gradient in health/mortality that the poorest people had the highest mortality (Marmot, 2003). Houweling & Kunst (2010), claimed disparities between regions are partly explained in socio-economic stratification and thereby exert their influence to biological determinants. Detail description on region of residence and other determinants in a thematic format follow the rest of the section.

2.3.1 Region of residence

The region of residence in this context was the area where people live as well as their health service use is allocated. Ethiopia's current administration system is structured in to nine regions and two city administrations. The regions are Tigray, Afar, Amhara, Oromia, Somali, Benishangul-Gumuz, Southern Nations Nationalities and Peoples (SNNP), Gambela, and Harari. The two city administration councils are Addis Ababa and Dire Dawa. These are further divided into 817 administrative districts, a decentralized governmental entities comprising a total of 16,235 villages (WHO, 2013).

The parent's region of residence holds an array of various inter-connected factors that potentially impact the survival of the under-five child. Essentially, it is associated with availability and accessibility of health services. In Ethiopia, evidence suggest that 32% of households in 2011 (largely in rural areas) were located more than 5km away from the nearest health facility (World Bank Group, 2015). In rural areas, access to health service is constrained by many factors such as shortage of transportation, inconvenient landscape, and terrains etc. (Chaya, 2007). According to Wang & Ramana (2014), in Ethiopia the population to health human resource ratio indicator in 2009/2010 was lowest in Somali and Afar regions. Chaya (2007) revealed that getting the poor for reproductive health services in remote areas in Ethiopia can be hindered due to weak infrastructure. Low health accessibility also impedes the control of preventable diarrheal and acute respiratory infections in children, weaken childhood immunization, hinder family planning services, and significant other impacts in particular to children and pregnant mothers (Skolnik, 2012). Other

than health service accessibility, children living in regions with access to improved technology, developed infrastructure, less polluted environment, less harmful cultural and traditional practices tend to have better health outcomes (Skolnik, 2012).

The prevalence of poverty in urban vs rural areas is also one factor where region of residence may make a difference in terms of under-five mortality differentials. Geography still matters, for example those who live in rural locations are poorer than those living in urban locations (Houweling & Kunst, 2010). Urban areas are commonly in closer proximity to markets and services (World Bank Group, 2015). Therefore, regions with more remote locations tend to hold larger proportion of poor households in socio-economic conditions which in turn has an indirect pathway to affect under-five children's survival.

Economy and social tradition also vary with region of residence. For instance, agrarian living and economic means predominates in the highland population. People in the lowlands tend to be mostly pastoralists (CSA Ethiopia and ICF International, 2012). Evidence also indicate harmful traditional practices such as early marriage practiced in the Northern part (Amhara, Tigray & Benishangul regions) whereas Female Genital Mutilation predominates in the Somali and Oromia region. Abduction is predominantly practiced in SNNP region (Assefa et al., 2005).The climate corresponding with the topography is among the ecological circumstances where regions differ in Ethiopia. The topography is as low as 110 meters below sea level in Afar depression (Afar region) and as high as 4,550 meters above sea level in Ras Dashen (Northern Amhara) (CSA Ethiopia and ICF International, 2012).

The impact of region of residence on under-five mortality has been documented in studies conducted in various developing countries. Studies conducted in Cöte d'Ivoire (Assi Kouame, 2014), in Nigeria (Antai, 2011), and in Bangladesh (Chowdhury, 2013) found significant differences in under-five mortality between regions.

2.3.2 Maternal factors

Maternal factors that impact the survival of the child constitute a continuum of diverse aspects. Essentially, the child is biologically related to the mother during pregnancy and lactation and hence the health, reproductive pattern and the nutritional status of the mother can bring an immediate or long term health outcome on the child. Non-biologically, the mother's health seeking abilities and purchasing power for the production of healthy child are subject to the knowledge/skill of the mother and household's economy (Mosley & Chen, 2003). Maternal factors also institute the foundation for inequalities in under-five mortality. Differences in maternal literacy level, accessibility and utilization of health services such as contraception, differences in the timing of pregnancy (age at first birth), occurrence of teenage pregnancy (high, mostly in lower socio-economic groups), and other maternity and general health service utilization and significant other are the basis of inequality ascending from the mother (Houweling & Kunst, 2010). Some selected maternal factors are discussed henceforth.

Maternal age: Young as well as advanced maternal age is accompanied with adverse child birth outcomes. Among other consequences, preterm birth and low birth weight appeared a common outcome in relation to teenage as well as advanced maternal age pregnancy (Laopaiboon et al., 2014, Yadav et al., 2008). Preterm birth accounts 16% of under-five death worldwide in 2015 (Gerland et al., 2015). Among widely accepted reason for teenage pregnancy is presumed to be a declining age of menarche as well as early initiation of sexual activity (Chen et al., 2007). At younger age, pregnancy tend to be difficult for the mother and the newborn. Adequate nutrition is required for normal growth of the fetus. Preterm delivery and low birth weight may result from inadequate prenatal care and nutrient deficiencies (Chen et al., 2007). After giving birth, teenage mothers face challenges to carry out the intense responsibilities in rearing the child including social exclusion and economic insufficiency that potentially endanger the survival of the child (Libretto, 2007). At advanced age, pregnancy is associated with higher risk of chromosomal abnormalities of the baby, a genetic defect with no cure. Women at 40 or older tend to have high blood pressure

problems, a health conditions that can cause health problems for the baby (Laopaiboon et al., 2014). Empirical evidence put forward the association between maternal age and child survival. A study in Ghana revealed that maternal younger age at birth was found protective factor for under-five mortality as compared to later years (Kanmiki et al., 2014). Study in Kenya revealed lower odds of under-five children dying from older mothers; arguing the element of their child rearing experience contributed for the benefit for those born from older mother (RR Ettarh, 2012).

Maternal Education: Maternal education is most acknowledged socio-economic marker that determine the survival of under-five children (Masuy-Stroobant, 2002). The evidence with increased education suggest that it works by mediating on the key child mortality determinants. For instance, an educated woman can avoid early marriage, a factor that prevents mortality of children as a result of low birth weight, lack of childbearing skill and from economic insufficiency. She can also avoid early sexual debut, and unintended first birth (Grepin & Bharadwaj, 2015). Moreover, her literacy allows to learn better practices and develop a tendency of risk minimization as they tend to have increased health seeking behavior (Güneş, 2015). Educated mothers also have employment which is a beneficial factor to the child through increasing resource allocation and decisions on health promoting actions in the household such as buying healthier food (Güneş, 2015). On the other hand, it has been documented that employed mothers have less spare time for breast feeding, hygiene, creating mother to child bonding and less caring. Studies elsewhere documented the benefit of maternal education in lowering the odds of under-five children's mortality (Negera et al., 2013); (Kanmiki et al., 2014)

Contraception Use: Spacing between pregnancies benefits the mother, the child and the entire family (Tsui, McDonald-Mosley, & Burke, 2010). Contraception methods are intended to give enough space between child deliveries or abandon unwanted pregnancy. Appropriate use of family planning methods involves simple to complex actions. With spaced pregnancy the child benefits from breast feeding, receives adequate caring time that eventually contributes also for reduction in mortality (WHO, 2015a). Highest child survival probabilities was evidenced elsewhere through

postponing preceding birth interval with the use of contraceptive methods (Chowdhury, 2007; Kanmiki et al., 2014; Antai, 2010).

Parity: Parity refers to the number of gestations conceded to the stage possible for the fetus live outside the uterus, usually at or above 24 weeks (Opara & Zaidi, 2007). There are ample evidence that support the association between low parity and better child health outcome elsewhere (Antai, 2010; Masuy-Stroobant, 2001; Kanmiki et al., 2014; Kozuki, Sonneveldt, & Walker, 2013; Girma & Berhane, 2011). Children from low parity mothers were less prone from childhood death (Girma & Berhane, 2011). The impact of parity in the survival of infants was also documented with higher risk of neonatal death among multiparous women (Neupane & Doku, 2014). However, Kozuki et al., (2013) argued as there was no physiological link between parity and child mortality in a study conducted on 47 low and middle income countries. The results of this study was in opposition to several studies. The conclusion from this particular study suggests women who have high fertility were at risk rather than the parity impact which was found negligible.

