Determinants of Infants and Under-Five Mortality Differentials in Tanzanian Zones: Evidence from Panel Data Analysis.

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Abstract

Infant and under-five mortality have shown a substantial decline of 49% and 47% respectively in Tanzania over the period (1992-2010). Despite these declines, under-five and infant mortality rates in Tanzania across regions/zones are heterogeneous and unequally distributed. The main purpose of this study was to identify factors determining infant and under-five mortality differentials in Tanzanian Zones using four rounds of Demographic Health Surveys (1992, 1996, 2004 and 2010) over the period 1992 to 2010. A panel data was used to estimate factors determining infants and under-five mortality differentials across zones/regions. Spearman correlation was used for association between explanatory variables and dependent variables. The results show attendant's birth skills, antenatal care providers, mothers education levels, ever breastfeeding and immunization coverage (vaccine measles) to contribute a strong role in improving child health and reducing infant and under-five mortality across Tanzanian zones over time. The results reveal that, zones with higher attendant's birth skills, immunization coverage (vaccine measles), mothers education levels, antenatal care providers and ever breastfeeding have better health outcomes. The highest and lowest infant and under-five mortality over time were observed in southern and northern zones respectively. The paper recommends the importance of expanding schooling and access to quality education to all levels, educating more women in primary, secondary or higher levels and strengthening stronger health system in the access to health care services including immunizations coverage, attendants' birth skills and antenatal care providers in the country to avoid health inequity within Tanzanian zones to achieve sustainable development goals.

Keywords: Fixed effects; Panel Data, Infant and under -five Mortality

1. Introduction

Tanzania is a country that has experienced considerable reductions of both infants and under- five mortality rates. Evidence from Tanzania demographic health surveys (TDHS) showed that, infant's mortality rates in Tanzania declined from 99 deaths per l000 live births in 1992 to 51 deaths per 1000 live births in 2010. Similarly, under-five mortality rates dropped from 154 deaths per 1000 live births in 1992 to 81 deaths per 1000 live births in 2010 (TDHS: 1992, 2010).

Despite these declines, it has been observed in TDHS (TDHS: 1992, 1996, 2004 and 2010) that under-five and infant mortality rates in Tanzania across regions/zones are heterogeneous and unequally distributed. For instance in 1992 TDHS, the under-five mortality rates estimate was 154 deaths per 1000 live births for the whole country, while it was 163, 79 and 191 deaths per 1000 live births in Southern, Northern and Central zones respectively (TDHS,1992). Similarly, the infant mortality rate in Southern zone for the year 1992 was 99.1 deaths per 1000 live births and increased to 121 deaths per 1000 live births in 2004 while in Northern zones the infant mortality was 56 deaths per 1000 live births in 1992 and increased to 67 deaths per 1000 live birth in 2004 (TDHS: 1992,2004).

With regard to evidence given in (Table 1), assessing fluctuation in the infants and under-five mortality rates at the national level might not be sufficient, thus sub-national zone studies can provide detailed information of heterogeneity in both infant and under-five mortality rates across the country over time. This heterogeneity motivates the authors to construct panel data that could explain determinant factors underlying variations in the infants and under-five mortality rates in Tanzania.

Panel data provide better opportunities to track determinants of infant and under-five mortality differentials in regions/zones over a period of time. It presents data when are available for a multiple time periods than cross sectional approaches and controls for omitted (unobserved) variables (e.g. cultural behavior, social norms, underreporting of infant and under-five deaths in different zones/regions). The limitations of cross sectional data are due to the fact that, it does not allow the analysis of change over time at the aggregate level for populations (Rafferty, 2011). It also provide only a snapshot at a given time point and in some cases can lead to misleading inferences, thus providing limited insights into processes of social change (Rafferty, 2011).

In this context, the infant and under-five mortality rates are selected because it's a global indicators of child health as well as of population health (Sen, 1998 & Hassen, 2014). In view of the health sector especially in Tanzania, the main causes of deaths for children less than five years are malaria, anaemia, pneumonia, diarrhea, malnutrition, HIV/AIDS and ARI (NIMR, 2013).

