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Introduction

Studies using data from the World Fertility Survey have shown that, on average, each one-year increment in maternal education corresponds to a reduction of 7 to 9 percent in mortality for children under 5 years of age (Cleland and Van Ginneken, 1988). While one of the most common findings in the child survival literature, this relationship still remains one of the least understood. In response to increased demand, the availability of formal education opportunities for females appears likely to increase in developing countries over the next few decades. Whether the resulting changes in the educational composition of households and communities may be expected to sustain the continuing decline in rates of childhood mortality (Hill and Pebley, 1990), will depend in part on the causal nature and dynamics of the education-mortality relationship.

There are many theories concerning the causal pathways through which mother's education, independent of its obvious link with economic conditions, may result in better prospects for child survival (Caldwell, 1979; Schultz, 1984; Cleland and van Ginneken, 1988). Of these, perhaps the most relevant and intuitive from the perspective of child health policy, is that which concerns the possible mediating role of modern health service utilization. The evidence for such a causal connection is, however, inconclusive at best. While participation in mass immunization programs may not be education-related (Freide et al., 1985; Belcher et al., 1978), there appears to be considerable evidence to support the thesis that, in many societies, better educated mothers more commonly use maternal and child health services than less educated mothers (Tekce and Shorter, 1984; Benyoussef et al., 1974; Caldwell et al., 1983; Mbacke and van de Walle, 1987).

Recent data from a small-scale study in Indonesia indicate that educated women have greater awareness of correct immunization schedules and that it is possession of this specific knowledge rather than formal education per se that leads a mother to ensure that her children receive available vaccines (Streatfield et al, 1990). Barbieri (1990), applying multivariate methods to the Senegal DHS data, concludes that the effect of maternal education on child survival does **not** operate through differential health service utilization, variations in exposure to disease or through different reproductive patterns.

If the relationship between education and mortality is indeed a causal one,[1] there seems no inherent reason to assume that the intervening mechanism(s) is necessarily the same in all contexts. It is, on the other hand, remarkable to find such a consistent and pronounced relationship across the diversity of socio-

[1] Behrman (1990) suggests that at least part of the effect of mother's education on child health and survival may indeed be spurious. The author argues that unobserved familial abilities and motivations are passed on to the daughter, now mother, and that it is these effects that in part drive the reported education-related differentials in childhood mortality.

demographic and epidemiologic conditions represented in previous comparative studies (see Cleland and van Ginneken, 1988 for a review). The study in which we are currently engaged is also comparative in nature and focuses on the particular role that the use of child health services may play in effecting the education advantage in child survival. The present working paper is meant to disseminate for critical comment the details of our methodological approach using as an example data from the DHS survey in Bolivia. Later extension of our analysis to several other countries representing a wide range of child health and mortality conditions will serve as a basis for drawing substantive conclusions regarding patterns of socio-cultural behavior that may be fundamental and generalizable.

Conceptual and Analytical Framework of the Study

This investigation pursues several related lines of inquiry, each line building on inference drawn from the previous. First, "does formal education increase a mother's propensity to use modern child health services?" In this preliminary analysis, multivariate methods are used to isolate the effect of maternal education on service utilization from the confounding influence of household economic condition and her pattern of family formation.