Antenatal care utilization: Antenatal care (ANC) refers to the utilization of health care services by pregnant mothers (WHO, 2007). The uptake of ANC is intended essentially to prevent, detect and treat health problems in pregnant mothers. But, the impact extends to benefit the survival of infants and children (Bwalya & Alebachew, 2012; Raatikainen, Heiskanen, & Heinonen, 2007). The WHO recommends that pregnant women shall have four or more antenatal checks during one pregnancy period where the first ANC visit preferably to occur during the first trimester (WHO, 2007). The essential elements of care in pregnancy constitutes undertaking various screenings, health checks, pregnancy surveillance for the woman and upcoming baby and undertaking preventive measures. Screening is done for anemia, malaria, sexually transmitted infections (STI), and for HIV/AIDS. Health checks are made for the recognition and treatment of health problems that are related to pregnancy and underlying health conditions. The antenatal visit period is also a time where women receive preventive measures including tetanus toxoid (TT) immunization to prevent maternal and neonatal tetanus; health education and promotion for own and family health (WHO, 2007). Studies suggest the association between utilization of antenatal care and enhanced

child survival apart from some inconsistent results. A population based study conducted in the United States concluded that inadequate utilization of ANC was associated with risk of prematurity, stillbirth, neonatal and infant deaths (Partridge et al., 2012).

Delivery Care: Access to quality obstetric care at the time of delivery is beneficial for the safe delivery and reduces mortality for mothers and newborns. Newborn's death accounts 45% of the under-five mortality and the contributing factors for their death among others include: preterm birth, birth asphyxia and infections which are linked with availability of delivery care by trained attendant (WHO, 2016a). Children born in health institutions have better chance of survival than those born at home (Charmarbagwala, Ranger, Waddington, & White, 2004). Medical assistance during pregnancy and delivery were found essentially associated with better infant and child health outcome in a cross country analysis among 62 developing countries during the 1990s (Rutstein, 2000).

Post-natal care utilization: the post-natal care period refers to the time after delivery and consist of three phases: acute period lasts 6-12 hours, sub-acute lasts 2-6 weeks, and delayed period lasts up to 6 months after delivery (Romano et al., 2010). The postpartum care for mothers in this period involves observation and examination of vaginal bleeding, uterine involution, blood pressure, body temperature and counselling on safe motherhood. Likewise, postnatal care for the baby among others involve cord care, hygiene & weight monitoring, initiation of breastfeeding, and neonatal immunization (Matthews, Severin, & Jelka, 2010). Two third of maternal and neonatal deaths occur within the first 48 hours after birth and hence, appropriate care by skilled attendant during birth could prevent majority of these deaths (Matthews et al., 2010). A study in Bangladesh revealed that first postnatal home visits conducted within the first 48 hours after birth were exceptionally associated with reduced neonatal mortality (Baqui et al., 2009). A study in the United States that analyzes 9,101 early postpartum discharges from hospital (less than 30 hours of birth) were also associated with higher risk of neonatal deaths (OR 3.65; 95% CI 1.56-8.54) and infant deaths (OR 1.6; 95% CI 1.10-2.36). In this study, mortality risk any time during the first year of birth was 84% higher than those discharged later (OR 1.84; 95% CI 1.31-2.60); of these deaths

due to infection accounts the highest (OR 4.72; 95% CI 1.13-19.67) (Malkin, Garber, Broder, & Keeler, 2000).

2.3.3 Child factors

Sex of child: Albeit few exceptions, male mortality exceeds female in all age group around the world, likewise, so is true in under-five mortality. The fact behind this is mostly biological and demographic but some exceptions are linked to cultural factors. For example, in most regions of India female mortality exceeds male and is more rampant in rural areas. (Kuntla, Goli, & Jain, 2013). The Indian case is attributable to cultural factors in that girls are marked as burdens while boys as resources. For that reason, excess female mortality is related to family building strategy. In an attempt to favor the boys, girls are deprived of food provisions such as breast feeding and less attention as regards to health care (Bhat & Zavier, 2003). The biological evidences on sex disparity on mortality suggest that baby girls mature faster than baby boys in the uterus/womb; their organs such as the lungs are more developed. This is partially explained as women pregnant with a boy have higher chances to experience placental problems, pre-eclampsia and blood pressure problems and these by extension result in prematurity (Lawn & Blencowe, 2013). The study led by London School of Hygiene and Tropical Medicine (2013) that participate 50 researchers in 35 institutions worldwide concluded that boys are at higher odds of being born premature (14%) as compared to girls. Besides, this study also identified the likelihood of preterm babies showing higher odds of mortality (10 times) in low income countries as compared to high income countries. In Ethiopia, there were evidences that suggest disparities on the status of child survival against the sex of the child. Negera, et.al (2013), concluded girls are less prone to death than boys at infant and under-five mortality analysis level (HR: 0.85 & 0.82 respectively). Samuel & Eshetu (2012), on their study about the determinants of infant mortality using the 2005 Ethiopian Demographic and Health Survey also argued that the risk of baby girls dying was lower by 20% than the baby boys (HR: 0.802; CI: 0.69-0.93). On the other hand, a study by Mekonnen (2011) indicated that there are no evidence of the sex of the child to affect the under-five mortality. A

study in Cöte d'Ivoire also revealed low hazard risk for baby girls compared to boys in under-five mortality analysis (Assi Kouame, 2014).

Birth order: The child's birth order is found to be subject to various kinds of outcomes in childhood and even in adulthood life where researchers see at times as advantages and sometimes as disadvantages. For that reason this subject area has long been criticized for the inconsistencies in its findings (Modin, 2002). Evidence also exist that suggest family members differ in health by their birth order (Baranowska-rataj, Barclay, & Kolk, 2014). Thomas Gualtieri and Robert E. Hicks (1985), proposed an immune-reactive theory to explain survival differences among son siblings by birth order. The theory suggests that successive born sons after the first born son are tend to be vulnerable by the antibody response from the mother's uterine environment which was triggered by the Y-chromosomes from the first pregnancy (son). This means that sons born lately are in disadvantage position as compared to the first born or earlier born son siblings. Even so, boys generally are not better-off than girls. A study in India on survival differences suggest that female children were better off in birth order 1. This same study also indicates sex do not have any noticeable difference on 2nd and 3rd birth order, however in birth order 4 and 5 female children were substantially at higher chances of death (Singh & Tripathi, 2013). The mechanics behind these inter-related complex concepts are also accompanied by other theories such as increasing maternal age, child's birth weight, birth interval, etc.; for instance, later born children are essentially born to an older mother; teenage pregnancies or shorter birth intervals between pregnancies result in low birth weight and this in turn risk for poor child health outcome (Barclay, 2014; Uthman, 2008). Empirical evidence suggests mixed findings for birth order's connection to under-five mortality. According to a study in Cöte d'Ivoire, born in 2nd to 5th birth order was a protective factor in under-five mortality compared to other birth orders (Assi Kouame, 2014). Conversely, under-five children in the 2nd or above birth order were at risk in a study conducted in Kenya (RR Ettarh, 2012).

