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Research Article

Maternal Mortality and Female Literacy Rates in Developing Countries during 1970–2000: A Latent Growth Curve Analysis

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Background. The gross longitudinal relationship between female literacy and maternal mortality ratios has not been adequately investigated even though the knowledge of the relationship is crucial for designing maternal mortality reduction programs through female literacy campaigns and improvements. The objective of the study was to examine the dynamic relationship between female literacy and mortality ratios. A longitudinal study design spanning three decades, 1970–2000, was used. Country level data on 143 nations belonging to six geographical regions for the duration 1970–2000 were secured from websites hosted by global agencies such as World Bank and the United Nations were utilized. Maternal mortality ratios (1970–2000) ranged from 147 to 271 across the six regions. The longitudinal relationship between female literacy rates and maternal mortality ratios was examined using a latent growth curve approach. The study found that rates of change in female literacy and maternal mortality ratios are negatively related. Steady rates of increase in female literacy were associated with declining maternal mortality ratios as well. We find that female literacy programs are of immense value in reducing maternal mortality ratios given their ability to yield sustained reductions in mortality levels in developing countries.

1. Introduction

Each year, globally, about 210 million women become pregnant [1]. Only about 75 percent of these pregnancies are safe without life threatening complications. As a result, annually an estimated half a million women die of either pregnancy or child birth [2]. One in 350 pregnancies carries a high mortality risk due to causes such as hemorrhage, infection, unsafe abortion, eclampsia, and obstructed labor [3]. These five problems contribute to almost 70 percent of maternal deaths [4, 5]. In developing countries, the likelihood of women dying from pregnancy related causes is nearly 1 in 50 [6]. Bezruchka [7] presents three categories of general sources of threat to the life of the mother during pregnancy and child birth. The first of the three, poor accessibility to health services in supply, is often the most immediate cause of death during child birth. The second category includes a large number of indicators of health status including woman's constitution, age, and parity. The last risk category is composed of several social economic and environmental factors such as literacy status income and cultural factors. Even though causes of maternal mortality are health related complications, unavailable, inaccessible, and unaffordable health services drive maternal mortality ratios. Socioeconomic risk factors almost always accompany the growth and development of maternal mortality related conditions. In particular, they contribute to the intervening morbidity conditions between pregnancy and mortality. Consequently, maternal mortality explanations must take into account the socioeconomic factors such as income and literacy [8].

In spite of the vast literature on the effects of socioeconomic determinants on maternal mortality, several aspects of this relationship remain underinvestigated both at the theoretical and methodological level [9–11]. At the theoretical level, the longitudinal effects of social development vectors such as literacy on maternal mortality in developing countries have not been adequately investigated [12–14]. Explanations of the changes in maternal mortality over time are mere extensions of the cross-sectional explanations taking into account the changes in the selected determinants [15–17].

Table 1: Sources of data for the selected determinants of maternal mortality ratio (1970–2000).

Variables	Data sources
Maternal mortality ratio	Retrieved July 18, 2012, from (http://data.worldbank.org/indicator/SH.STA.MMRT), World Development Indicators, 2012, and a study published in the Lancet [19]; http://unstats.un.org/unsd/demographic/products/dyb/dybsets/1980%20DYB.pdf, Demographic Year Book, 1980
GDP per capita	Retrieved July 26, 2012, from (http://data.worldbank.org/indicator/NY.GDP.PCAP.CD), World Development Indicators, 2012
Female literacy rate	Retrieved August 10, 2012, from (http://data.worldbank.org/indicator/SE.ADT.LITR.FE.ZS), World Development Indicators, 2012
Age at marriage	Retrieved August 12, from (http://www.un.org/esa/population/publications/WMD2008/Data/UNPD_WMD_2008_MARITAL_STATUS.xls), World Marriage Data, 2008, and http://statinfo.biz/Data.aspx?act=2029&lang=2, Daily Caloric Intake Data, 2012

Even though socioeconomic conditions contribute to high levels of morbidity resulting in maternal mortality, maternal mortality research focuses on proximate causes of death such as lack of emergency medical care for child birth [18]. The role of social factors such as literacy in the development of broad-based social programs targeted towards lowering morbidity levels warrants a refocus in maternal mortality research [18]. Maternal mortality explanations must take into account the socioeconomic factors such as income and literacy.