Beyond the health sector, various literature (Byaro & Musonda, 2016; Ezeh et al., 2015; Mekonnen, et al., 2011; Ettarh & Kimani, 2012; Bokhari et al., 2007; Mondal et al., 2009; Oti & Odimegwu, 2011) found the main determinant of infant and under-five mortality to be income, household environment, water and sanitation, education, urban setting and access to health care service (e.g., immunization, antenatal care, place of delivery) etc. The underlying reason beyond the health sector might be due to the fact that, most health problems are related to social determinants (e.g. income and social wellbeing) which are the causes. Findings of the most previous research (Mondal et al., 2009; Kamal, 2012; Susuman & Hamisi, 2012; Ezeh, 2015) used logistic regression to determine infant and under-five mortality. By contrast, previous studies produce different results due to model specification, variable selection and sample size taken.

The main contribution of this paper is to provide an existing literature on the determinants of infants and under-five mortality that lie within sub-national zone panel data in which most previous studies (Muldoon et al., 2011; Wellington, 2014; Jamison et al., 2016) have used cross country data. Single country studies are useful to estimate the determinants of regional/zones mortality rates and trends (Nakamura et al., 2011). It is also useful to inform domestic policies and build national strategic plans (MOHSW, 2008). The paper adopt analytical framework proposed by Mosley and Chen (1984) to construct the panel data model. With regard to this framework, child deaths (infant or under-five mortality) are attributable to a range of hierarchical proximal determinants (e.g. maternal factors, nutrition deficiency, health services utilization, infectious, injuries); intermediate determinants (e.g. access to food, safe water, vaccinations, health services); distal (e.g. education, unemployment, national income, income distribution, public health spending).

2. Materials and Methods

2.1 Data Sources and Variables Selection

This paper used secondary data drawn from the Tanzania Demographic Health Surveys (TDHS) comparable over time due to sampling design and questionnaires. All these surveys were conducted by the Tanzania National Bureau of statistics (NBS) and Ministry of Health. We used four different TDHS of 1992, 1996, 2004 and 2010 to construct repeated observations or panel data in Tanzanian Zones. All information used in this paper was obtained from women aged 15 to 49 years during the demographic surveys. The variable selection was based from existing literature particularly Mosley & Chen (1984) and those that suit panel data model. The main variables we used are indicated in Table 2. All variables were expressed in percentages except infants and under-five mortality which are expressed in (number of deaths per 1000 live births).

In choosing valid covariates into panel regression model, we dropped the correlated explanatory variables using Spearman's correlation (rho) with cut off point of +/- 0.5 (See Table 2a and 2b**).** Finally, we selected potential explanatory variables to capture both infant and under-five mortality differentials. These variables are vaccine coverage indicated by the percentage of children under age five receiving immunizations (vaccine measles), health service delivery indicated by the percentage of antenatal care provider, births skills (percentage assistance during delivery by doctor/clinical officer, nurse/midwife), breastfeeding *(*percentage of children under age five who ever breastfeeding) and socioeconomic indicators represented by percentage of mothers with no education, secondary or higher education levels.

2.2 Mode Specification

We estimate a panel regression model for both infant and under-five mortality as dependent variables. A linear panel data regression model with repeated measurements of time (t) for a sample of (n) zones/regions was considered as random effect as follows:-

$$y_{it}=x'_{it}\beta + \alpha_i + e_{it} \quad \text{.......... (1)}$$

Where t =1… T, time periods, i =1………n, cross sectional units (zones).

y_{it} = Dependent variable
x_{it} = Observed parts of the heterogeneity (explanatory variables)
β = Vector of parameter

α_i = Omitted variables constant over time for every unit i, and induce unobserved heterogeneity in the model.

e_{it} = Remaining omitted variables.

The error term e_{it} in equation (1) is uncorrelated across time and individuals (Wooldridge, 2002). In contrast, the correlation between the unobservable individual/zones effects (α_i) and the explanatory variables (x_{it}) lead to an omitted variable bias and inconsistent estimates of the β. Applying least squares to the mean deviations gives the covariance or within group's estimator of β (Jones, 2007). Therefore in equation (1), dummy variable is introduced in order to control for unobserved heterogeneity by estimating least squares dummy variable (LSDV) as follows:-

$$y_{it} = \alpha_i D_i^1 + \ldots + \alpha_n D_i^n + x'_{it}\beta + e_{it}, \text{ where } D_i^j = 1 \text{ if } i = j \text{ and zero if } i \neq j \ldots\ldots (2)$$

D represents dummy variables while the error term (e_{it}) consists of omitted variable and unobserved variables. The fixed effects (α_i) captures all unobservable, time invariant factors (e.g. cultural behavior, geography, national policies, distance to hospital) that might affect both infant and under-five mortality. The coefficient sign of the dummy variable for each zone in equation (2) helps us to compare which zones have better health status in the country.

