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Differential in Child Mortality in Malawi

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INTRODUCTION[1]

Mortality rates among children under the age of five remain strikingly high throughout the majority of sub-Saharan Africa. While other areas of the world have experienced declining rates of childhood mortality over the last 30 years, this area, for the most part, still maintains relatively high rates. It has been recently noted that 18 of the 20 countries across the world with the highest childhood mortality rates were in sub-Saharan Africa (United Nations, 1995). As the world enters into the 21th century, childhood mortality remains a big issue for these developing countries, especially as researchers attempt to distinguish what factors contribute to the high levels.

Information on the causes of the high childhood mortality in Africa is limited. Additionally, the information that is available is often from studies based within hospitals. While there may be some valuable information gained from these studies on some of the causes of death, they may not be a good representation of the vast proportion of childhood deaths which take place outside of a health care facility (Slutsker et al, 1996). The problems of getting accurate estimates of childhood mortality in sub-Sahara Africa are the result of the lack of accurate vital registration systems. As a result, indirect estimates of childhood mortality are often employed in order to get a picture of the mortality conditions of the region.

Malawi, like other African countries, does not have comprehensive data on the causes of death (Kalipeni, 1993). Overall, this country has one of the highest under-five mortality in southern Africa. Currently, about one in four Malawian children do not live to until their fifth birthday. The level of mortality varies considerably among the three

[1] The author would like to thank Etienne van de Walle, Doug Ewbank, and Herb Smith for their helpful advice, suggestions, and comments.

administrative districts of Malawi, the Northern, Southern and Central regions. Due to the high levels of infrastructure and schooling in the Northern region, I hypothesize that the North will have greater average levels of wealth, sanitation, and schooling than the other two regions, which will consequently be contributing factors to the lowest child mortality rates in this region.

The first objective of this paper is to estimate recent rates of childhood mortality for the areas included in Susan Watkins' 1998 Malawi Diffusion and Ideological Change Project survey, applying the Brass indirect estimation of levels of child mortality from survey data on the proportion dead among children ever born establishing geographic mortality differentials. The second part of the study consists of the examination of the factors which may account for the regional variation through employing a multivariate regression with an individual woman's index of child mortality as the dependent variable (Trussell and Preston, 1982). By using this technique, I hope to address whether the regional variation established in the survey data is due to different levels of factors that are often related to a reduction in child mortality, such as sanitation facilities and maternal education, and if this is an adequate explanation of the differential. This study will allow us to expand our knowledge and understanding of the trends and differentials in child mortality in Malawi.

CHILD MORTALITY DIFFERENTIALS IN MALAWI

Malawi provides a good opportunity to study child mortality conditions in a developing country. It is one of the least economically developed countries in the world, lying on the southern end of the great Rift Valley in eastern Africa. Ninety percent of the people in this fourth world country are farmers, and primarily small land holding subsistence farmers. Despite attempts over the last 35 years, industrial development efforts have not taken off due to the scarcity of mineral resources, limited access to ports, and few trained personnel (National Health Plan Malawi, 1986).

Many indicators of development have striking differences within the three main administrative regions of Malawi. Much of this diversity can be attributed to geography, colonial circumstances, and socio-cultural differences despite the partial success of attempts to distribute commercial, industrial, and educational infrastructures more equitably across the three regions (National Health Plan Malawi, 1986). As one might expect, under-five mortality is not exempt from this regional differentiation. Due to the imbalance of investment in infrastructure favoring the North and Center, one might expect the under-five mortality rates to be lowest in these areas and highest in the south. This may be due to better facilities often associated with development as well as to the history of education in Malawi. Yet, estimates of under five mortality as reported in the 1992 DHS report are 201.9 per 1000 live births in the North, followed by 230 per 1000 in the South, and 261.6 per 1000 in the Center, placing South with considerably lower child mortality than the Center (1992). It is interesting to explore why this regional differentiation exists and to see whether we can find an explanation for what may account for it.

In attempts to disentangle the factors that may be responsible for the regional differentiation, I chose 7 variables to consider in a multivariate regression analysis: education of the mother, mother's use of family planning after the birth of a child, household measurement of wealth, employment status of the mother, access to maternal and child health care, sanitation facilities, and region. For the purposes of this study, I grouped the variables into three categories: education, medical or health characteristics, and other socio-economic characteristics.