At the methodological level, improvement in rates among countries with low literacy is expected to have the same effect on maternal mortality as those countries at higher literacy rates [20–22]. This assumption may not be valid methodologically [23]. Most of the studies lack robust methodological design [24]. In order to address these research gaps, this paper examines the role of female literacy on maternal mortality ratios in developing countries over a period of thirty years, from 1970 to 2000 using a latent growth curve modeling approach.

Maternal mortality ratios are a function of both economic and social development. Of all the social indicators, one that clearly discriminates between developing and developed countries is maternal mortality ratio [24]. Socioeconomic explanations of macrolevel (country level) maternal mortality generally focus on the negative relationship between gross domestic product (GDP) per capita and maternal mortality ratios [25]. Shiffman [25] found that the wealth indicators explained only a small proportion of the variance in maternal mortality ratios in developing countries. Other variables such as women's literacy rates and proportion of deliveries attended by trained birth attendants were found to be far more effective predictors of maternal mortality than per capita income [25]. This study focuses on the effect of a selected macro-level socioeconomic indicator, female literacy level, on maternal mortality ratios.

The relationship between literacy on maternal morality is both direct and indirect through availability of reproductive health care facilities. Literate women are less likely to experience poverty [26, 27], more likely to maintain adequate nutritional status [28, 29] and make decisions with respect to health and well-being [30, 31], access and use information [32, 33], and have fewer children [34]. These gains resulting from improvements in female literacy reduce maternal morbidity and maternal mortality. As female literacy levels increase, maternal mortality levels are expected to decrease. In addition, positive growth in female literacy rates over time is expected to be associated with decreases in maternal mortality growth rates. More specifically, the two empirical propositions tested in this study are as follows: (1) there is a significant relationship between female literacy levels and rate of change in maternal mortality ratios; (2) rate of change in female literacy is significantly related to maternal mortality ratio change.

2. Methods

2.1. Variables and Data. The developing countries included in this study are low income, lower middle income, and upper middle income countries as defined by the World Bank [35]. Economies are divided according to 2011 GNI per capita (in US dollars), calculated using the World Bank Atlas method. The groups developed by the World Bank are low income, $1,025 or less annually; lower middle income, $1,026–$4,035 annually; and upper middle income, $4,036–$12,475 annually. These three categories include 143 countries.

Data were gathered on four variables, maternal mortality ratio, female literacy rates, age at marriage, more specifically singulate mean age at marriage as defined below, and GDP per capita for three waves, 1970–1980; 1981–1990; and 1991–2000. Though maternal mortality ratio was available for 2007, data for a large number of countries were missing. It was therefore decided to limit our study to the duration of 1970 to 2000. The maternal mortality ratio (MMR) is the ratio of the number of maternal deaths during a given year per 100,000 live births during the same year. The sources of all data are given in Table 1. GDP per capita is gross domestic product divided by mid-year population. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. Female literacy rate is the percentage of females aged 15 and above who can, with comprehension, read and write a brief simple statement on their everyday life. The variable age at marriage was measured as "singulate mean age at marriage" defined as the average length of single life expressed in years among those who marry before age 50. In most instances, data were not available for all the years commencing from 1970. When data were available for more than one year for any of the three waves 1970–1980, 1980–1990, and 1990–2000, the average of all the values within a wave was used.

In a few instances, data for only one year for a country within a given wave were available. When data were not available for any country for a specific wave, data were imputed.

Several methods were used to impute data. All imputations were implemented separately for the three waves. Missing data was not a problem for maternal mortality ratios for the last two waves, 1980–1990 and 1990–2000. Nearly 20 percent of the countries had missing maternal mortality data for 1970–1980. For the missing cases, data were imputed using a group mean imputation procedure as follows. The 143 countries in our study were grouped into six regions. A new variable "region" was created. The 6 regions are East Asia, Africa, Europe and central Asia, Latin America and Caribbean, Middle-East and North Africa, and South Asia. Average maternal mortality ratio for each of the three waves was calculated, and the mean region and wave specific maternal mortality ratio was assigned to the countries with missing data.