2.3 Data Analysis

The units of analysis from Demographic Health Surveys between the years 1992 and 2010, showed creation of new zones due to partition of other zones. The new zones formed are eastern zone and western zone. Other regions were merging to form the new zone from previously existing zones (e.g. Lake Zone). Therefore, for the purpose of organizing panel data, we dropped the new zones created and partition zones to remain with zones that are compatible throughout the examined period of time. As a result, we remained with 4 Tanzanian zones as units of observation derived from Demographic Health Surveys in the years 1992, 1996, 2004 and 2010.

Although the sample size taken are small, in such a way that the number of periods are equal to the number of panel units, including too many variables in the model can mask the truly significant of other variables and it may leads to over parameterization. To avoid that, the study includes two potential regressors in different panel fixed effects models. Those independent variables strongly correlated to each other (endogeneity) were not all adding up to better predict the infant and under-five mortality regression models **(**See Table 2). The multiple correlations among other explanatory variables which reduce statistical power were not a serious problem as revealed by the low correlation coefficients from the correlation matrix.

To select which model was appropriate for the panel data (fixed or random effects), we adopted Hausman Specification Test (1978) to choose between random effects and fixed effects. From these two tests, our results favored fixed effects model over random effects model. This tells us that, infant and under-five mortality in Tanzania are zone/regions specific and varied over time. Therefore, the fixed effects (least squares dummy variables) models were reported for robustness of results. To check whether the model was appropriate, both autocorrelation and Heteroskedasticity were corrected to ensure that standard errors are completely robust to any kind of serial correlation and Heteroskedasticity (Woodridge, 2002; Beck and Katz, 1995). The data was analyzed by using STATA version 12.

3. Results

The results of the descriptive statistics for the outcome measures (Infant and under-five mortality) and some of explanatory variables were summarized in Table 3.

Table (3) shows that, for all zones the median of infant mortality in Tanzanian zones between the years 1992 to 2010 was 77 deaths per 1000 live births within the given interquartile range. Similarly the median of under-five mortality rate for all zones was 130 deaths per 1000 live births within the given interquartile range.

Before deciding to estimate regression model in the fixed effect model, we check for correlation analysis of variables under study to avoid multicollinearity. For this reason, spearman's correlation (rho) was used as a non parametric alternative in a fixed effects panel data model. Spearman's correlation between under-five mortality and independent variables was shown in (Table 2a and 2b). As it appears, all variables (e.g. *births skills* (assistance during delivery by doctor/clinical officer, nurse/midwife), *birth intervals* (18-23months), *mothers with primary, secondary or higher education levels, breastfeeding (*children who ever breastfeeding) were found to have significant and negative association with under-five mortality (P<0.0001). Similarly, in (Table 2b) except *birth skills*, the same variables were significant and negative correlated with infant mortality (P<0.0001).

Mothers with no education levels were positive and significant correlated with both infant and under-five mortality (P<0.0001).

Table 3: Descriptive Statistics of the Variables

Variable	Obs.	Median	(Interquartile Range)	
			Q1	Q3
Infant mortality	16	77.45	62	100.3
Under five mortality	16	130.1	89	158.05
Women with no education	16	26.35	19.6	37.75
Women with sec education	16	5.6	3.6	11.7
Immunization(measles)	16	86.3	84.04	88.75
Breastfeeding	16	97.85	97.08	98.6
Birth skills	16	46.38	36.25	50.3
Antenatal care provider	16	76.95	49.6	97.9

Source: Authors Analysis (2016).

Other variables (e.g. mothers who receives antenatal care (ANC) from a skilled provider for recent birth, immunization coverage (vaccine measles) were negative correlated with both infant and under- five mortality but insignificant (P>0.05).

The summarized results in Table (4 &5) were based on the fixed effects model estimation with zones least squares dummy variable. In estimating pooled ordinary least square regressions (OLS), we used Beck and Katz (1995) panels corrected standard errors (PCSEs) to correct both heteroskedasticity and autocorrelation because, the test perform well in small panels. The overall model fit (R^2) shows the influences of the fixed effect dummies, which control for the influences of unobserved variable in fixed effects. In addition to that, the decision to include time fixed effects was also considered after testing a joint test to see if dummies for all years are equal to zero. The joint test showed that there is no need to include time fixed effects. Therefore, both models are free from robustness checks.