ANALYTIC FRAMEWORK

There are a number of different analytical frameworks through which to view the effects of different determinants on childhood mortality. Demographic research by Mosley and Chen (1984) and by Schultz (1984) has made the distinction between variables considered to be exogenous or socioeconomic (i.e. cultural, social, economic, community, and regional factors) and endogenous or biomedical factors (i.e. breast-feeding patterns, hygiene, sanitary measures, and nutrition). The effects of the exogenous variables are considered indirect because they operate through the endogenous bio-medical factors. Likewise, the bio-medical factors are called intermediate variables or proximate determinants because they constitute the middle step between the exogenous variables and child mortality (Jain, 1988; Mosley and Chen, 1984; Schultz, 1984; UN, 1985).

Mosley and Chen (1984) were among the first to study the intermediate biomedical factors affecting child mortality, labeled `proximate determinants.' They distinguished 14 proximate determinants and categorized them into 4 groups: maternal [fertility] factors, environmental sanitation factors, availability of nutrients to the fetus and infant, injuries, and personal illness control factors. Yet, Mosley and Chen failed to consider the effect of the nutritional status of the mother on her childrens' mortality and also leave open difficulties of measurement of the variables (Jain, 1988).

For this study, I borrow heavily from the distinctions made by Mosley and Chen and by Schultz between the exogenous and endogenous variables. Unfortunately, I am not able to measure many of the variables of interest from the available data. There is no direct information in the data on the ecological conditions of the areas or intermediate biomedical factors, except sanitation and distance to maternal and child health clinics and those can be interpreted as either proximate or socio-economic. The United Nations (1985) point out it is often difficult to get information about intermediate variables since most of the data usually relate to socioeconomic factors. Their volume on socio-economic differentials in child mortality demonstrates how one may learn about the nature of the unobserved biomedical variables through their clustering with socioeconomic variables (United Nations, 1985). Additionally, Frankenberg (1995) notes that as a child ages, socioeconomic factors replace biomedical factors as the most important mortality determinants. Even though the data do not contain much information about the biomedical factors, I still feel confident t% hat a lot can be learned about the determinants of child mortality.

DETERMINANTS OF CHILD MORTALITY

Numerous socio-economic determinants have been studied in the context of child mortality in sub-Saharan Africa. In many of the studies, the education of the mother is found to be the most significant determinant of child survival, even when other variables associated with education are controlled (Caldwell, 1979; Farah and Preston, 1982; Merrick, 1985; UN, 1985). Even though it is generally accepted that education is an important factor, the pathway by which education operates on mortality is much less certain. Caldwell (1993) suggests that increased maternal education works by increasing a woman's autonomy. An educated woman is more likely to take her children or herself to a health clinic when ill may feel more comfortable dealing with health professionals, and is more likely to identify with and use modern medical knowledge. Behrman and Wolfe (1987) give a differing opinion, proposing that the maternal education and child mortality relationship maybe a reflection of the mother's childhood endowments and the environment in which she was raised, which are more influential. In their study, maternal education is no longer a significant factor when controlling for the mother's childhood endowments, thus challenging Caldwell's hypothesis (Behrman and Wolfe, 1987). Despite the uncertainty as to how education works on mortality, it is important to test to see if it is an important determinant of the child mortality differentials, especially considering the history of education in Malawi.

A common argument made by advocates of family planning is that there is a high, relationship between low fertility and low child mortality. Others, including Trussell (1988) suggest that family planning alone cannot reduce child mortality dramatically. Potter (1988) points out that it is not certain exactly how family planning reduces child mortality, whether it is by promoting better maternal care or even shaping birth cohorts in ways which have positive effects on child mortality (1988). Initial analysis reveals multicollinearity between the family planning variable and distance to maternal and child health clinic. This is not surprising considering the farther a person is from a health clinic, the less access the person has to family planning supplies. Due to the ambiguous relationship between use of family planning and child mortality, distance to maternal and child health clinic appears to be a better predictor of child mortality. For these reasons, the family planning variable was left out of the final regressions.

Access to sanitation facilities is considered to have a significant negative effect on child mortality (Merrick, 1985). Studies by Lindskog et al. (1988) show that poor environmental sanitation was consistently related to child mortality, even when the effects of the type of water source were no longer significant. Lindskog et al. assert that this may be because it is likely that in environments with high exposure to intestinal pathogens, improved sanitation is more important than improved water source.