Missing data for "age at marriage" and "female literacy rates" were dealt with as follows. First, wave specific (1970–1980, 1980–1990, and 1990–2000) and region (six regions in all) specific rates were calculated following the same procedures described for imputation of data for cases with missing values for maternal mortality ratios. Once the averages (wave and region specific) were obtained, the regions were ranked in ascending order. Each region was given a rank depending upon its position in the ascending order in each of the three specific waves. Each country was given a rank depending upon the rank of the geographic region to which it belonged. Thus all the countries in the same region were assigned the same rank as the rank of the geographic region the countries belonged to. A new variable "rank" was created for each of the three waves. This variable was used as an independent variable. Regression method was used to impute data for missing cases in each of the three waves. For female literacy rates, the variables "rank"; "percent urban"; and "life expectancy" were used as predictors. Three regression functions were estimated, one for each wave. Missing values for countries in each of the three waves were assigned the predicted value. The same method was followed to treat missing data in "age at marriage." The predictors used were "rank" and "total fertility rate." The "rank" variable was computed as the wave specific average "age at marriage" for each of the six regions arranged in ascending order. For those countries, with missing data in total fertility rate, the countries were assigned the "average age at marriage" for the geographic region to which the countries belonged. The number of such imputations made was small, four only. The final data set had four variables, maternal mortality ratios, female literacy rates, age at marriage, and GDP per capita. All the values assigned to countries with missing data for any of the four variables, maternal mortality ratio, age at marriage, GDP per capita, and female literacy are presented in Table 8.

2.2. Analysis and Results. Latent growth curve (LGC) modeling approaches provide an excellent set of tools to examine the effects of female literacy longitudinally. In our application of LGC models, the unit of analysis is a country in the developing world. LGC models are essentially longitudinal models aiding explanations of levels and rate of change in outcome variables such maternal mortality ratios.

In LGC models, the overall average of the country specific maternal mortality ratios (π_0) and the mean variability in the rate of change in country specific mortality ratios is represented by π_1. The LGC models include several others including the two parameters associated with the measure of growth of maternal mortality ratios. They are the variance of the initial level of maternal mortality ratios and variance in the country specific rates of change in maternal mortality ratios over a period of thirty years, 1970–2000. A significant variance in the rate of change is suggestive of heterogeneity in the maternal mortality ratios which may be explained by selected and hypothesized covariates such as female literacy. In our study, the selected determinant, "female literacy rates," is expected to account for the variability in both the initial level of maternal mortality ratios π_i, and the variability in the rate of change, π_s. Both π_i and π_s belong to a set of growth parameters that can be estimated using LGC models.

A general expression for the growth models of maternal mortality ratios and female literacy is as follows: $Y_{kt} = \pi_{ik} + \pi_{sk}a_t + e_{kt}$, where Y is the outcome observation for a number of countries 1 to k at specific time points. In this study, as mentioned earlier, the observations are for 1970–1980, 1981–1990, and 1991–2000. π_{ik} is the initial level i (for either mortality ratio or female literacy) for each of the k countries while π_{sk} is the growth rate or slope s (for either mortality ratio or female literacy) for each of the k countries. The slopes are multiplied by coefficient a_t which takes values 0, 1, and 2 for the three time periods in this study. The term e_{kt} represents the time specific random residuals. The proposed model of maternal mortality suggests that the rate of change and the initial levels of female literacy account for the rate of change in maternal mortality ratios.

In order to test the hypotheses that maternal mortality ratios are strongly associated with female literacy rates both at the cross-sectional and longitudinal levels, we associate 1980 mean female literacy rates as well as mean rate of change in female literacy levels during 1970–2000 with growth parameters of maternal mortality ratios.

The empirical test of the proposed hypothesis is performed in several stages. First, univariate analysis describes maternal mortality ratios and female literacy rates associated with each of the three waves of data, 1970–80, 1980–90, and 1990–2000. Second, maternal mortality ratios are regressed on female literacy levels controlling for two variables, age at marriage and GDP per capita for each of the three waves of data. The estimates from the regression analysis are likely to be useful in examining the cross-sectional net association between maternal mortality and female literacy rates. Third, interaction between each of the three waves (1970–80, 1980–90 and 1990–2000) and female literacy rates is examined using regression to assess if the effect (slope) of female literacy on maternal mortality varies over time. The results are likely to be useful in assessing the longitudinal associations between female literacy and maternal mortality.

Fourth, two latent growth curve models are tested separately for female literacy and maternal mortality ratios. These separate models will yield several growth parameters such

Table 2: Description of variables.