The dependent variables of this paper includes both infant and under-five mortality rates. Infant mortality was examined as (the number of deaths of children under 1 year of age per 1000 live births) and under-five mortality (the number of deaths of children under 5 years of age per 1000 live births). We used the log of infant and under-five mortality on the left hand side (instead of raw data levels) to allow comparison of the results in which the coefficients are on the log scale of percentage mortality (see, Jamison et al., 2016). Given the results for parsimonious models in Table 4, we include mother's education levels, antenatal care provider, immunization coverage (vaccine measles), attendant birth skills and breastfeeding variables in explaining under-five mortality differentials across Tanzanian zones.

Table 4: Summary Results for Fixed Effects

	Under five mortality (log scale)			
Independent Variable	Coefficient(P- values)		(95% confidence intervals)	
Mothers, secondary or higher education	-0.03	(<0.0001)	-0.05	-0.02
Immunization(vaccine measles)	-0.03	(0.04)	-0.06	-0.01
Antenatal Care Providers	-0.01	(0.002)	-0.01	-0.02
Breastfeeding	-0.08	(0.02)	-0.15	-0.01
Mothers with no education	0.01	(0.03)	0.00	0.02
Birth skills (Midwives, doctors, nurses)	-0.01	(<0.0001)	-0.02	-0.01
North zone dummy	-0.70	(<0.0001)	-0.87	-0.54
Central zone dummy	-0.28	(0.04)	-0.56	-0.01
Southern zone dummy *(reference category)*	-		-	-
Southern Highlands zone dummy	-0.36	(0.02)	-0.66	-0.05
Constant term	7.5	(<0.0001)	4.79	10.21
Overall R^2	0.78			

Note: Values in ( ) are p- value at 95% level of significance.

The coefficient estimates and signs of explanatory variables on infant and under-five mortality correspond to prior expectations. From table 4, the coefficient estimates of immunization coverage (vaccine measles), antenatal care providers, breastfeeding, attendants birth skills (Midwives, doctors, nurses) and mothers with primary, secondary or higher education levels are negative meaning that an increase of any of these variables have significant effect on reducing under-five mortality. Furthermore, the coefficients of mothers with no education levels were positive meaning that an increase of mothers with no education increases under-five mortality.
Since the dependent variables were transformed in natural logarithm, the exponentiated coefficient for (north zone dummy) is the ratio of expected mean for north zone dummy over the expected mean for the southern zone dummy(*reference category*) when other explanatory variables are held at constant.
Since exp (-0.70) = 0.496, under-five mortality was 50% lower for north zone than the southern zone. Similarly, under-five mortality was 76% and 70% lower for central and southern highland zones respectively than southern zone.

One unit increase in mothers with secondary or higher education levels result about a 3% fall in under-five mortality while holding other factors constant. If immunization coverage (vaccine measles) increased by one unit, under-five mortality decreased by 3%, holding other factors constant. In contrast, one unit increase in antenatal care provider, attendants' birth skills and ever breastfeeding lead to decrease under-five mortality by 1%, 1% and 8% respectively. The result also shows that, mothers with no education levels increase under-five mortality rate. As mothers with no education increases by one unit, under-five mortality increases by 1%.

The coefficient of a dummy variable for each zones show the highest under-five mortality were observed in Southern zone (Lindi, Mtwara & Ruvuma Regions) followed by Central zone (Dodoma & Singida Regions) and Southern highland zone (Mbeya, Iringa & Rukwa Regions). Northern Zone (Kilimanjaro & Arusha Regions) has the lowest infant and under-five mortality rates compared to other zones. The significant differences observed for under-five mortality rates in fixed effects zones over a period of time, were better explained by immunization coverage (vaccine measles), birth skills, antenatal care providers, mothers with no education, breastfeeding and mothers with secondary or higher education levels.