Utilization of and access to maternal and child health care facilities appears to also be an important determinant of child mortality. The access to health care facilities is often cited as an explanation why mortality in the urban areas is generally lower than in the rural areas, which usually has fewer facilities (Gule, 1990). Since health facilities in developing countries tend not only to be few, but also concentrated in specific areas of the country, it is interesting to test if this variable may account for some of the regional differentiation (Frankenberg, 1995). Yet, it must be acknowledged that the effect of access to health care facilities often varies with the education of the mother, since the more educated are more likely to take advantage of and correctly use the medical technology.

Similar to education, the way in which household income and wealth affect child mortality is also complex. Income is often used as a proxy for children's consumption of goods and services that may affect their health, such as shelter, nutrition, and adult supervision (UN, 1985). This follows the thinking that the higher the income, the lower the child mortality risks. The problem with this logic, as the UN points out, is that it assumes that children in wealthier homes will receive more 'health-enhancing goods and services' (per capita) than those in poorer homes (1985: 191). Additionally, if the higher income is a result of extra hours of work, this may sacrifice time spent on child care, which could have adverse consequences. Due to difficulties in monetary conversion, household wealth is often used as a proxy for income. Wealth is primarily measured from a set of objects owned by a family, such as durable goods. The UN (1985) points out that even though wealth is not as good of an indicator of consumption as income, one would still expect a negative association with child mortality.

There is no firm evidence linking employment status of the mother to child mortality. Some studies suggest that the added income generated through the mother working may increase the household income and consumption, thus indirectly contributing to a decrease in mortality (UN, 1985). Others suggest that the mother's work may decrease the number of hours given to child care, which may result in an increase in child mortality (Peterson, 1986). Farah and Preston suggest that the employment of the mother is an indicator of economic hardship, in the case of Sudan. Thus, it was logical that they found higher mortality of the children with working mothers than the mortality of those without working mothers (1982). For these reasons, it is interesting to see if there is an effect of maternal employment on child mortality in Malawi, and if so, in what direction.

Regional mortality differentials have been observed in various countries. Regions often differ in their geography as well as in their disease environment. Numerous studies have shown variation of child mortality between regions within a country even after controlling for other factors (Farah and Preston, 1982; Kalipeni, 1993). This may be due to the issue that often services are unequitably distributed across a country, or .because one area of the country may have higher disease prevalence than other areas. Region in and of itself is not a determinant of mortality like the other socio-economic factors we are looking at; it is rather a proxy for other variables that are determinants (Farah and Preston, 1982). It is impossible on the basis of this study to say exactly what region is a proxy for, but it is likely to be a proxy for disease environment as well as religion and ethnicity. This is indicated by the fact that religion and ethnicity were significant indicators of child mortality when not controlling region, but once controls for the three regions were introduced, they both lost their significance. It is also important to note that in studies which included region as a variable, regional variation in socio-economic factors has shown to be an important explanatory variable (Kalipeni, 1993).

DATA

The data used in this study were gathered in Malawi during the summer of 1998 as part of the Malawi Diffusion and Ideological Change Project. It was collected from the three administrative districts of Malawi: the North, Center, and South. The survey consisted of a large range of questions on demographic information as well as on socio economic characteristics, on family planning behavior, and AIDS knowledge. In addition to the individual level data, the survey also contained community level information on group characteristics, development initiatives, and agriculture. These community characteristics were instrumental in helping to control for regional differences.

The data came from three sites in Malawi: Balaka in the South, Mchinji in the Center, and Rumphi in the North. These sites are very different with respect to social organization, yet they have similar economic characteristics; they are all rural, predominately agricultural, with almost subsistence levels of production. The villages 1 used in the sample were chosen at random from clusters of villages within the larger administrative regions. The sample within each village consisted of ever-married women ages 15-49 and their husband. For the purposes of the present analysis, I looked at 1314 ever-married women aged 15-49. Since the sample only included ever-married women, this may add a bit of selectivity and may not be nationally representative. However, since the vast majority of childbearing takes place within marriage and the mean age of marriage is young, it is sufficient for identifying some of the trends and differentials among the three districts.