Year	1970–1980		1980–1990		1990–2000	
Variables	Mean	SD	Mean	SD	Mean	SD
			East Asia/Pacific/South Asia			
Female literacy	52.71%	26.64	60.37%	21.56	70.04%	21.25
Age at marriage	21.35	2.18	22.17	1.97	22.36	1.51
GDP per capita ($)	768.94	575.51	1048.00	1012.50	1316.20	1282.90
Maternal mortality ratio	491.38	442.66	446.23	368.81	356.44	184.53
			Latin America/Caribbean			
Female literacy	74.43%	16.19	79.35%	12.15	86.27%	10.47
Age at marriage	23.54	3.24	24.69	3.90	23.23	3.00
GDP per capita ($)	1440.70	885.82	1854.80	1292.60	3150.20	2257.00
Maternal mortality ratio	126.98	144.96	162.44	184.53	129.98	154.72
			Africa/MENA			
Female literacy	30.50%	20.62	44.82%	18.92	55.21%	24.59
Age at marriage	20.40	2.36	22.35	2.81	22.34	2.59
GDP per capita ($)	991.21	995.68	1074.40	1357.50	1176.60	1564.30
Maternal mortality ratio	441.87	250.76	534.54	376.22	559.23	427.92
			Europe/Central Asia			
Female literacy	70.20%	12.70	66.40%	16.45	95.53%	6.63
Age at marriage	21.81	0.83	22.99	1.38	24.69	1.95
GDP per capita ($)	1735.50	225.83	1732.40	798.60	1473.80	1007.60
Maternal mortality ratio	72.00	79.00	53.64	50.11	39.19	26.31

as the average initial levels, the average rates of change, and the covariance between initial level and rate of change associated with the two variables. Fifth, an associative latent growth model is estimated to examine the association among the growth parameters estimated for maternal mortality and female literacy rates separately in stage four. Sixth, the intercepts of maternal mortality ratios are regressed on female literacy levels in an attempt to explain the variations in the levels of maternal mortality ratios controlling for age at marriage. Finally, the slopes of maternal mortality ratios are regressed on the two parameters of female literacy rates (intercepts and slopes) controlling for "age at marriage."

Table 2 presents the averages and standard deviations of all the variables in this study by regions.

As seen in Table 2, mean maternal mortality ratio increased from 147 per 100,000 births to 271 per 100,000 births for all the regions. Most of the increase was due to worsening condition of mortality ratio in Africa/MENA and Latin America/Caribbean regions. The standard deviation of the rates is high indicating high level variability in the rates. Female literacy was as low as 50 percent in 1970 for all regions. The rate increased considerably to 70 percent in 2000. The average age at marriage is 22 years. During the thirty years, 1970–2000, the average increased to about 23 years across all regions.

The second stage of data analysis involved estimating a number of regression models.

The results are presented in Table 3. These models provide a preliminary assessment of empirical support for the expected relationship between female literacy and maternal mortality ratios, controlling for two variables, age at marriage and GDP per capita. The effect of female literacy on maternal mortality ratio is consistently negative and significant across the three time periods. There was also an increase in the strength of female literacy effect on maternal mortality. Of the two control variables, the beta coefficient of GDP per capita was insignificant in the second and third waves of data. GDP per capita will be excluded from the rest of the analysis.

The net effects of female literacy on maternal mortality ratios across the six regions vary considerably. In 1970–1980 female literacy was significant at the 0.05 level only for the Latin American region. The negative effect of female literacy on maternal mortality ratios become significant for more regions during 1980–1990 and 1990–2000. In South and MENA regions female literacy rates have for the most part no effect on maternal mortality ratios. In the next stage, the third, the interaction effects of female literacy and the third waves (durations) were assessed.

Table 4 presents the interaction effect of duration and female literacy with the 1970–1980 duration considered as the reference category. The coefficients of interaction of the second (1980–1990) and third duration (1990–2000) with female literacy are significant at the 0.05 level. There is a noticeable increase in the magnitude of the interaction coefficient, compared to the coefficient of the interaction between duration one (the base category) and female literacy. In general the results suggest that increases in female literacy have contributed to reductions in maternal mortality in developing countries.

Table 3: Regression of maternal mortality ratios on selected determinants by region and all regions.

Year	1970–80	1980–1990	1990–2000
Variables	*B*	*B*	*B*
Female literacy	−0.539*	−0.590*	−0.618*
Age at marriage	−0.078*	−0.141*	−0.135*
GDP per capita	−0.026*	−0.055	−0.051
Regions			
East Asia/Pacific	−0.116	−0.496*	−0.586*
Africa	−0.347	−0.547*	−0.392*
Europe/Central Asia	−0.364	−0.201	−0.684*
Latin America/Caribbean	−0.595*	−0.641*	−0.685*
MENA	−0.591	−0.841*	−0.099
South Asia	−0.508	−0.507	−0.583

*$P < 0.05$.