Table 5: Summary Results for Fixed Effects

Infant mortality (log scale)			
Independent Variable	Coefficient (P- values)	(95% confidence intervals)	
Mothers, secondary or higher education	−0.02 (0.008)	-0.04	-0.01
Immunization(vaccine measles)	-0.03 (0.05)	-0.05	-0.00
Antenatal Care Providers	-0.004 (0.05)	-0.01	0.00
Birth skills (Midwives, doctors, nurses)	-0. 01 (0.002)	-0.01	-0.00
North zone dummy	-0.67 (<0.0001)	-0.87	-0.46
Central zone dummy	-0.29 (0.12)	-0.43	-0.14
Southern zone dummy *(reference category)*	-	-	-
Southern Highlands zone dummy	-0.38 (0.04)	-0.60	-0.15
Constant term	7.27(<0.0001)	4.55	9.99
Overall R^2	0.71		

Note: Values in ( ) are p- value at 95% level of significance.

Northern Zone (Kilimanjaro & Arusha Regions)\
Central Zone (Dodoma & Singida Regions)
Southern Zone (Lindi, Mtwara & Ruvuma Regions)
Southern Highlands Zone (Mbeya, Iringa & Rukwa Regions)

The results indicated in (Table 5) shows that, mothers with secondary or higher education levels, immunization coverage (vaccine measles), antenatal care providers and attendants birth skills were significant and negative related to infant mortality.

One unit increase in mothers with secondary or higher education levels result about 2% decrease in infant mortality while holding other factors constant. In turn, one unit increase of immunization coverage (vaccine measles) decrease infant mortality by 3%, while holding other factor constant. A unit increase in antenatal care provider and attendant's birth skills decrease infant mortality by 0.4% and 1% respectively.

The coefficient of dummy variables shows that, infant mortality was 51% lower for north zone than the southern zone. Furthermore, infant mortality was 75% and 68% lower for central and southern highland zones respectively than southern zone.

It is also important to remember that other determinants factors included in the study such as fertility, delivery in health facility and home, birth intervals were not significant in predicting both infant and under-five mortality rates. Mothers with no education and primary education were not significant in predicting infant mortality.

4. Discussion of Results

The main purpose of this study was to identify factors determining infant and under-five mortality differentials in Tanzanian Zones using four rounds of Demographic Health Survey (TDHS) over the period (1992-2010).
The trends of selected variables under study showed that, in 1992 infant mortality in north zone (Kilimanjaro and Arusha) were 55.5 deaths per 1000 live births to 40 deaths per 1000 live birth in 2010. Similarly, under-five mortality was 78.6 deaths per 1000 live births in 1992 to 58 deaths per 1000 live births in 2010. The decline of infant and under-five mortality at north zone was lower compared to the national average of infant and under-five mortality of 99 deaths per 1000 live births in 1992 to 51 deaths per 1000 live births in 2010, and 154 deaths per 1000 live births in 1992 to 81deaths per 1000 in 2010 respectively (See Table 1).

In turn, the southern zone (Lindi, Mtwara and Ruvuma) showed high infant and under-five mortality compared to the average National of infant and under-five mortality. While the national average of under-five mortality was 154 deaths per 1000 live births in 1992 to 81deaths per 1000 in 2010, the southern zone was 163 deaths per 1000 live births in 1992 to 94 deaths per 1000 live births (TDHS; 1992, 2010). Also, the percentage of women aged (15- 49 years) with secondary education or higher was 12.3 in North zone (Arusha and Kilimanjaro) compared to 1.1 in southern zone in 1992(TDHS; 1992).

Despite of continuous decline in infant and under-five mortality in a national level, the decline is not evenly distributed resulting in major health inequities within countries. These variations suggests important considerations for the implementation of an efficient and equitable health system to determine what extent the observed differences in childhood mortality are either differences in the access to quality of the health service delivery or whether it arise from geographic differences in environmental and socio economic risk factors (Tottrup et al., 2009). The variations of infant and under-five mortality across each zones indicates an element of health inequity in providing health services across Tanzania.

Previous findings also showed that the northern regions(zone) have substantially reduced under- five mortality rate while the southern regions(zone) like Lindi and Mtwara still have small reductions on under-five mortality (Tottrup et al., 2009; MOHSW, 2008). The results findings of this paper indicate the highest infant and under-five mortality in Southern zone (Lindi, Mtwara & Ruvuma Regions) while Northern zone (Kilimanjaro & Arusha Regions) has the lowest infant and under-five mortality compared to other zones.