Birth size: Low birth weight at birth escalate for serious health risk in children during their early ages of life and is supposedly negatively associated with poor outcomes in the short and long run

in the course of the individual's life (Barclay, 2014). Low birth weight is usually characterized as a birth weight less than 2500g and evidently children in this weight category have impaired immune function and prone to encounter disease conditions and more likely to remain undernourished for long (Uthman, 2008). It has been documented that a weight between 3000 to 4000 g tend to have low risk of dying (Kliegman, 2011). Despite these theoretical and evidence based foundations, smaller birth size children were found low risk for both infant and under-five mortality in a study that analyzes three DHS surveys conducted from 2000 – 2011 in Ethiopia (Negera et al., 2013). The explanation for such discrepancy may be attributable to other determinants that tend to obscure these solid grounds; which on the other hand, calls for further study to unravel the factors behind these all.

Breastfeeding: Breastfeeding denotes nourishing of infants and small children by woman's breast. Human milk contains an ideal balance of nutrients including fat, carbohydrates, proteins, vitamins, minerals and water. Besides, it contains antibodies that enhance natural disease resistance thereby protecting against deadly infection (WHO, 2009). Elements of effective breastfeeding practices among others involve: early initiation (within 1 hour after delivery); giving colostrum, which is special milk produced in the first 2-3 days after delivery; and breastfeeding on demand, about 800ml/24hr in average (Unicef, 2011). Various studies concluded that breastfeeding decreases infant and child mortality (Cockey, 2004; Samuel & Eshetu, 2012; Chowdhury, 2013). A study in Bangladesh and a meta-analysis of 70 systematic reviews addressing breastfeeding found exclusive breastfeeding reduces neonatal and infant deaths from acute respiratory infection (ARI), sepsis and diarrhea (Arifeen et al., 2001; Khan, Vesel, Bahl, & Martines, 2014). It has been estimated that one-fifth of the under-five mortality in developing countries could be prevented through exclusive breast feeding for six months and initiation of complementary feeding at six months (Unicef, 2011).

Immunization: Immunization refers to the stimulation of body's own immune system against disease causing agents through the administration of vaccines. The various target diseases that are covered in immunization programs for children world-wide include diphtheria, tetanus, pertussis,

measles, polio, tuberculosis, hepatitis B, haemophilus influenza (type b), mumps, pneumococcal diseases, rotavirus, rubella, yellow fever and Japanese encephalitis (Maurice & Davey, 2009). There exist ample evidence that suggest immunization for better child health outcome (Girma & Berhane, 2011; You et al., 2014; Juhee, 2001). About 2.5 million children are saved a year by immunization against infectious diseases (Maurice & Davey, 2009). In Ethiopia, "Expanded Program of Immunization (EPI)" was introduced in 1980. It has shown a slight progress in coverage and child protection against communicable diseases has broadened in scope (Griffiths et al., 2009). Moreover, the introduction of pentavalent vaccination in March 2007 extended the domain of diseases prevention against two additional infectious diseases namely, hepatitis b and haemophilus influenza type b (Hib) (Griffiths et al., 2009).

2.3.4 Environmental factors

Environmental factors encompass the exposure with the chemical, nutritional, the built and the psychosocial environment, as well as the interaction among these environments (Landrigan, 2016). The environment is a medium within which the interface between agent and host occur. In infectious disease, environmental factors can facilitate the viability of the agent and its transmission to the host (Gordis, 2009). The impact of environmental determinants for health were understood since the miasmic theory where the then experts understood diseases conditions were the interaction of environmental factors (Peterson & Lupton, 1996). According to WHO's new estimates, all global deaths that are attributable to environmental factors accounts 23% which is predicted to 12.6 million each year (WHO, 2016b).

Major routes of environmental contamination involve air, food, water, skin and soil. Hence, when an environmental assessment is required one or more of these measures may be used to obtain a composite index (Mosley & Chen, 2003). Environmental factors affect the under-five mortality in the same way they do to the general population, however children's vulnerability differ from adults

significantly. For instance, diarrheal diseases are most frequent causes of mortality in children under-five year in the sub-Saharan region (Unicef, 2012). They generally are caused by infectious agents transmitted in the fecal-oral root predominately in areas where access to safe drinking water or toilet facility is low. In Ethiopia 20% of childhood deaths was due to diarrhea with varying degree across various areas of the country as high as 30% in the west and 27% in the central Ethiopia (Mihrete, Alemie, & Teferra, 2014). Indoor environment is polluted by smoke arising from inside cooking with poor ventilation system. Polluting fuel sources put under-five children's life at risk through contaminating the inhaled air and affecting the respiratory system. In Ethiopia percentage of care seeking under-five children for suspected pneumonia accounts 27% (Unicef, 2012). According to a study conducted in Nigeria by Godson & Nnamdi (2011), under-five children's mortality was associated with polluting fuel sources particularly, those fuel sources other than electricity, liquefied petroleum, or kerosene..

2.3.5 Socio-economic factors

Contemporary health problems comprise elements of socio-economic aspects. Significant portion of personal live are redefined as health related, a fact which require a different perspective (Marmot, 2003). The daily activities are involved directly or indirectly with social and economic condition. Among other factors, it may include the position in nutrition, employment status, education, place of residence, access to services, culture and significant others. For instance, the quality and quantity of foods and drinks are subject to individual's current purchasing power. Evidence suggest that households with better income consume foods and drinks that produce better health outcome. Employment is source of income that in turn determine the household's budget allocation for healthily lifestyle. Increased awareness (education) promote preventive attitude, and increases health seeking behavior. The place of residence (urban/rural) is associated with the proximity to services and market. Culture determine how one feels about health and illness and indicates the health pursuing practices (Skolnik, 2012). Therefore, contemporary health determinants are multivariate involving largely social aspects of daily life (Peterson & Lupton, 1996).

Family size: it is frequently pragmatic that family size diminish opportunity for health and longevity in children and there exist evidence affirming the wellbeing of children in line with their parent's resources (Baranowska-rataj et al., 2014). In addition, growing in large family essentially create competition with space and greater dilution of resources. The larger the family size the higher the mortality risk on younger children (Asmare, 2011). On the other hand, growing in large family increases disease exposure and hence, contracting diseases at early age in life foster building natural immunity (Baranowska-rataj et al., 2014). An increase in the number of under-five children in a household was associated with a higher likelihood of infant and child mortality in a study conducted in Angola (Sjursen, 2011).

Marital Status: Marriage is a legally recognized institution and relatively stable interpersonal union for cohabitation (Lind, 2008). Theoretical explanation for the relationship between marital status and child mortality may possibly be seen from different perspectives in comparison to other sexual unions. Wright (1997) argues that marriage is associated with fertility, and fertility in-turn is also related with infant mortality. Therefore, this supposition encompasses marriage and infant mortality through fertility. The second perspective is that marriage increases availability and deployment of household resources as compared to other sexual unions, which has positive impact on children's health and longevity (Wright, 1997). Another standpoint consider marriage as a selective process where men and women are better suited for better reproductive outcome as compared to other sexual unions (Goldman, 1993). Empirically, children of married families were found better off in a demographic study conducted in Ethiopia (Negera et al., 2013). Infant mortality reduced by 40% among married mothers in a demographic study in Ethiopia (Asmare, 2011). On the other hand, inconsistent results also appear in some studies conducted in different sub-Saharan countries. The survival of under-five children were better off among divorced mothers in a study conducted in Cöte d'Ivoire (Assi Kouame, 2014). In opposition to this finding, divorced status of the mother was a risk factor in a study conducted in Nigeria (Antai, 2011). In Ghana, marital union as well as not in polygamous union were protective factors for under five children survival (Kanmiki et al., 2014). In contrast, the effect of un-marital status to under-five children

mortality among whites and blacks was determined by external factors in a study conducted in the USA. While increase with maternal age was mostly associated with child deaths among un-married blacks, for college educated white women they were not affected by their un-married status (Bennett et al., 1994).