Unfortunately, the data provide very little information on the intervening biomedical variables. The available data relate primarily to the socio-economic and cultural variables. Part of the reason for the limitation of this data is that the survey was not designed and administered for the purpose of mortality research[2]. Still, a lot can be learned about regional differentials in under five mortality without direct information on biomedical variables (UN 1995).

MEASUREMENT OF CHILD MORTALITY

Due to the inadequacies of the registration of deaths in Malawi, indirect methods are employed to estimate levels and trends of mortality. One of the most widely used is a technique developed by Brass which is based upon retrospective reports of children ever born and children surviving (UN, 1983). This technique involves taking the proportion of

[2] The UN acknowledges similar limitations in the majority of the data used in their studies (1985: 4).

the children dead to those ever born to women categorized by age group. The proportions were converted into probabilities of dying by using Trussell's North model coefficient.[3]

This is done by multiplying the proportion of children dead among children ever born to women of age group *i* by *k*(*i*), an adjustment factor that is based on comparisons of cumulative parities of women of different age groups (Preston et al., 1998). In order to get the adjustment factor, *k*(*i*), one must first calculate parity ratio P_1/P_2, the mean number of children ever born to women aged 15-19 divided by the mean number of children ever born to women aged 20-24, and Pz/P3, the mean number of children ever born to women aged 20-24 divided by the mean number of children ever born to women aged 25-29. The parity ratios are multiplied by Trussell variant coefficients $a_{i,}$ b_i, and c_i (Preston et. al, 1998):

$$k(i) = a_i + b_i*P_1/P_2 + c_i*P_2/P_3$$

$$q(x)=k(i) * D(i)$$

The equation will give estimates of the probability of dying from birth to age x for the children born to women in each age group, which corresponds to: q(1), q(2), q(3), q(5), q(10), q(15). Using the *q*(*x*)-s, I was able to find the levels of mortality from the North Model life table, using 1.03 as the sex ratio at birth (Brass et al., 1968).

The data only contained information on ever married women and unfortunately the marital duration question did not specify duration since first marriage. Thus, I could not use marital duration as the proxy index of children's exposure to the risk of mortality. So, I used ages of the mother as the proxy. Since I only had the ages of *ever-married*

[3] The North mortality schedule was employed because it most accurately resembles the mortality schedule mortality schedule of the sample.

women, I had to adjust the number of women in each age group, accounting for those who never married in each group in order to fit the requirements of the Brass procedure.[4] I used 1992 DHS information on the proportion never married within each age group to inflate my numbers so that they reflected this distribution (DHS, 1992). Additionally, since the number of women in each cell is rather low, I averaged the levels of mortality corresponding to q(2), q(3), and q(5) for each region. This reduces the uncertainty of the estimates and produces more robust levels of under-five mortality.

Even though the indirect estimation methods may not accurately estimate mortality, comparisons with the DHS data indicate that the discrepancies are moderate (Table 1). What the Brass estimation does reveal, which corresponds with DHS estimates, is the internal consistency of regional variation in under-five mortality. Under-five mortality is considerably lower in the Northern region with 182 deaths per 1000 live births compared with 262 per 1000 in the South and 300 per 1000 in the Center.

Table l: *Indirect Estimations of Under-Five Mortality from MDICP Survey Data and 1992 DHS*

Region	MDICP Survey		1992 DHS	
	$_5q_0$	Level	$_5q_0$	level
North	0.1818	13.45	0.2019	13.0
Center	0.2997	8.50	0.2616	10.0
South	0.2617	10.00	0.2300	11.5

Since the data are from three small areas in the three district regions, they cannot be representative of the whole region, but may show regional differences. Yet their differentials reflect the actual differentials in the population as indicated by DHS. It is not

[4] See van de Walle (1993) for further support of the use of age groups instead of marriage duration to calculate exposure.

surprising that the mortality levels estimated were slightly higher than those of DHS considering that the 1998 survey is performed on a smaller sample and is only from the rural areas whereas DHS's sample is much larger and contains both rural and urban information.

DHS attributes a majority of the regional differentiation to childhood mortality, the mortality of children between the ages of one and four, since, according to their estimates, infant mortality (under age 1) does not vary much among the three districts (DHS, 1992). For this reason and the nature of the Brass estimates which gives a mortality level of ${}_5q_0$, I am focusing my attention on under-five mortality instead of just infant mortality in order to help identify some of the factors contributing to the regional variation in mortality.