Breastfeeding is also perceived as essential to baby's health as it strengthens the physical and spiritual bond between mothers and their children (Agunbiade & Ogunleye, 2012). Early introduction of breast milk to new born babies after delivery provides infants with nutritional content and improves infant immunity against diseases through mother's antibodies which lower the risk of early childhood deaths (Kramer & Kakuma, 2004). Earlier study in Tanzania showed that among other factors, immunization and exclusive breastfeeding contributed to child survival gains (Masanja et al., 2008). Our study findings showed that, ever breastfeeding contribute 8% decrease in under-five mortality within four Tanzanian zones.

Education is also a key to basic human right and significant factor in the development of children, communities and countries. Its attainment is well described in social determinant of health through many mechanisms such as health literacy and health behaviours (Cohen & Syme, 2013). Since education is linked to development goals (e.g. improving child health), educating girls/women is important for attaining sustainable development goal target of 25 deaths per 1000 live births.

Our study shows that, mothers with primary, secondary or higher education levels significantly lower under-five mortality than mothers with no education. Mothers with secondary or higher levels have greater impact on lowering under-five mortality compared to mothers with primary education. Similarly, mothers with secondary or higher education levels lower infant mortality rates. The results concur with other previous studies that address maternal education as a key role in both infant and under-five mortality declines (Jamison et al., 2016, Ezeh et al., 2015, Hassen, 2014; Kumar et al., 2013; Susuman & Hamisi, 2012; Buor, 2003; Caldwel & McDonald 1982; Cleland &Van Ginneken, 1988; Chen & Li, 2009; Mekonnen 2011; Mulugeta 2012; Pandey & Lee 2011; Aslam & Kingdon 2012).

Previous study on emphasizing the importance of intersectoral factors in promoting equity oriented universal health coverage in Bangladesh found those mothers with education levels lower infant and under-five mortality compared to non educated mothers (Huda et al., 2016). In contrast, other study carried out in Tanzania found maternal education to play a major role on infant and under-five mortality reductions by influencing mother's

behavior in usage of available health services to improve the health of children (Susuman & Khamis, 2012). Our study still consistency with these findings.

The contribution of mother's education on health is due to the fact that when mother's education levels increase, their knowledge related to nutrition, disease treatment, hygiene, preventive care, and health service utilization improves chances for child survival (Huda et al., 2016; Mosley and Chen, 1984). Through education trained mothers is likely to respond to receive antenatal care from trained medical provider than non educated mothers. In the same vein, skilled birth attendants (medical doctors, nurses, midwives) can acquire knowledge and skills related to disease, pregnancy complications, and surgery to perform safe delivery. Furthermore, education interventions are important to contribute the increase of breastfeeding rates (Bora, 2016).

Our findings implies that, educating women had higher impact in achieving better success in reducing both infant and under-five mortality differentials in the country. To emphasis this, the government of Tanzania had made initiative of constructing at least one secondary school each ward all over the country since 2008. If the community and government real focus on educating women in secondary or higher levels of education, it contributes to high impact on health outcomes and health behavior which in turn, it can lead to economic growth, poverty reduction and inequality since clear linkages exist (Barro, 2001; Abdullah et al., 2015).

On the other hand, immunization status is one among different indicators measuring child health (Hassen, 2014). Change in vaccination coverage (immunization) lead to change in infant and under-five mortality rates. Jamison et al. (2016) found that vaccine coverage and physician coverage contribute to decline of under-five mortality in different countries. Furthermore, the study also found that, countries with greater vaccine coverage (immunization) reduce annual rate of mortality. Similarly, in assessed the extent of progress between 1990 and 2014 in reproductive, maternal, newborn, and child health to inform priorities for post-2015, the authors found that around 39% of child mortality reduction in Tanzania was linked to increases in coverage of interventions, especially of immunization (Holmes et al., 2015). Our study still consistent with previous findings that found immunization coverage (vaccine measles) and attendants birth skills in lowering both infant and under-five mortality in Tanzanian zones over time.

5. Limitations of the Study

One of the limitations of this paper is the sample size taken due to availability of four rounds of Tanzania Demographic Health Surveys (TDHS) only conducted so far in the country. Our sample size (n= 4 zones within the country) also limit the choices of including many number of variables in the panel regression model at once. Our variable selection was also limited to methodological designs (panel data). However, the said limitation does not invalidate the results of this study. Future research should examine other factors associated with differentials in health outcomes using different methodological approach.