Religious affiliation: The underpinning for religious affiliation in infant and child mortality differentials stems with the lifestyles inherent to the tradition. On the other hand, social isolation based on religious affiliation were found beneficial by reducing contacts thereby avoiding possible risks that could otherwise be means of disease transmission from large religious crowds (Van Poppel, Schellekens, & Liefbroer, 2002). Asmare (2011) point out that the impact of religion on child mortality may be associated with socio-cultural practices and beliefs in his analysis of the 2000 and 2005 EDHS. He observed that infant mortality had reduced among Muslim, Protestant and other followers as compared to Orthodox followers; although impact at significance was only realized among protestant followers.

Father's Education: Education increases skills and knowledge and is a vehicle to deal with new ideas, and source of better income (Caldwell, 1979). The effect of the father's education to children's survival has been a subject of discussion in child survival studies. Evidence suggest that father's education is important in the same way as maternal education even-though the degree of impact between the two differ in reducing child mortality (Breierova & Duflo, 2004; Caldwell, 1979; Chowdhury, 2013). Many argue as father's education is applicable through its effect on income generating power for the household where the child is benefited from that income (Asmare, 2011; Charmarbagwala et al., 2004; Semba & Bloem, 2008). Indeed, income differences matter as income increases purchasing power. The effect of father's education for child survival has limited theoretical foundations, and often neglected, because its effect often compared with maternal education. However, its influence may not have limited to income generation. An earlier study in Nigeria found that mortality index of children among husbands with primary and secondary education had reduced by 10 and 20% respectively while their wives' had no education (Caldwell, 1979). This may be because of father's education complements less educated mothers through

their tendency or orientation for better child care services and in their influence in choice of consumption goods (Mosley & Chen, 2003).

2.4 Summary of findings from Selected Previous Research

Table 1: Summary findings of selected earlier studies

First Author's (Last Name, Year), Country	Study sample (n=)	Statistical Method	Outcome and determinants of the study	Summary of findings
Assi Kouame 2014 Cöte d'Ivoire	7511	Logistic Regression	Statistically significant variation in child mortality across regions were found in Cöte d'Ivoire. Maternal education, wealth index, sex of the child, birth interval and birth order were major determinants.	Child's odds of death decreased by 0.99 for women at least with secondary education. Higher wealth index; higher birth interval; 2nd to 5th birth order: being a girl; born from divorced mother; were found protective factors.
Antai, 2011 Nigeria	6029	Cox Regression	High under-fife mortality was seen among disadvantaged regions such as Nile Delta in Nigeria: Significant determinants include: birth order, maternal education, wealth index, and marital status	Children being ≥ 5th birth order; from mothers without or with primary education; and from poor wealth index; from divorced mother; were found at risk.
Negera, 2013 Ethiopia	32,388	Cox Regression	The trend of under-five child mortality rate was found declining in 3 consecutive DHS conducted during 2000,	Being a girl; born after ≥ 3 years' birth interval; small/very small birth size; secondary & above maternal education;

First Author's (Last Name, Year), Country	Study sample (n=)	Statistical Method	Outcome and determinants of the study	Summary of findings
			2005 and 2011 in Ethiopia. Significant determinants for infant and under-five mortality include: region, sex of the child, birth interval, birth size, maternal education, marital status, and availability of toilet facility.	currently in union were protective factors for both infant and under 5 mortality. surprisingly non improved toilet was found protective for under 5 mortality. Risk factors for infant mortality include: Place of residence in Amhara & Gambela regions. Also being in Amhara, Afar, Benishangul, SNNP and Gambela regions were risks for under five mortality.
RR Ettarh, 2012 Kenya	16,162	Cox Regression	Determinants of under-five mortality differ in urban and rural areas in Kenya. Significant determinants include: rurality, maternal age, Birth order, Wealth index, province and duration of breastfeeding,	Maternal age ≥ 32 for rural, ≥ 21 years for urban; and duration of breast feeding for ≥ 6 months for both urban and rural places was protective factor. Birth order ≥ 2 in both urban and rural (more in urban), wealth index in rural places, being in the rural parts of the Coast, Nyanza and Western provinces were found risk factors for under 5 mortality.
Kanmiki et al. 2014 Ghana	3,975	Logistic Regression	Maternal socio-economic and demographic factors affect childhood mortality in rural	Maternal younger age; primary and above education; marital status; not in polygamous union were protective factors for

First Author's (Last Name, Year), Country	Study sample (n=)	Statistical Method	Outcome and determinants of the study	Summary of findings
			Northern Ghana. Major factors include: maternal education, age, marital status, and presence of co-wives.	under-five mortality. In this study age group 20 and above were associated with some degree of risk compared to the reference group (15-19), but the odds of child deaths increase by 3 fold for maternal age ≥ 35.
Chowdhury, 2013 Bangladesh	6,150	Cox Regression	Proximate determinants had stronger impact on childhood mortality than socio-economic factors in Bangladesh. Significant determinants include: father's education, place of residence, region of residence, number of children under five years of age, previous death of sibling, mother's age, breastfeeding, contraceptive use and preceding birth interval.	Father's ≥ secondary education; residing in Chittagong region; preceding birth interval ≥ 25 months; maternal age under 35; contraceptive use; and breast feeding were protective factors for under-five mortality. Rural living; ≥ 2 under-five children in the household; previous death of sibling were risk factors for under-five mortality.

Work Description

My motivation to complete my thesis work on child survival has essentially initiated from my previous work experience and education. I had the chance to work for under-privileged societies in Northern Ethiopia in a project that targets improving maternal and child health outcomes. Over there, I got the opportunity to appreciate the multifaceted perspectives of the various challenges affecting child survival in the project districts. My position to coordinate and monitor many district's performances had also let me make inquiries for their differences. The desire to unravel the mystery behind these challenges was accompanied and enriched through my current study in public health.

I picked the topic of this thesis, however the description of the working title was formed later in collaboration with my supervisor. I downloaded the data from MEASURE DHS (USAID) up on official permission following my request. My supervisor Dr. Subas Neupane (PhD) has given general guidance to the design of data presentation and verified method appropriateness at all times. He also has helped in weighting the sample. His inputs were also significant in guiding the method and results section of the article version in a better scientific and academic elegance. He also helped in choosing and submitting the manuscript to scientific journals.

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Appendix: Copy of original paper

Regional Disparities in Under-Five Mortality in Ethiopia: A Cross-Sectional Analysis of Nationally Representative Sample

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Abstract

Objective: This study evaluates the significance of regional disparities for the risk of under-five mortality and identifies various determinants that explain for under-five death and disparity using a nationally representative sample of women in Ethiopia.

Methods: a nationally representative cross sectional data from the 2011 Ethiopia Demographic and Health Survey (EDHS) was used. Data comprised 1,184 children born within five years preceding the survey. Demographic information including maternal and child characteristics, socio-economic characteristics and environmental characteristics were measured from home interview. Cox proportional hazard regression analysis was used to calculate hazard ratios (HRs) and their 95% confidence interval (CI) for the regional disparities in under-five mortality.

Results: the prevalence of under-five mortality at national level was 7.2 deaths per 100 live births (N=809) with the highest mortality in Benishangul Gumuz region (9.2 deaths per 100 live births, HR 2.11, 95% CI 1.06 – 4.19) and lowest in Addis Ababa as the reference group (3.6 deaths per 100 live births). In multivariate analysis, contraceptive use (being not user), parity (having more than one child), size of the child at birth (being either large or very small), and sex of the child (being male) were significantly associated with under-five mortality. Environmental characteristics contributed relatively little to the under-five mortality.

Conclusions: The findings suggest that significant disparity on under-five children mortality exist among regions of Ethiopia. The determinants for under-five death and disparity were mostly attributable to maternal and child factors.

Key words: Under-five mortality, regional disparity, child factors, socio-economic factors, environmental factors, maternal factors

Significance

What is already known on this subject? Health disparities in children are health outcomes from inequitable differences in health and health care. Studies suggest the mechanisms behind health disparities in under-five mortality among regions are multidimensional.