Table 4: Regression of maternal mortality ratios (1970–2000) on female literacy and its interaction with three periods (1970–1980; 1980–1990; 1990–2000).

Variable	(*B*)
Female literacy rate	−0.427
Age at marriage	−0.125
Year (1980–1990)	0.427*
Year (1990–2000)	0.627*
Year (1970–1980) (ref.)	
Interaction variables	
Female literacy ∗ year (1980–1990)	−0.319*
Female literacy ∗ year (1990–2000)	−0.432*

*$P < 0.05$.

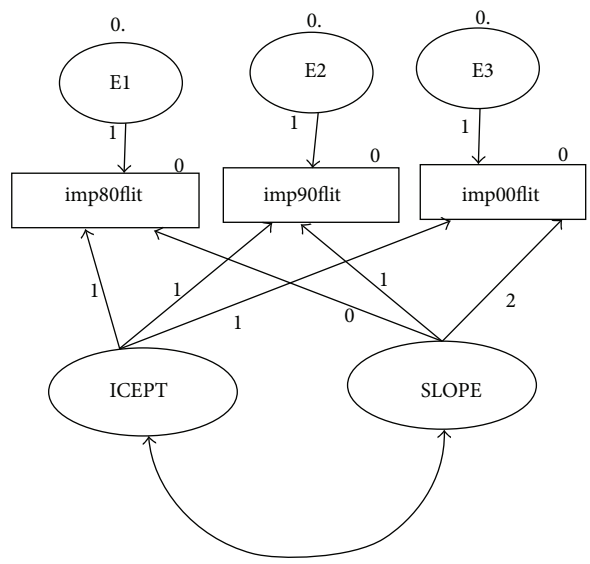

Figure 1: Growth model of female literacy rates in developing countries. imp80flit = female literacy rate in 1970–1980. imp90flit = female literacy rate in 1980–1990. imp00flit = female literacy rate in 1990–2000. ICEPT = initial levels – female literacy. SLOPE = rate of change in female literacy.

The preliminary support for changes in the slopes of female literacy with maternal mortality is tested in the fourth stage using LGC models. Figures 1 and 2 present the growth models for maternal mortality and female literacy, respectively. Estimates of the univariate growth trajectories for maternal and female literacy rates are presented in Table 5.

The average maternal mortality ratio initially was 343 deaths per 100,000 births. However, the variation in the initial maternal mortality ratios is not only high but also significant at the 0.05 level. There was a significant increase in the rate of change in maternal mortality ratios during 1970–2000. The variance in the rate of change was significant at the 0.05 level. See Table 5. The covariance between initial level of maternal mortality ratios and rate of change over time was significant, positive but weak with a magnitude of 0.357 (not shown in Table 5). Thus countries with high mortality ratios also experienced high rates of change during 1970–2000. The estimated maternal mortality growth model possesses a good fit with CFI at 0.998 and NFI at 0.992.

There was a statistically significant female literacy rate at the initial level in 1970–1980. The variance in the female literacy rates was significant at the 0.05 level. There was significant increase also in the rate of change in female literacy rates during 1970–2000. The female literacy rates increased by 10 percentage points in every duration of ten years beginning at an average female literacy rate of 50 percent. The covariance between mean initial level of female literacy and rate of change was negative with a magnitude of 0.692. Thus countries with high female literacy levels also experienced slow rates of literacy growth over time. The estimated growth model yields good fit as indicated by a CFI of 0.919 and NFI of 0.914. See Table 5.

In the fifth stage, we examined whether or not the growth in female literacy rates are associated significantly with growth in maternal mortality ratios. This is accomplished by testing an associative LGC model presented in Figure 3.

Results from the associative LGC model is presented in Table 6. Model fitting procedures for associative LGM yielded values $\chi^2(9, n = 141) = 39.83, P \leq 0.05; cfi = 0.959$ and $nfi = 0.948$; $aic = 75.83$. The correlation between mean female literacy rates and mean maternal mortality ratios is strong

Table 5: Estimates of the univariate growth trajectories for maternal mortality ratios and female literacy rates in developing countries (1970–2000).