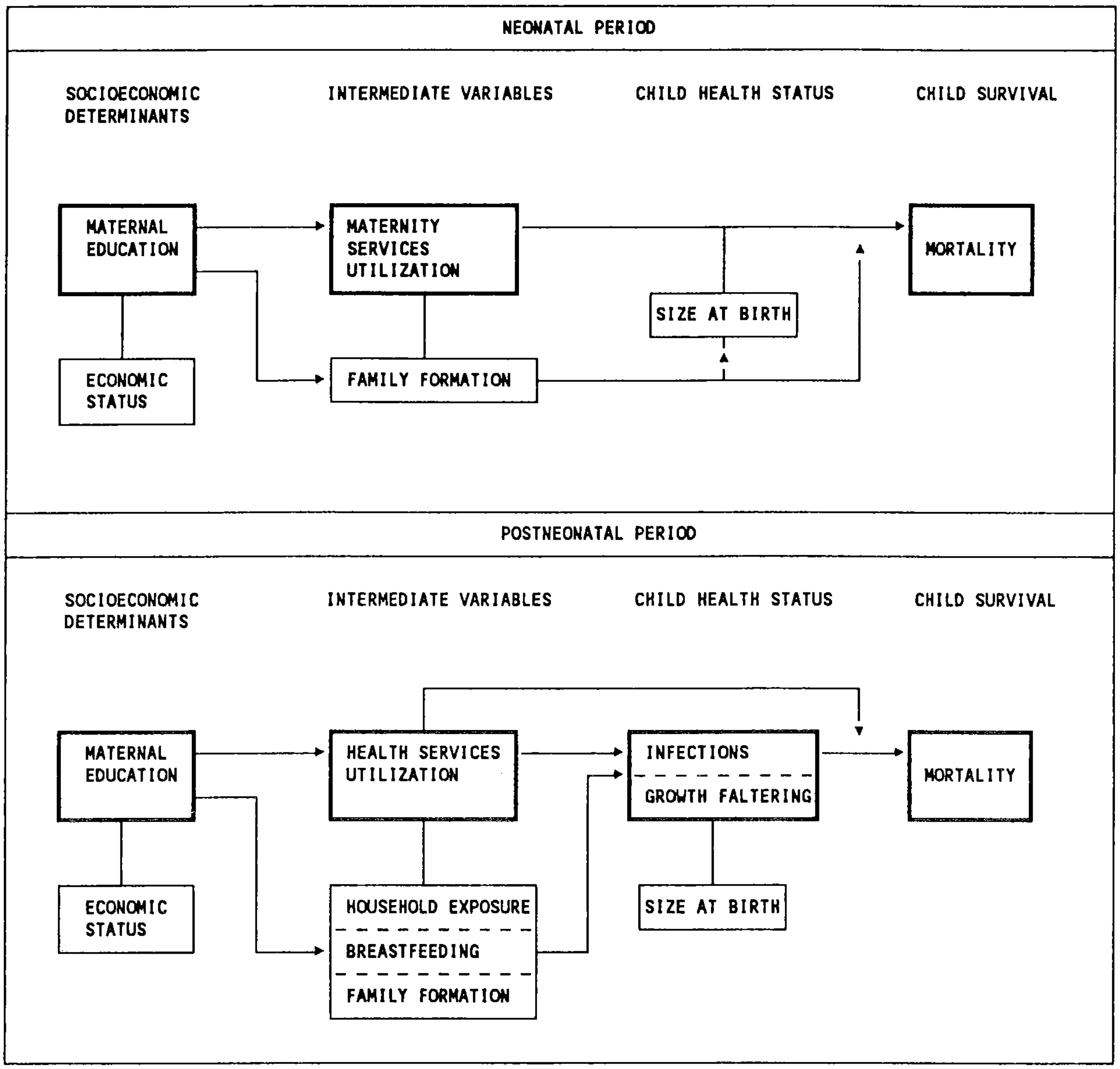
Maternal education and indicators of health services use are then placed within a broader analytical framework of the determinants of childhood morbidity and mortality (see Figure 1). The framework builds on the earlier conceptual models of Mosley and Chen (1984) and Van Norren and Van Vianen (1986), with modifications based on the limitations and peculiarities of the DHS data. Explicit here, as in the original Mosley-Chen framework, is that there exists a finite number of variables, called proximate or intermediate determinants (e.g., modern health services), through which background socioeconomic factors (e.g., maternal education) must operate to influence survival chances.

Household economic conditions, household sanitation (exposure to disease), family formation pattern, and children's size at birth are each known to be important determinants of childhood mortality and may, at the same time, be associated with a mother's level of education and use of health services. The DHS data include information that will allow a measure of control over the perturbing influence of these variables on estimation and inference.[2] The second phase of analysis thus focuses on maternal education as a determinant of early childhood mortality and the particular role of health services use in mediating the relationship. Separate conceptual models are posited for neonatal mortality and mortality after the first month. The reason for this distinction is explained in later sections.

[2] See Trussell and Menken (1984) for a review of problems related to unobserved heterogeneity in observational studies of child survival.

FIGURE 1

Conceptual framework for the analysis of the effects of maternal education on child survival, focusing on the mediating role of health services utilization.



Ideally, we would wish to have age-specific measures of past illnesses, nutritional inputs and growth that would allow controls for health heterogeneity in our study populations (Mosley and Becker, 1990). The DHS morbidity and nutritional status data are cross-sectional and thus restricted to living children, making use of a single statistical model (with both morbidity and mortality measures) unfeasible. We will nonetheless argue that these data are useful in assessing how it is that maternal education improves survival chances. Let us proceed under the operational assumption that the large majority of early childhood deaths (after the neonatal period) in our study populations are due to repeated bouts of infection and deteriorating nutritional status. This assumption appears quite reasonable under conditions of moderate to high child mortality (Mosley, 1985; Van Norren and van Vianen, 1986).