What this study adds? This study provides estimates on the significance of regional disparities and identify the determinants for the risk of under-five mortality in Ethiopia. The determinants for the mortality differential were disaggregated among thematically categorized factors. The study delivers the basis for prioritizing intervention strategies in resource constrained setting. It expands empirical evidence on child health in Ethiopia with detailed inequality analysis.

Introduction

Reducing the under-five mortality has long been an international target. However, the world is still facing high under-five mortality. In 2015, the global under-five mortality rate was 43 deaths per 1000 live births, still high, although it has reduced by 53% from the rate in 1990. Some 5.9 million children under the age of five died in 2015 worldwide of which 49.6% died in sub-Saharan Africa[1]. The child's risk of dying is highest during the neonatal period accounting for 45% of all under five deaths. Therefore, the global target for under-five mortality reduction by 2/3 was not met. Reducing the under-five mortality is yet a global health strategy, which is stipulated in the new framework, the Sustainable Development Goals (SDGs). It aims to bring the under-five mortality down to at least 25 deaths per 1000 live births by 2030[2].

The mortality rate for under-five children in Ethiopia continues to decline. In 2015, it dropped to 59.2 deaths per 1000 live births (95% CI: 40.6 - 83.0)[2]. It reduced by 59.3% since the beginning of the millennium and by 71.2% since the rate in 1990[1]. Among other strategies, the fruitful implementation of the Health Extension Program (HEP) has been credited for the change[3,4]. On the other hand, some evidence indicates that huge disparity on under-five mortality prevails between Ethiopia's administrative regions[5-6].

Despite recent developments in health, disparities in life expectancy and various key health outcomes have become a common feature of all societies, even in developed countries. In 2015

children in low income countries died 10.8 times more frequently than their counterparts in high income countries[1]. Differences in under-five mortality between communities or regions are evident indicators of health disparity[7]. In this regard, the facts suggest various maternal and child factors mostly related with pregnancy and birth, environmental conditions, demographic and socio-economic factors relate with this phenomenon. These factors have contributed for health outcome differentials among children[8,9].

The extent of Ethiopia's regional disparity in under-five mortality is poorly understood, albeit various studies have been conducted on child mortality determinants. These studies mostly indicate among other factors, the role of communicable diseases, nutritional deficiencies and poor socio-economic conditions related with poor child health outcomes. However, research in particular to health disparities is generally limited. Therefore, an evidence-based approach is required to determine the significance of inequality differentials and the factors associated with it. Reduction of inequalities is one among the 17 targets in SDGs set to be achieved by 2030[10].

This study aims to investigate if there are substantial regional disparities in risk of under-five mortality in Ethiopia; and to determine other factors that explain the risk of under-five death as well as the determinants for mortality differentials among regions in the country.

Methods

A nationally representative cross sectional data from Ethiopian demographic and health survey (EDHS) collected in 2011 was used. Data was found from Measure DHS up on request for research purposes. The sampling frame was adapted from the Ethiopian population and housing census conducted in 2007 consisting of 85,057 Enumeration Areas (EAs) used as the basis for first stage sampling unit. Households were selected in the second stage of the sampling design using stratification and clustering. A representative sample of 17,817 households was selected for the 2011 EDHS from 596 EAs. The sample contained a total (*de facto*) of 11,654 live births taking place within five years preceding the survey. All women aged 15-49 who were usual residents or slept there the night before the survey were eligible for the survey. However, as this study underpins region of residence for analysis, 269 of the cases were excluded. In these cases, the region in which the mothers were surveyed was not a *de jure* residence. In addition, 201 cases were excluded for which the child's age (time) $\geq$ 60 months, bringing the study sample size to 11,184 children.

Ethics Statement

Ethical approval for the survey was provided by Ethiopian Health and Nutrition Research Institute (EHNRI), the National Research Ethics Review Committee (NRERC) at the Ethiopian Ministry of Science and Technology, the institutional review board of ICF international and Center for Disease Control (CDC).

Measurement of variables

Outcome: Under five mortality was the outcome of interest in this study, which is defined as the death of children under the age of five.

Predictor variable: The region was used as the main predictor in this study and they were: Tigray, Afar, Amhara, Oromia, Somali, Benishangul Gumuz, Southern Nations and Nationalities and people (SNNP), Gambela, Harari, Dire Dawa and Addis Ababa. The last two (Dire Dawa and Addis Ababa) were city administrations.

Covariates: Various biological, socio-economic and demographic determinants pertaining to child survival were used as covariates based on Mosley and Chen's framework[8] developed in 1984 and from related studies in the field; nevertheless, selection was subject to availability and completeness of survey data.

Maternal level variables: Maternal age at first birth (≤18 years & > 18 years); contraceptive use (users and not users), maternal educational status (no education, primary education and secondary education and above) and birth in the last 5 years (one, two births, and 3 or more births).

Child level variables: Sex of the child (boy and girl), birth order (1st birth, 2nd to 5th born, and ≥ 6th born), size of the child at birth (five groups: very large size, larger than average size, average size, smaller than average size and very small size).

Environmental level variables: Toilet facility (no toilet facility or using bush/field, and having toilet facility), source of drinking water (protected, not protected source). Similarly, household's source of fuel (four categories: using either electricity or gas or no cooking in the household, using charcoal or coal or ignite, using plant source such as wood, grass or crop and using animal sources such as dung).

Socio economic related variables: Type of place of residence (urban and rural), wealth index (poor, middle and rich). The wealth index was constructed based on household's possession of durable

goods, which are the building blocks in the creation of wealth scores for households. A five level wealth quantile were obtained by computing area specific scores through a regression on the common factor scores. However, in this study the index was categorized in to three groups. Besides, the created scores were made adaptable with urban and rural settings. Husband's educational status (three groups: no education, primary education and secondary education) were used.

Statistical analysis

The frequency distribution and percentages for characteristics of studied variables were presented first. The data was weighted using sampling weight procedure in order to achieve the representativeness of the data. Cox regression was used for the multivariate analysis which involves survival time (follow up time) differences and censoring between child's status (alive or dead). Time variable was created by subtracting the year, month and date of birth from year, month and date of interview through converting all time units in to month using the following formula: Age in months = [((Year of interview x 12) + (month of interview) + (day of interview/30.42)) - ((Year of birth x 12) + (month of birth) + (day of birth/30.42))]. Age in months was determined for alive and dead children. The time interval between birth and date of interview constitute the survival period where the event of interest was included. The event of interest was the death of the under-five child and time to event was measured in months. Children survived at the time of data collection are counted as censored cases.

The crude survival curves for under-five children were drawn according to the regions. The multivariate analysis comprised of six model. The variable *"Region"* was used as the main independent variable in each of the models. Model one was a crude model with only the regions. The objective of setting this ideal model is to rule out the gross effect of *'region of residence'* on mortality of under-five children and also act as a platform for examining the influences of other factors set in other models. Model two includes maternal factors, four variables: maternal age at first birth, education, maternal contraception use and maternal birth with in the last 5 years along with the regions. Similarly, three child related factors: sex of the child, birth order and child's size at birth were added in Model three along with the regions. Model four contains three environmental factors: toilet facility, source of drinking water, and household's source of fuel and the regions. In model five, again three socio-economic determinants: type of place of residence, wealth index and husband's education were investigated as covariates and regions. The final model (Model six) was then created by putting all covariates in the model to explore the overall effects in under-five mortality and differences across regional states.

All statistical analysis was performed using statistical package software known as SPSS version 21.

Results

Characteristics of studied population

Table 1 shows the characteristics of the studied population. Of 11, 184 children 5739 were boys and 5445 were girls. About two third of these children's mothers and 53% of their fathers had no education and 83% were from rural areas. Majority of children were from poor (49 %) wealth quintile. Oromia region constituted the highest number of the study sample (15%). Similarly, 52% of households had no toilet facility, 49% had un-protected source of drinking water and 86.5% used plant sources for fuel for cooking. Majority of women had two or more births (62%) five years preceding the survey and only a fifth used some sort of contraceptive methods. Nearly more than 50% of women had their first birth at age ≤ 18 years. Majority (55%) of children were 2nd to 5th born. While 39% of all children had average size, 17% and 22% had very large and very small size respectively.