	Initial level		Rate of change		Fit indexes	
Variable	Mean	Variance	Mean	Variance	CFI	NFI
Maternal mortality ratios	343.08*	610.61*	11.42*	1437.7*	0.998	0.992
Female literacy rates	50.33*	746.86*	9.98*	31.46*	0.919	0.914

*$P < 0.05$.

Table 6: Correlation between female literacy and maternal mortality initial levels and slopes from the associative latent growth curve model.

	Female literacy		Maternal mortality	
	Intercept (ICPT)	Slope (SLOPE)	Intercept (ICPT1)	Slope (SLOPE1)
ICPT	1			
SLOPE	−0.697*	1		
ICPT1	−0.863*	0.416*	1	
SLOPE1	−0.370	0.235	0.415*	1

*$P < 0.05$.

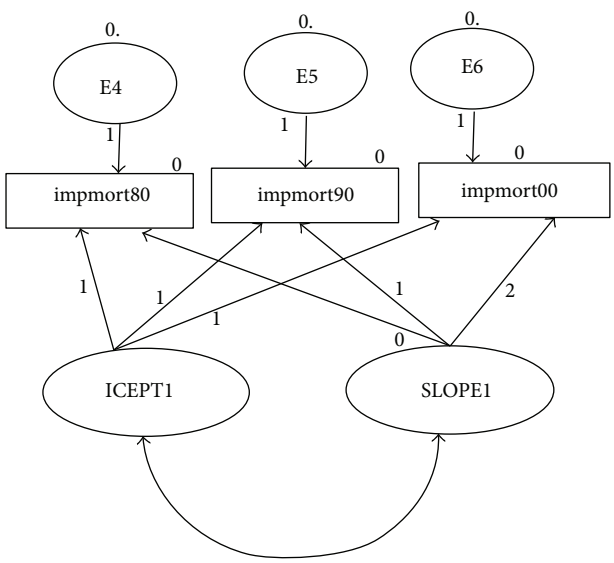

Figure 2: Growth model of maternal mortality ratios in developing countries. impmort80 = maternal mortality ratios in 70–80. impmort90 = maternal mortality ratios in 80–90. impmort00 = Maternal mortality ratios in 90–00. ICEPT1 = initial levels – maternal mortality. SLOPE1 = rate of change in female literacy.

(−0.863) and significant. See Table 6. High literacy levels are associated with low rates of maternal mortality with a significant level of variance. The correlation between mean levels of maternal mortality ratios and mean rates of change (slopes) in female literacy is significant and positive. The correlation between mean levels of female literacy and mean rates of change (slopes) in maternal mortality is significant and negative with a magnitude of 0.370.

In general, while there is a negative association between the initial level of female literacy and female literacy rate of change, the association between maternal mortality levels (ICPT1) and maternal mortality ratio of change (SLOPE1) is positive. Thus the two variables, maternal mortality and female mortality ratios, grow in opposite directions. However, the correlation between the two rates was found to be 0.235, but not significant at the 0.05 level.

Finally, the intercepts as well as the slopes of maternal mortality ratios are regressed on the same two parameters of female literacy rates controlling for "age at marriage." The model is presented in Figure 4.

Table 7 presents all the regression coefficient estimates. As expected, regression of maternal mortality intercepts on female literacy intercepts is negative and significant, controlling for age at marriage. The standardized regression coefficient is −0.854. Now consider the regression of maternal mortality ratio of change on female literacy levels (intercept) and slopes. The standardized regression coefficients are −0.540 and −0.232, respectively. Increases in initial level as well as growth (rate of change) in literacy rates are associated with deceasing rates of growth in maternal mortality ratio of change. Female literacy gains not only result in desired maternal mortality reductions, but also growth in female literacy rates is significantly associated with negative growth in maternal mortality ratios.

3. Discussion and Conclusion

The objective of this paper is to explore the net longitudinal association of female literacy with maternal mortality ratios in developing countries. In this section, we attempt to locate female literacy programs in relation to two well-known broad based approaches to maternal mortality reduction, women's empowerment and enhancement of women's reproductive rights. In so doing, the relevance of female literacy programs in policies targeting maternal mortality reduction from multiple perspectives may be highlighted.