REGRESSION ANALYSIS

Measurement of the Predictor Variables

The data on the level of a woman's education are gathered by asking a woman how many years of education she had completed. The information was transformed into dummy variables of the following education categories: no education, denoted by 'none'; 1-7 years of schooling, denoted by 'primary', and more than 7 years of schooling, denoted by 'secondary'.

Sanitation was measured by asking whether the respondent owned a pit latrine. A pit latrine is simply a hole in the ground that is covered with planks or concrete (Lindskog et al., 1988). It is the most common form of toilet in Malawi, used by 73 % of the women in the sample. Although this is a rather crude measure, this was the only measurement of sanitation available in the data.

Access to maternal and child health clinics is measured by a continuous variable indicating the average distance to the clinic in kilometers, denoted by 'Distance to MCH'. The three distance categories are 0-4 kilometers, 5-14.kilometers, and 15 kilometers or more. This gives a sense of community access to health facilities.

From the information available in the survey, I was able to create a measurement of wealth based on the number of durable goods (i.e. lamp, bicycle, radio) owned by the household out of a certain number of items. The UN (1985) uses this method as a measurement of wealth for various countries because it avoids the problem of measuring income in rural areas. Furthermore, the UN considers it to be 'a reasonable indicator of economic status' (1985: 195). This ordinal variable is denoted by 'durgoods.' (ix)

The employment of mother was ascertained by asking the woman if she participated in income generating work. This variable was put in the regression as a dummy variable, denoted by 'female employment'.

It is also important to introduce controls for region in the analysis, and this was done through the creation of dummy variables for the Northern, Southern and Central regions. Due to the multicollinearity among ethnicity, religion, and region, only region was retained to use in the regression models.

Descriptive analysis

A preliminary simple descriptive analysis was conducted to show the spatial variation of the independent variables. Table 2 presents the results of the bivariate analysis and the significance levels. All the independent variables clearly vary between the three regions. It is clear that the samples from the regions are very different with respect to ethnic group and religion. Additionally, North appears to have the highest levels of education, pit latrine usage, use of family planning, mother participating in income generating work, average wealth measured by durable goods, and the lowest average distance to maternal and child health clinics. The Center region appears to come in second behind North with respect to level of education and other socio-economic factors, yet the South appears to have more beneficial levels of health factors than the Center. These findings confirm the fact that the three regions are very different in regards to these factors.

***Table 2**: Sample Characteristics by Region, Females*

	Northern Region	Central Region	Southern Region	Pearson's chi-square	Pearson's p-value
Sample size	484	688	582		
Main Ethnic Group	Tumbuka	Chewa	Yao	2310.15	0.00
Primary Religion	Protestant	Protestant	Muslim	861.15	0.00
Education (%)				352.6	0.00
None	4.4	38.2	62.7	318.3	0.00
Primary	84.0	59.0	35.9	161.3	0.00
Secondary	11.6	2.8	1.4	54.1	0.00
Health Factors (%)					
Pit latrine	89.1	59.0	72.1	105.2	0.00
Using family planning	70.5	44.7	46.8	38.1	0.00
Average distance to MCH clinic (km)	4.7	8.7	5.0	97.9	0.00
Other SES Factors (%)					
Mother Working	80.99	74.91	65.23	29.88	0.00
Durable Goods (%)					
0	31.8	34.1	38.5		
1	16.7	25.1	25.3		
2	19.4	23.6	25.6		
3	15.1	12.1	7.0		
4	16.9	5.1	3.6		

Multivariate regression

Now that the regional differential has been established in the sample, I proceeded with multivariate regression in attempts to try to discover what might account for the variation.

I employed Poisson regressions to look at the relationship between the different variables and child mortality. The Poisson regression is appropriate when the dependent variable is a count. The advantage of using this type of regression for count data is that it is especially designed for the discrete and often skewed distribution of the count dependent variable (Allison, 1998).

Unfortunately, Poisson regressions are prone it overdispersion, which can produce overestimates of test statistics and underestimates of standard errors (Allison, 1998). In order to adjust for this, I tested each model for overdispersion and, where appropriate, produced more efficient estimates via the method of negative binomial regression. This type of regression is a generalization of the Poisson model that includes a disturbance term to account for over dispersion (Allison, 1998):

$$\log \lambda_I = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \ldots + \beta_k x_{ik} + \varepsilon$$

The negative binomial distribution works well if the counts of events all take place within the same interval of time (Allison, 1998). Unfortunately, the indirect methods calculate the number of deaths by asking women of different ages how many children they had and how many are surviving. This means that the older the woman, the longer the period of exposure to childbearing and the longer the woman's children will have been exposure to the risk of dying. Thus, there is a need for standardization. In order to do this, I created a variable representing the expected number of dead children per woman and entered the log of this variable as an offset.