6. Conclusion

The main purpose of this study was to identify factors determining infant and under-five mortality differentials in Tanzanian zones using four rounds of Demographic Health Surveys (TDHS) over the period (1992-2010). A fixed effects model using least square dummy variable was estimated. Attendants birth skills, antenatal care providers; education of mothers, ever breastfeeding, immunization coverage (vaccine measles) contributed a strong role in improving child health and reducing infant and under-five mortality. These factors should be taken into considerations to continue progress on achieving sustainable developments goals (SDG).

The policy maker should also integrate inter-sectoral approach in both health and education sector to encourage and strengthen female and mothers education levels, attendants birth skill, antenatal care providers and high coverage of immunization to continue reducing infant and under-five mortality differentials within the country. Female education, ever breastfeeding, attendants birth skill and immunization (vaccine measles) could be set in priority for all zones to reduce infant and under-five mortality differentials over a period of time.

The country health policy should also put emphasis on attendants' birth skills coverage at primary health facilities and provide child health education programs to women. The paper recommends the importance of expanding schooling and access to quality education at all levels, educating more women in secondary or higher levels, ever breastfeeding, strengthening stronger health system in the access to health care services including antenatal care providers, immunizations (vaccine measles) program in the country to avoid health inequity across the Tanzanian zones.

Authors Contributions

Mwoya Byaro and Patrick Musonda were involved in the critical analysis of this study. Mwoya Byaro conducted the literature review, carried out the analysis and drafted the manuscript. All authors read and approved the manuscript.

Journal of Economics and Sustainable Development
ISSN 2222-1700 (Paper) ISSN 2222-2855 (Online)
Vol.7, No.18, 2016
www.iiste.org

Ethical Consideration

The study involved secondary analysis of data from 1992- 2010 Tanzania Demographic Health Surveys (TDHS) which excluded participant identifiers. However, ethical approval was obtained from Tanzania National Institute of Medical Research (NIMR) ethical review committee.

Conflict of Interest

Mwoya Byaro and Patrick Musonda have no conflicts of interest to declare.

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Appendices: Supporting Information for the Manuscript.

Table 1: Infant and Under-Five Mortality Rates by Zones in Tanzania (per 1000 live births).

	Zones	Year	Infant mortality rate	Under -five mortality rate
1.	North zone	1992	55.5	78.6
2.	Central zone	1992	127.9	190.6
3.	Southern zone	1992	99.1	163.1
4.	Southern Highland	1992	79.9	130.2
1.	North zone	1996	40.6	69.3
2.	Central zone	1996	98.1	152.7
3.	Southern zone	1996	107.9	164.2
4.	Southern Highland	1996	101.5	165.9
1.	North zone	2004	67	105
2.	Central zone	2004	75	130
3.	Southern zone	2004	121	153
4.	Southern Highland	2004	82	136
1.	North zone	2010	40	58
2.	Central zone	2010	57	84
3.	Southern zone	2010	68	94
4.	Southern Highland	2010	70	102

Source: (TDHS 1992, 1996, 2004 & 2010)

Source: Tanzania Demographic Health Surveys (1992, 1996, 2004 and 2010)
*rho significance levels at 5%, p values in ( ) less than 0.001

Table 2(a): Spearman's Correlation (rho)