Maternal deaths result from both direct and indirect causes. Whereas the direct causes stem from obstetric complications of pregnancy, the indirect ones originate from health problems prior to the pregnancy. Ability to recognize threats to pregnancy and to make decisions with respect to

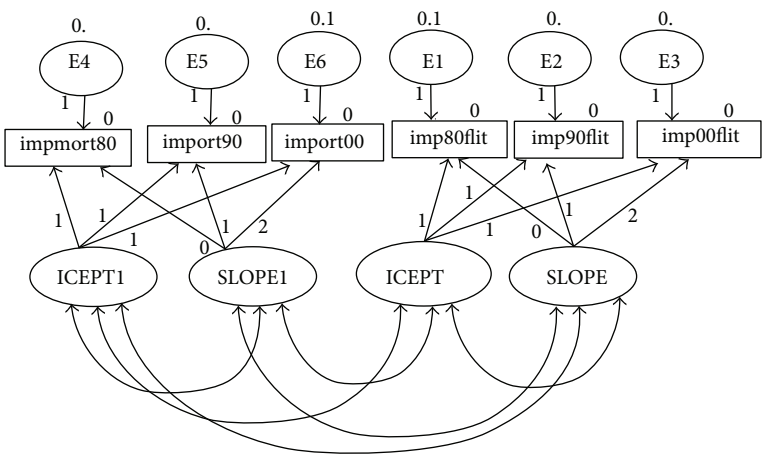

Figure 3: Associative growth model of female literacy and maternal mortality rates.

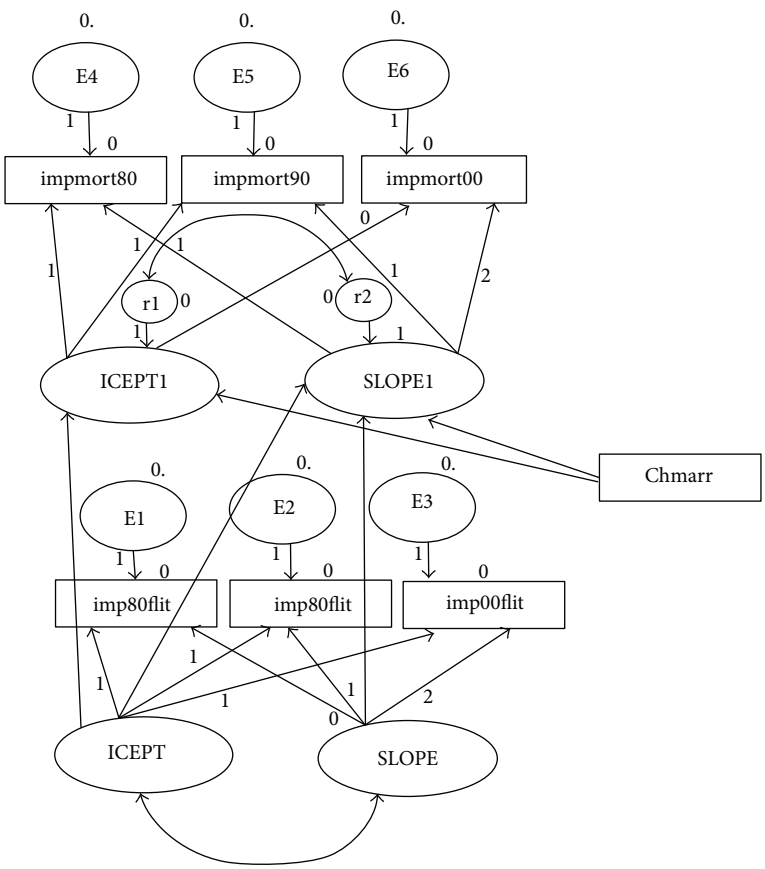

Figure 4: Regression of growth parameters on female literacy slope and intercept (Chmarr = age at marriage).

the preservation of well-being constitute a preliminary step in the prevention of maternal deaths [36, 37]. The next step involves enabling women to contact and avail themselves of appropriate health care services [38, 39]. Finally, the effective utilization of health care services involves coordination of human and material resources. All through these steps, literacy is essential for purposeful and gainful consumption of health care services to address pregnancy related complications [40, 41]. Thus investing in improving female literacy is among a number of core programs that yield sustainable reduction of maternal deaths [42, 43].

The focus on female literacy as an instrument of women's empowerment is in sharp contrast with the widespread influence of neoliberal Malthusian thinking that has influenced

Table 7: Regression of maternal mortality growth parameters on female literacy growth over 1970–2000.