The variable representing the expected number of dead children per woman was produced in several steps. I first estimated an expected proportion dead for women in each age group for each region using methods described by Trussell and Preston (1982).

This was done by choosing selected $q_s(a)$ standards taken from the Coale-Demeny North model life table corresponding to level 11, the estimated level for all of Malawi. I then divided the $q_s(a)$ values by $k(d)$, the adjustment estimated for each age group within each region as a step in the Brass estimation:

$$PD_s(d) = q_s\,(a)/k(d)$$

From here I estimated the expected number of deaths (END) for each woman by multiplying the number of births born to the woman by the corresponding PDs(d) for her age group and region (Trussell and Preston, 1982):

$$END = PD_s(d) * B_i(d)$$

The ratio of the dependent variable, the number dead, to the expected number dead is 0.98, which indicates that the $q_s(a)$ values chosen are a good representation of the average level of mortality in the sample (Farah and Preston, 1982).

By entering the log of END as an offset, it is differentiated from the other coefficients in the regression equation by being carried through as a constant and forced to have a coefficient of one:

$$D = END\ e^{\beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \ldots + \beta_k x_{ik}}$$

This indicates that the expected number of dead children will equal the deaths if the coefficients of the independent variables, denoted by β, are equal to zero. Since the log of END is offset as a constant, any variation in the coefficients of the independent variables will show up affecting the dependent variable, not the expected number dead.

Several multivariate regressions were estimated to show how the relationship between region and child mortality changes when controls for factors previously listed are introduced. All the regressions contained above mentioned offset as well as a variable that controls for the mortality differences of the different time periods to which the Brass estimates apply. If mortality has been changing, Brass's assumption of constant mortality creates problems because the estimated $q(x)$ values pertain to different years (Gule, 1990). Since year may have a nonlinear effect, the square of year is also included to test for a parabolic pattern.

RESULTS OF POISSON REGRESSION ANALYSIS

Having established a pattern of regional differentiation, I proceed with multivariate regressions in attempts to discover what it is about the regions that explains the differences in mortality. To discern how the different variables of interest operate to affect mortality, the variables are introduced into the regression in stages. The first model only includes dummy variables for the region the mother was living in at the time of the survey. This establishes regional differentiation of mortality. Due to the vast differences in educational infrastructure among the three regions, the second model tested whether the regional differentiation is explained by education. The third model adds controls for medical and health environment and the final model added other socioeconomic controls in attempts to explain away the differential. Results of the regression analysis can be found in Table 3.

Table 3: *Results of Poisson regression analysis*

	Model 1^		Model 2^		Model 3^		Model 4^	
Variable	**Coefficient**	**Standard Error**	**Coefficient**	**Standard Error**	**Coefficient**	**Standard Error**	**Coefficient**	**Standard Error**
Region								
North	0.2063	0.1609	0.4277*	0.1822	0:5388*	0.214	.5241*	0.2222
Center	0.4886*	0.1548	0.6181 **	0.1627	0.6391 **	0.1958	.6265**	0.2041
South	0.4511 *	0.1539	0.5515**	0.1583	0.5776**	0.1915	.5646**	0.1985
Education								
Primary			-0.1570**	0.0703	-.2102**	0.0732	-0.2001	0.0747
Secondary			-0.432**	0.2117	-.7763**	0.277	-.7615**	0.278
Health Factors								
Sanitation-Pit Latrine					-0.0726	0.0674	-0.5717	0.0703
Distance to MCH					.0936*	0.039	.0944*	0.0392
SES								
Mother Working							0.0231	0.0714
Durable Goods							-0.026	0.0273
year	-0.1126'''	0.0452	-0.1217	0.0452	-.1603**	0.0478	-.1575**	0.0479
year2	0.0074''`	0.003	0.0076	0.003	.0102**	0.0032	.001**	0.0031
Tests of Regional Differentiation	χ^2	Prob > χ^2	χ^2	Prob > χ^2	χ^2	Prob > χ^2	χ^2	Prob > χ^2
North = Center	1428	0.0002	5.31	0.0212	1.15	0.2842	1.19	0.2746
Center = South	0.31	0.5803	0.94	0.3336	0.75	0.3853	0.76	0.3841
South = Center	10.13	0.0015	1.86	0.1729	0.75	0.3853	0.17	0.6835
Odds Ratios								
South vs. North		1.27		1.13		1.04		
Center vs. North		1.32		1.21		1.06		

^ :Used negative binomial regression to adjust for overdispersion.