[Table 1: Here]

Table 2 shows the prevalence of under-five mortality according to the study characteristics. Significantly higher prevalence was found among mothers who are not contraceptive user (7.8%), not educated (7.6%) and having three or more births in the last 5 years (16.2%). Similarly, under-five mortality was significantly higher among children who had very large (9.8%), larger than average (9.2%) and very small size (7%) at birth and being baby boy (7.9%). Regarding environmental factors, significantly higher prevalence was found among those mothers having no toilet facility (7.8%), use of unprotected source of water (7.7%) and use of plant (7.4%) and animal sources (7.7%) for household's fuel consumption. Similarly, being rural residents (7.4%), poor

wealth index (8.0%), fathers with no education (7.8%), and those residing in Afar (8.5%), Benishangul Gumuz (9.2%) and Gambela (7.9%) regions had significantly higher prevalence of under-five mortality.

[Table 2: Here]

The results of multivariate analysis for regional differences in under-five mortality in Ethiopia are shown in Table 3. Model I shows the crude association between the region and mortality, which shows the high regional disparities in under-five mortality. Except for Dire Dawa and Tigray region all the regions had nearly or higher than twofold risk of mortality compared to the capital Addis Ababa (reference category); hazard ratio (HR) varied between the regions with highest risk in Benishangul Gumuz region (HR: 2.34; 95% CI: 1.33 – 4.11) and lowest in Amhara (HR: 1.76 95% CI: 1.00 - 3.02).

The association between the regions and the mortality turned out to be non-significant when maternal factors (model II) were added to Model I. Child factors (Model III) strengthened the association between region and under-five mortality at even higher level of significance. The risk of under-five mortality remained highest in Benishangul Gumuz and lowest in Afar regions when Environmental factors were added in Model IV. The risk of under-five mortality continued to be highest in Benishangul Gumuz region and lowest in Harari region after socio-economic factors were added in Model V.

The relationship between region of residence and under-five mortality were also evaluated containing all the covariates to model-I. The results of this composite model (Model VI) still supported the presence of significant disparities between regions. Under-five children in Afar, Amhara and Benishangul Gumuz region had about two-fold higher risk than the capital Addis Ababa (HR: 1.98, 1.99, & 2.11 respectively). These differences were significantly attributable to maternal and child factors. For e.g. women being no contraceptive users (HR: 1.49; 95% CI: 1.20 –0.86), having two or more than two births (HR for 3 or more births: 3.22; 95% CI: 2.62 – 3.97), larger than average to very large or very small size of the child at birth (HR for very large birth size: 1.62; 95% CI: 1.33 – 1.96) and male sex (HR: 1.17; 95% CI: 1.01 – 1.35) were significantly associated to under-five mortality.

Table 3: Here

Discussion

The findings of this study explain high disparities in under-five mortality in Ethiopia associated with region of residence. The odds of under-five children dying in regions such as Benishangul Gumuz and Afar was more than twofold compared to Addis Ababa. The evidence in this study also suggests the presence of high under five mortality (7.2%; N=809) at national level. Especially the prevalence in emerging regions such as Benishangul Gumuz and Afar was high, 9.2% and 8.5% respectively. This may be attributable to disparities in community development in the society. In particular, this partially reflects the case for emerging regions: Benishangul Gumuz, Afar, and Somali regions which are characterized by low wealth quantile, health and educational attainment [5,11]. Similar variability between regions has been reported in cot 'devour and Nigeria [12,13]. Dire Dawa city administration was an exception not significantly affected by any factor in the study, while other regions were affected at least for one or more factors.

Findings in this study also indicate that maternal contraceptive use, parity, child's birth size, and sex, were the main predictors for under-five mortality in Ethiopia. Maternal contraceptive use lowers the risk of under-five death by half, plausible with previous findings in Bangladesh[14]. Similarly, low parity women were at lower risk for under-five death. As parity goes higher by one more birth, the mortality of under-five children increases by at least 42% relative to mothers with one birth (Para I). This indicates that mortality increases as number of birth increases, consistent with similar study in Nepal[15,16]. Both the effects of contraceptive use and parity could be because of under-nutrition as a result of resource insufficiency in families with lowest wealth quantile. In Ethiopia the lowest wealth quantile in regions such as Afar accounts as high as 57%, in Somali

44%, and in Gambela 35%[5]. Children of very large, larger than average or very small birth size have higher risk of dying than average or smaller than average children. This result seems to contradict with the study by Negera. et.al. (2013) where they argued that very small birth size children were better off as regards to under-five mortality compared to average or larger birth size. The variance may be attributable to differences in variable categorization, in that Negera.et al. had categorized the variable into two while in this study the data was analyzed in 5 categories. Nevertheless, analysis from self-reported (proxy) data shall be inferred with care. As regards the sex differentials, baby boys have 17% more odds of dying than baby girls. These results were in line with known facts and consistent with evidence from earlier studies [18]. Lawn & Blencowe, (2013) argued that baby girls were at greater biological survival advantage than baby boys as the latter are at a higher risk of mortality and disability due to preterm birth. The underlying reasons for prematurity for baby boys was related to higher likelihood for developing placental problems, pre-eclampsia and high blood pressure in women pregnant with a boy suggesting the importance of prenatal visits during pregnancy and early detection of complicated pregnancy. The fact on sex disparities favoring for girls in children's survival was also supported in other earlier studies in the field [18, 20]. On the contrary, sex disparities in favor of boys have been documented in India mostly associated with cultural reasons [21]. Some research findings also indicate sex disparities were insignificant [22].

The evidence from the cox model in this study also indicate that child, environmental and socio-economic factors influence the relationship between region of residence and mortality among under-five children. All regions, but Dire Dawa had higher although varied hazard risk for child related factors, in accordance with the results found in model I. Environmental related factors in

general were also influential in Afar and Benishangul Gumuz regions. The facts in these regions are suggestive of low environmental health service coverage that is in line with previous studies [23], [24]. The effect of socio-economic factors were reflected significantly in Afar, Somali, Benishangul, and Harari regions. The poorest households had the highest risk in under-five mortality also in accordance with earlier findings [14]. The study also reveals that the disparity between urban and rural is not statistically significant. This fact was also supported by recent study by [3] using the same data source. This may be attributable to the current health extension program for shortening the gap between urban-rural differences. Studies in Nepal (for infant mortality) and cot 'devour had shown similar findings, while studies in Bangladesh and Kenya had shown the urban-rural differences had significance in under-five mortality. Ambel et al., (2015) argued that the effect of place of residence between urban and rural is more important for quality of services than health outcome, even though quality implicated in outcome eventually. Maternal factors were not prominent in the disparity differential of regions for under-five mortality. However, being a non-contraceptive user and having two or more births were related with higher risk for child survival. Weather low contraceptive prevalence as well as higher number of births were widespread to result in insignificant disparities in child survival among region of Ethiopia was the consequential new hypothesis for the fact shown in maternal factors. Hence it is worth be tested and further explored in empirical research.

It was surprising to see maternal age at first birth was not significantly associated with under-five mortality while nearly above half of women had their first birth at age ≤ 18 years; albeit, it has been described a major factor in similar studies [14], [24]. However, similar results were also found in Kenya and Nepal [20], [15] suggestive of variances in the factors behind under-five children's mortality

attributed to the countries health systems. It was also unexpected to see socio-economic factors (in model five) turned higher hazard risk in Harari region despite the region has the least (2%) proportion in lowest wealth quantile and other socio-economic measures.