	Dependent variable	**Independent Variables**						Birth interval(months)	
Independent variables	Under five mortality	fertility	breastfeeding	Vaccine measles	Antenatal care	Birth skill	Health facility	7-17	18-23
Mothers (no education	0.57* (0.02)	0.57* (0.02)	-0.35 (0.19)	-0.20 (0.45)	-0.69* (0.00)	-0.88* (0.00)	-0.32 (0.23)	0.09 (0.72)	-0.54* (0.03)
Mothers (primary education	-0.64* (0.01)	-0.38 (0.15)	0.32 (0.22)	0.21 (0.43)	0.63* (0.01)	0.81* (0.0)	0.18 (0.49)	-0.12 (0.65)	-0.11 (0.69)
Mothers(secondary education+	-0.73* (0.00)	-0.37 (0.16)	0.64* (0.01)	0.05 (0.86)	0.40 (0.12)	0.62* (0.01)	0.08 (0.76)	0.19 (0.49)	0.40 (0.12)
Fertility rate	0.16(0.56)	1	0.07(0.79)	-0.29(0.26)	-0.56*(0.02)	-0.30(0.26)	-0.25	-0.25	0.47
Birth intervals(months)									
Birth 7-17	-0.24(0.36)	0.31(0.24)	0.09(0.71)	-0.54*(0.02)	-0.33(0.21)	-0.02(0.95)	-0.39	1	0.63*
Birth 18-23	-0.54* (0.029)	0.47(0.07)	0.45(0.08)	-0.20	-0.29(0.29)	-0.65*(0.01)	-0.21	0.63*	1
Breastfeeding	-5.6* (0.02)	0.07(0.79)	1	0.11(0.68)	-0.23(0.39)	0.37(0.16)	0.37	0.09(0.71)	0.44(0.08)
Vaccine measles	-0.15(0.58)	-0.30(0.3)	0.11(0.68)	1	0.17(0.52)	0.17(0.52)	0.40	-0.54*(0.03)	-0.20
Antenatal Care provider	-0.21(0.43)	-0.56*	-0.23(0.39)	0.17(0.52)	1	0.67*(0.00)	-0.04	-0.33(0.21)	-0.28
Birth skills	-0.46* (0.07)	-0.62*	0.37(0.15)	0.37(0.14)	0.67(0.00)	1	0.44	-0.29	-0.01
Place of Delivery									
Home	0.07(0.80)	0.23	-0.48(0.06)	-0.48(0.06)	0.12(0.66)	-0.39(0.12)	-0.97*	0.35(0.19)	0.19
Health facility	-0.04(0.88)	-0.34	0.39(0.12)	0.45(0.07)	-0.04(0.87)	0.44(0.09)	1	-0.33(0.20)	-0.25

Source: Tanzania Demographic Health Surveys (1992, 1996, 2004 and 2010)
*rho significance levels at 5%, p values in ( ) less than 0.001

Table 2(b): Spearman's Correlation (rho)

	Dependent variable	**Independent Variables**						Birth interval(months)	
Independent variables	Infant mortality	fertility	breastfeeding	Vaccine measles	Antenatal care	Birth skill	Health facility	7-17	18-23
Mothers (no education	0.50*(0.05)	0.56* (0.02)	-0.34	-0.20 (0.45)	-0.68* (0.00)	-0.88*(0.00)	-0.32	0.09	-0.10
Mothers (primary education	-0.58*(0.02)	-0.37	0.32	0.21 (0.43)	0.63* (0.00)	0.81* (0.00)	0.18	-0.12	0.23
Mothers(secondary education	-0.69*(0.00)	-0.3	0.64*(0.01)	0.04(0.86)	0.40(0.12)	0.69*(0.00)	0.08	0.18	0.40
Fertility rate	0.11(0.68)	1	0.06 (0.79)	-0.29	-0.56* (0.02)	-0.61*(0.01)	-0.34	0.31	0.46(0.06)
Birth intervals(months)									
Birth 7-17	-0.32(0.23)	0.31	0.09(0.71)	-0.54*(0.02)	-0.32	-0.29(0.26)	-0.33	1	0.62*(0.00)
Birth 18-23	-0.63(0.00*)	0.46	0.44(0.08)	-0.20 (0.45)	-0.28	-0.02(0.95)	-0.25	0.62*(0.00)	1
Breastfeeding	-0.56(0.02*)	0.06	1	0.11(0.68)	-0.22	0.37(0.15)	0.39	0.09 (0.71)	0.44(0.08)
Vaccine measles	-0.07(0.79)	-0.29	0.11(0.68)	1	0.17(0.52)	0.37(0.14)	0.45(0.07)	-0.54*(0.02)	-0.20 (0.45)
Antenatal Care provider	-0.10(0.70)	-0.56*	-0.22	0.17(0.52)	1	0.67*(0.00)	-0.04	-0.04(0.87)	-0.28
Birth skills	-0.35(0.18)	-0.61*	0.37	0.37(0.14)	0.67*(0.00)	1	0.43	0.43(0.09)	-0.02(0.95)
Place of Delivery									
Home	-0.002(0.99)	0.22	-0.48(0.06)	-0.48 (0.06)	0.11 (0.66)	-0.39(0.12)	-0.97*	0.34	0.19
Health facility	0.03(0.89)	-0.34	0.39	0.45(0.07)	-0.04(0.87)	0.43(0.09)	1	-0.33(0.20)	-0.25(0.34)

Source: Tanzania Demographic Health Surveys (1992, 1996, 2004 and 2010)
*rho significance levels at 5%, p values in ( ) less than 0.001