+p<=.10; *p<=.05; **p<=.01.

Results from the first model show the large effects of regional dummy variables on child mortality. The relative risk of child mortality in the South relative to the North is 1.27, and the relative risk in the Center relative to the North is 1.32. There appears to be only a small difference between the child mortality of the South and Center, and the difference between the two regions is not statistically significant.

The second model includes controls for mother's education. As expected, education does have a strong inverse relationship with child mortality. In comparison to a mother with no education, the risk of child mortality decreases 14.5% for a mother with a primary education and 35% for a mother with a secondary education. The introduction of the education controls also changes the relative risks of child mortality in each region. With controls, the relative risk in the South relative to the North is 1.13 and the relative risk in the Center relative to the North is 1.21. These show a reduction from the regional differences in the first model. Statistically, the North is no longer significantly different from the South, but it is still different from the Center. Thus, the evidence suggests that what looked like a regional effect is now explained by the education variable.

The third model adds controls for sanitation and health environment, the dummy variable for pit latrine and distance to maternal and child health clinics. Owning a pit latrine does not have a significant effect on child mortality but distance to maternal and child health clinics are significant at the .05 level. The regression suggests that the risks of child mortality increase by 9.8% for each increment of distance from a maternal and child health clinic (see above for scale). There is a further reduction of the regional effects on mortality with the introduction of the medical and health environment controls. The relative risk of being in the South relative to the North is now 1.04 and in the Center relative to the North is 1.06. The controls also render the difference between the North and Center insignificant. Thus, it appears this regional difference can be explained by differences in health factors.

The fourth model added controls for other socio-economic variables, durable goods and the dummy variable for employment of the mother. Neither variable turns out to be a significant predictor of child death and causes no significant change to the coefficients of the other variables. The analyses just described assume that the three regions of Malawi have the same structural relationships between the explanatory variables and child mortality. However, it is quite likely that the nature of the relationships could differ considering the demographic and socio-economic differences of the three regions (Peterson, 1986). Thus, for each variable I tested for interactions with the region dummy variables. None of the interactions turned out to be statistically significant, so the interactions were left out of the final models.

DISCUSSION

The results of the bivariate and regression analyses show some interesting relationships between the regional variation of child mortality and several of the variables. Without controls, there is a significant difference in child mortality between the North and the South and between the North and the Center, but not between the South and the Center. Once adding educational controls, the difference between the North and the South are insignificant. This suggests that the differential in child mortality between the two regions is explained by education.

While the colonial administration established itself in the Southern region of Malawi, the Missionaries went to the Northern region and set up schools. This history, coupled with the present lack of resources allocated to education, has resulted in regional inequalities in educational infrastructures which exist to this day (Kalipeni, 1993). The Central and Northern regions were primarily neglected until independence, when there was a great effort to deal with this inequity. Capital transferred to the Northern region as the focus shifted to commercial agriculture and the development of infrastructure in the North and Center (Kalipeni, 1993). In addition to the higher levels of economic development, the Northern region consistently enjoys the highest literacy and enrollment rates in the country with only 33% of the total population over the age of 5 with no education. The vast educational difference between the North and the South appears to be a significant explanation of the mortality differential between the two regions. If educational differences are the main explanation of the regional differential in child mortality, one would expect the Central region to have the second lowest mortality, with the South following last. But this is not the case. It is not until controls for sanitation and health factors are introduced that the child mortality differential between the North and Center is rendered insignificant. The evidence from this region suggests that education may not have the expected effect in decreasing child mortality differential if health services not readily available.