The study has both methodological strengths and limitations. The data used for the study were representative at national level and the use of cox proportional multivariate hazard model as a tool for statistical analysis are worth to mention as the strengths of this study. However, the interpretation of the results from the multivariate analysis are limited to the variables under study. The effects of other variables that were not included in the cox model may differ in the results. The use of cross sectional data may not also provide complete information on changes during the survival time frame. Therefore, the analysis was based on the data gathered at a cross sectional level. Therefore, these shortcomings limit to draw conclusions for causality.

Further research is needed to unravel the reason behind significant directional change influenced by maternal and child factors on the association between region of residence and under-five mortality. It is worth to assess if the adjustment in maternal and child factors implicated any statistical interactions. Further research is also needed to investigate the basis of unprecedented susceptibility for under-five mortality in Harari region influenced by socio-economic factors besides region of residence.

Conclusion

Considerable reduction in under-five mortality rate has been attained in Ethiopia over the last decade since the beginning of the millennium. However, the findings suggest that significant disparity on under-five children mortality exist among regions of Ethiopia. The determinants for under-five death and disparity were mostly attributable to maternal and child factors. Child survival interventions shall consider regional differences and the factors associated in order to minimize inequality differences and thereby reducing the under-five mortality in the country. Disaggregated reporting of health metrics with relevant determinants could be more informative and can serve as early warning system.

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Tables:

Table 1: Socio-demographic and environmental characteristics of studied population based on Ethiopian Demographic and Health Survey 2011.

Characteristics	N= 11,184	Percent
Maternal factors		
Maternal age at first birth		
≤18 years	5620	50.3
>18 years	5564	49.7
Contraceptive use		
User	2313	20.7
Not user	8871	79.3
Maternal educational status		
No education	7838	70.1
Primary	2796	25.0
Secondary	550	4.9
Births in the past 5 years		
One	4307	38.5
Two	5229	46.8
Three or more births	1648	14.7
Child factors		
Size of the child at birth		
Very large size	1926	17.2
Larger than average size	1363	12.2
Average size	4384	39.4
Smaller than average size	966	8.6
Very small size	2488	22.2
Sex of child		
Male	5739	51.3
Female	5445	48.7

Characteristics	N= 11,184	Percent
Birth order		
1st born	2165	19.4
2nd – 5th born	6164	55.1
≥ 6th born	2855	25.5
Environmental factors		
Toilet facility		
No toilet facility, bush/field	5772	51.6
Have toilet facility	5412	48.4
Source of drinking water		
Protected sources	5758	51.5
Unprotected sources	5426	48.5
Household's source of fuel		
Electricity/Gas/no cooking inside HH	275	2.5
Charcoal, coal or ignite	819	7.3
Plant sources (wood, grass, crop)	9676	86.5
Animal sources (dung), other	414	3.7
Socio-economic factors		
Type of place of residence		
Urban	1910	17.1
Rural	9274	82.9
Wealth index		
Poor	5506	49.2
Middle	1807	16.2
Rich	3871	34.6
Husband's Educational Status		
No education	5886	52.6
Primary	4005	35.8

Characteristics	N= 11,184	Percent
Secondary	1293	11.6
Region		
Addis Ababa	390	3.5
Tigray	1146	10.2
Afar	1106	9.9
Amhara	1218	10.9
Oromia	1665	14.9
Somali	1003	9.0
Benishangul Gumuz	979	8.8
SNNP	1573	14.1
Gambela	813	7.3
Harari	636	5.7
Dire Dawa	655	5.9

Table 2: Prevalence of under-five mortality by study characteristics (n=809).

Characteristics	Child not alive (%) N=809 (7.2%)	χ^2 P-value
Maternal factors		
Maternal age at first birth		
≤18 years	426 (7.6%)	0.15
>18 years	383 (6.9%)	
Contraceptive use		
User	113 (4.9%)	<0.001
Not user	696 (7.8%)	
Maternal educational status		
No education	593 (7.6)	0.006
Primary	194 (6.9)	
Secondary	22 (4.0)	
Births in the past 5 years		
One	178 (4.1%)	<0.001
Two	364 (7.0%)	
Three or more births	267 (16.2%)	
Child factors		
Size of the child at birth		
Very large size	189 (9.8%)	<0.001
Larger than average size	126 (9.2%)	
Average size	260 (5.9%)	
Smaller than average size	48 (5.0%)	
Very small size	158 (7.0%)	
Sex of child		
Male	452 (7.9%)	0.007
Female	357 (6.6%)	
Birth order		
1st born	161 (7.4%)	0.489

Characteristics	Child not alive (%) N=809 (7.2%)	χ^2 P-value
2^{nd} – 5^{th} born	430 (7.0%)	
≥ 6^{th} born	218 (7.6%)	
Environmental factors		
Toilet facility		
No toilet facility, bush/field	450 (7.8%)	0.018
Have toilet facility	359 (6.6%)	
Source of drinking water		
Protected sources	390 (6.8%)	0.053
Unprotected sources	419 (7.7%)	
Household's source of fuel		
Electricity/Gas/no cooking inside HH	10 (3.6%)	0.040
Charcoal, coal or ignite	48 (5.9)	
Plant sources (wood, grass, crop)	719 (7.4%)	
Animal sources (dung), other	32 (7.7)	
Socio-economic factors		
Type of place of residence		
Urban	119 (6.2%)	0.063
Rural	690 (7.4%)	
Wealth index		
Poor	438 (8.0%)	0.006
Middle	130 (7.2%)	
Rich	241 (6.2%)	
Husband's Educational Status		
No education	462 (7.8%)	0.021
Primary	269 (6.7%)	
Secondary	78 (6.0%)	
Region		
Addis Ababa	14 (3.6%)	0.017

Characteristics	Child not alive (%) N=809 (7.2%)	χ^2 P-value
Tigray	76 (6.6%)	
Afar	94 (8.5%)	
Amhara	88 (7.2%)	
Oromia	115 (6.9%)	
Somali	75 (7.5%)	
Benishangul Gumuz	90 (9.2%)	
SNNP	117 (7.4%)	
Gambela	64 (7.9%)	
Harari	41 (6.4%)	
Dire Dawa	35 (5.3%)	

Table 3: Hazard Ratios (HR) and their 95% Confidence Intervals (CI) for under-five mortality due to region of residence, and other models