Dependent variables	Maternal mortality intercept		Maternal mortality ratio of change	
Independent variables	(b)	(B)	(b)	(B)
	ICEPT1		SLOPE1	
Female literacy levels (ICEPT)	−7.648*	−0.854*	−2.31*	−0.540*
Female rate of change (SLOPE)			−4.92*	−0.232*
Age at marriage	0.052	0.007	−4.55	−0.090

* $P < 0.05$; b and B are unstandardized and standardized regression coefficients.

Table 8: Values imputed to variables with missing values.

Variable	Region	1980	1990	2000
Fem. Lit	1	72.52	74.03	77.73
	2	27.83	49.48	50.13
	3	53.04	61.71	96.69
	4	76.23	81.62	88.49
	5	33.08	38.13	63.28
	6	39.18	43.31	60.64
Age marry	1	22.5	22.98	22.8
	2	19.79	21.82	21.48
	3	21.77	22.66	24.7
	4	23.87	24.97	23.03
	5	22.1	24.55	25.03
	6	19.48	20.5	21.47
GDP	1	865.0	1154.0	1447.0
	2	825.0	932.0	979.0
	3	1762.0	1718.0	1459.0
	4	1464.0	1894.0	3168.0
	5	1698.0	1757.0	2033.0
	6	238.0	448.0	764.0
Mat. Mort	1	326.5	321.0	232.0
	2	508.02	654.15	759.0
	3	56.83	46.5	36.9
	4	108.08	145.88	119.0
	5	346.55	240.41	155.0
	6	782.875	622.55	505.0

Codes for regions: 1 = East Asia/Pacific, 2 = Africa, 3 = Europe and central Asia, 4 = Latin America, 5 = Middle East and North Africa (MENA), and 6 = South Asia.

health care policies in developing countries [44, 45]. Neo-Malthusians identify population growth as the single most important determinant of a number of cataclysmic social problems such as poverty, war, environmental degradation, and political instability [46–48]. As a result, fertility control emerged as a sociopolitical movement focused on curtailing total fertility rates while paying scant attention to women's well-being at the physical, emotional, and social levels [49–51]. One consequence of this is high maternal mortality in developing countries. In fact, differentials in maternal mortality ratios mark the sharpest divide between developed and developing countries. Improving female literacy rates through concerted policy initiatives remains one of the most effective tools in developing women's agency and organizations dedicated to reducing maternal deaths [52, 53]. Prior studies suggest that increases in female literacy rates are associated with improvements in nutritional intake reducing the likelihood of pregnancy complications [54–56].

Maternal mortality has been the subject of attention among advocates of rights based development [57]. Health in general is socially produced and rights advocates strongly believe that maternal mortality in developing countries may not be reduced without addressing issues of reproductive rights [58–60]. Reproductive rights are of two types: rights to make choices with regard to all aspects of reproduction and the right to have access to quality reproductive health care [61–63]. However, the number of reproductive choices available is predicated on women's capacity to acquire and utilize information necessary to promote reproductive health [64–66]. Female literacy rate increases are positively correlated

with reproductive health care utilization and reduction in maternal mortality ratios [32, 67, 68].

Our results support the proposed theoretical expectations with respect to the relationship between female literacy and maternal mortality ratios in developing countries. The effects of the initial levels as well as the growth rates in female literacy on maternal mortality were expected to be negative. The proposed relationships were supported controlling for "age at marriage." In this regard, this study provides evidence of a significant relationship between female literacy and maternal mortality ratios. Latent growth curve modeling approach used in this study facilitated the examination of the relationships between female literacy rates and maternal mortality ratios in developing countries at several levels such as compositional and longitudinal. The finding that female literacy growth rates reduce maternal mortality growth has policy implications. Female literacy programs depress maternal mortality ratios not only in the short run (immediately) but also have long-term effects of reducing maternal mortality ratios. Thus female literacy programs may be used to achieve sustainable long-term reduction in maternal mortality.

There are a few limitations to consider. Cross-national data on many of the correlates of maternal mortality are scarce. It was not possible to include many of the well-known determinants of maternal mortality as controls. In this study, we found it more difficult to obtain 1970–1980 data than 1980–1990 and 1990–2000 data on key variables. At the empirical level, we observed that the correlation between female literacy and maternal mortality slopes was positive but insignificant at the 0.05 level while the net effect of female literacy slopes on maternal mortality slopes was negative and significant. This switching in the sign of the relationship could not be adequately addressed due to data limitations. Given these limitations, our finding should only be considered preliminary. The proposed hypotheses in this paper should be tested as more data become available.

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