Despite considerable investment historically in infrastructure in the Central region, it appears that there is less access to health facilities. In this survey, the respondents from the Central region have the longest average distance from maternal and child health clinics. DHS (1992) research also suggests that access to health services is most difficult in the Central region. According to DHS, the median estimated time to the nearest health facility for a woman in the Central region is 2 hours, about twice as long as the median time for a woman in either the Northern or Southern regions (1992). Likewise, it is also interesting to note that children in the Central region are less frequently taken to a health facility when sick, which may be a reflection of the long traveling times to the clinics (DHS, 1992). One would expect these factors would result in dramatically high child mortality in the Central region relative to the other regions. Yet, mortality is not significantly different between the South and Center even before controls are introduced. It is possible that the women in the center are practicing health beneficial behavior, possibly acquired with education.

Contrary to the original hypothesis, the variable for pit latrine did not turn out to be significant. This variable is not a good measure of sanitation environment and has many limitations. Just because a household has sanitation facilities (such as a pit latrine) does not mean that it will be used hygienically or by all members of the household. In Lindskog et al.'s study of child mortality in relation to water supply and nutritional status in Malawi, the authors note that the young children often did not use the pit latrines, and consequently there was much fecal contamination around the homes (1988). Even though pit latrines protect against some parasitic diseases, they appear not to protect against diarrhea, one of the major contributors to child mortality.

Wealth measured by durable goods also did not turn out to be a statistically significant predictor of child mortality. This may also be due to poor measurement. A more holistic measure that includes income, household possessions, and number of livestock might be a better measure of relative household wealth than just the number of durable goods.

It is interesting to note that the South has the lowest average distance to health facilities and relatively high frequency of use of health clinics, despite lowest educational level (DHS, 1992). This suggests that access to health care may have some substitutive effects for education. This factor is important to think about when looking at child mortality differentials. The study also shows that educating women may not be the only answer to reducing child mortality differentials if it is not in conjunction with availability of medical services.

It appears that the relationships between education and access to health clinics and child mortality are more complex than can be explained by this initial study. It is a lot less clear exactly how education works to have a significant negative effect on child mortality, and how this effect may be altered by differences in the prevalence of health services. One also cannot exclude the possibility that part of the mortality differential may be due to unobserved factors intrinsic to the regional dummy variable that are unable to distinguish without further analysis. This study is a broad explanatory stroke and the model in this study is a relatively simple model. Further study into the biomedical factors such as nutrition and growth history of children could greatly add to the study of regional differentials in child mortality.

We have been looking at a cross section of child mortality in Malawi but further research could include looking at the changes in mortality over time. A preliminary plot of mortality relative to the earliest reference date of the Brass estimates indicates that mortality has been changing over time. Since there appears to be different rates of change relative to base years across the three regions, there is suggestive evidence that there is more affecting mortality than discerned in this initial study. Additionally, for the purposes of this study, mortality levels were standardized to account for age effects. But an initial look at the relationship between woman's age, educational attainment and proportion of children dead suggests mortality has not had a stable relationship over time, which could be due to change in educational attainment or a change in the effect of education (*see* Appendix). Again this points to a complex relationship between predictor variables and their effects on child mortality over time and on the regional differential, which may be better explained with further research. It would also be interesting to rerun the regressions using the Trussell and Preston (1982) technique that assumes a linear relationship, and compare the results with the results from the Poisson regressions analysis in this study, which assumes an exponential relationship. These are areas that should be explored with further research to gain a more holistic understanding of differences in child mortality and their changes over time.

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APPENDIX

NORTH	Educational Attainment		
Women's Ages	**none**	**primary**	**secondary**
15-29	-	0.159	-
20-24	0.278*	0.118	0*
25-29	0.389*	0.22	0*
30-34	0.333*	0.174	0.312*
35-39	0.454*	0.222	0.248*
40-44	0.209*	0.235	0.333*

CENTER	Educational Attainment		
Women's Ages	**none**	**primary**	**secondary**
15-29	0*	0.174	-
20-24	0.181	0.295	0.125*
25-29	0.21	0.217	0.25*
30-34	0.223	0.289	0.333*
35-39	0.312	0.186	0*
40-44	0.317	0.313*	-

SOUTH	Educational Attainment		
Women's Ages	**none**	**primary**	**secondary**
15-29	0.067*	0	-
20-24	0.222	0.192	0.167*
25-29	0.231	0.124	0.1*
30-34	0.24	0.217	-
35-39	0.291	0.293*	-
40-44	0.295	0.117*	.222*

* If cell contains less than 20 people.