Covariates	**HR (95% CI)**					
	Model One	**Model Two**	**Model Three**	**Model Four**	**Model Five**	**Model Six**
Region of residence						
Addis Ababa	1	1	1	1	1	1
Tigray	1.64 (0.93 – 2.90)	1.23 (0.68 – 2.22)	2.05 (1.08 – 3.87)*	1.42 (0.77 – 2.62)	1.55 (0.85 – 2.84)	1.73 (0.87 – 3.42)
Afar	2.29 (1.31 – 4.02)**	1.42 (0.78 – 2.56)	2.93 (1.56 – 5.49)**	1.88 (1.01 – 3.49)*	2.08 (1.15 – 3.80)*	1.98 (1.001 – 3.93)*
Amhara	1.76 (1.002 – 3.09)*	1.48 (0.83 – 2.66)	2.16 (1.15 – 4.05)*	1.52 (0.82 – 2.82)	1.65 (0.90 – 3.01)	1.99 (1.004 – 3.95)*
Oromia	1.79 (1.03 – 3.13)*	1.20 (0.67 – 2.14)	1.99 (1.07 – 3.72)*	1.56 (0.85 – 2.87)	1.75 (0.97 – 3.16)	1.54 (0.78 – 3.03)
Somali	2.05 (1.16 – 3.63)*	1.06 (0.58 – 1.92)	2.32 (1.23 – 4.40)*	1.75 (0.95 – 3.23)	1.91 (1.06 – 3.47)*	1.25 (0.63 – 2.48)
Benishangul-Gumuz	2.34 (1.33 – 4.11)**	1.58 (0.88 – 2.85	2.67 (1.42 – 5.02)**	2.06 (1.11 – 3.82)*	2.23 (1.23 – 4.05)*	2.11 (1.06 – 4.19)*
SNNP	1.78 (1.02 – 3.11)*	1.24 (0.69 – 2.19)	2.16 (1.16 – 4.03)*	1.60 (0.87 – 2.95)	1.72 (0.95 – 3.09)	1.79 (0.91 – 3.53)
Gambela	1.94 (1.08 – 3.46)*	1.37 (0.76 – 2.49)	2.22 (1.16 – 4.23)*	1.64 (0.88 – 3.08)	1.83 (0.99 – 3.39)	1.80 (0.89 – 3.64)
Harari	1.84(1.002 – 3.37)*	1.25 (0.67 – 2.32)	2.17 (1.11 – 4.23)*	1.65 (0.87 – 3.10)	1.87 (1.002 – 3.49)*	1.69 (0.84 – 3.41)
Dire Dawa	1.36 (0.73 – 2.53)	0.85 (0.45 – 1.61)	1.60 (0.81 – 3.17)	1.18 (0.62 – 2.25)	1.31 (0.63 – 2.46)	1.07 (0.52 – 2.19)
Maternal age at 1st birth						
≤18 years		1.03 (0.89 – 1.18)				1.04 (0.89 – 1.20)
>18 years		1				1
Contraceptive use						
User		1				1
Not user		1.44 (1.16 – 1.77) **				1.49 (1.20 – 1.86)***
Maternal Education						
No Education		1.03 (0.66 – 1.62)				1.23 (0.72 – 2.10)
Primary		1.16 (0.73 – 1.83)				1.39 (0.82 – 2.35)
Secondary		1				1

Covariates	HR (95% CI)					
	Model One	**Model Two**	**Model Three**	**Model Four**	**Model Five**	**Model Six**
Births in past 5 years						
one		1				1
two		1.38 (1.15 – 1.66)**				1.42 (1.18 – 1.72)***
3 or more births		3.12 (2.55 – 3.82)***				3.22 (2.62 – 3.97)***
Size of the child at birth						
Very large			1.59 (1.31 – 1.92)***			1.62 (1.33 – 1.96)***
Larger than average			1.51 (1.22 – 1.87)***			1.49 (1.20 – 1.84)***
Average			1			1
Smaller than average			0.82 (0.61 – 1.13)			0.81 (0.60 – 1.11)
Very small			1.25 (1.02 – 1.53)*			1.26 (1.03 – 1.54)*
Sex of child						
Male			1.135 (0.98 – 1.31)			1.17 (1.01 – 1.35)*
Female			1			1
Birth order						
1st			1			1
2nd – 5th			0.94 (0.79 – 1.14)			0.91 (0.75 – 1.09)
≥6th			1.38 (0.89 – 1.18)			1.05 (0.84 – 1.31)
Toilet facility						
No toilet facility,				1.15 (0.98 – 1.35)		1.06 (0.89 – 1.27)
bush				1		1
Have toilet facility						

Covariates	HR (95% CI)					
	Model One	**Model Two**	**Model Three**	**Model Four**	**Model Five**	**Model Six**
Source of drinking H_2O				1		1
Protected source				1.05 (0.91 – 1.23)		1.02 (0.87 – 1.20)
Unprotected source						
Household source of fuel				1		1
Electricity/gas				1.48 (0.74 – 2.97)		1.38 (0.63 – 3.01)
Charcoal/coal/ignite				1.36 (0.69 – 2.66)		1.06 (0.48 – 2.34)
Plant source (wood)				1.49 (0.70 – 3.20)		1.37 (0.57 – 3.26)
Animal sources (dung)						
Place of residence type						
Urban					1	1
Rural					0.88 (0.69 – 1.14)	0.79 (0.60 – 1.05)
Husband's education						
No Education					1.05 (0.79 – 1.38)	1.04 (0.77 – 1.42)
Primary					0.99 (0.76 – 1.31)	1.00 (0.75 – 1.34)
Secondary					1	1
Wealth Index					1.23 (1.01 – 1.49)*	1.07 (0.86 – 1.33)
Poor					1.18 (0.93 – 1.50)	1.12 (0.87 – 1.42)
Middle					1	1
Rich						

* = P <0.05; ** = P <0.01; *** = P< 0.00

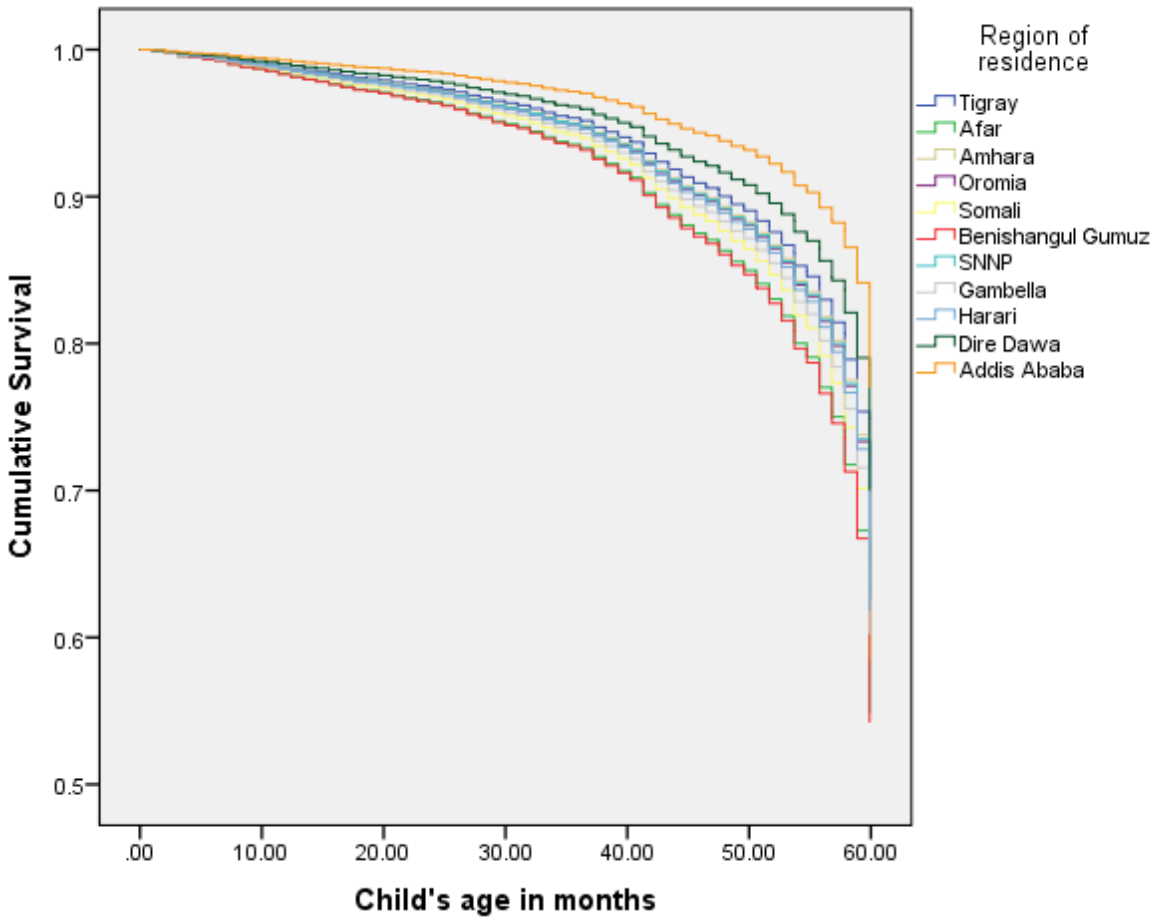

***Figure 1**: Survival function plot for region of residence and under-five mortality based on EDHS 2011*