Should it be found that the effect of maternal education on mortality is effected wholly or in part through use of child health services, there are three possible scenarios:

(1) Education-conditioned health behaviors are largely preventive in nature and decrease mortality risk through decreased frequency and/or duration of illnesses and improved nutritional status. Under this scenario, one expects differences in disease prevalence and nutritional status by mother's education of roughly the same magnitude as are observed with respect to child mortality.

(2) Education-conditioned health behaviors are largely curative in nature and decrease mortality risk through diminished case fatality. Under this hypothesis, one expects to find smaller education-related differentials in morbidity than are found with respect to survival. For instance, in the case where children of educated mothers fare no better with respect to disease prevalence but die less frequently, it is reasoned that curative behaviors are key in effecting the education advantage. It is also expected that in response to successful therapeutic intervention and appropriate nutritional inputs during and after serious infections, the likelihood of chronic undernutrition will diminish. Height-for-age (stunting) is thought to be especially sensitive to the cumulative effects of inappropriate treatment/feeding patterns and is relatively unaffected by any fluctuation in food availability around the survey date.

(3) Both (1) and (2) are operative.

The third phase of analysis thus centers on whether education per se and health behaviors conditioned by maternal education operate to decrease disease prevalence[3] or to diminish case-fatality. Our approach is to assess the effects of mother's education within three multivariate morbidity models based on data for children surviving to the survey date: (1) stunting at survey date, (2) diarrheal illness (past 2 weeks), and

[3] The distinction between incidence and duration cannot be made using DHS-type data.

(3) symptoms associated with severe lower respiratory infection (past 2 weeks).

A problem commonly faced in the interpretation of findings related to the determinants of nutritional status and morbidity using survey data is selection bias. As only living children are observed in data of this type, it can be argued that estimates of the effects of education on stunting, for instance, will be biased towards zero (i.e., masking or attenuating genuine effects), since the least healthy children will have died. One way to evaluate the potential impact of such selection bias is to include dead children in an analysis under the extreme assumption that all would have been stunted had they survived to the survey date. The findings of this experiment are presented in the results.

Lacking detailed data on physical access to modern health services (an almost certain determinant of use), all analyses are stratified by urban-rural residence under the reasonable assumption that, for the countries under study, urban access is greater than rural access. While these strata are clearly not internally homogeneous, comparison of the two residence models are expected to provide insight into possible access-related differences in the relationship between education and health behavior, and later, the relationship between these variables and morbidity and mortality.

While this approach to disentangling a complex web of causality is admittedly crude, it should allow some basic hypotheses to be put forward about whether, and how, the relationship between education and mortality may be effected through modern health behaviors. Comparable findings in a series of countries or consistent urban-rural patterns in the effect of education on survival would augment the level of causal inference that is supportable.

Data and Analytical Methods

The Data. From February to May 1989, a national-level DHS survey was carried out in Bolivia. The sample included 7,923 women aged 15-49 years, from whom birth history information was collected, as well as information concerning personal and household characteristics, health service utilization, child morbidity, children's size at birth, and nutritional status at the time of the survey. The following Bolivian data will be used to illustrate and evaluate the methodology presented in this study:

- *Mortality*: Survival status at the time of the survey and the age at death (in single months) for all births since January 1984 (except those in the month of survey) are used in the analysis of childhood mortality. The restriction of analysis to recent births serves three purposes. First, the quality of birth history information for recent births should be better than for more distant births. Second, the assumption of a static risk profile using retrospective data is least violated using recent births. Third, and most compelling, is that some key health service data were collected only for births occurring since that January 1984.

Two age segments are examined: the neonatal period (under 1 month), and the postneonatal/toddler period (1 to 23 months). Heaping of age at death at 12 months is common in survey data of this type (Sullivan et al., 1990). Collapsing the postneonatal and toddler periods serves to avoid biases introduced by any relationships between age at death misreporting and the explanatory variables. Further, the small number of deaths in older age categories and the heavy right-censoring precludes statistically relevant results for a separate toddler model.[4] This age segment will henceforth be referred to as the postneonatal period.

- *Stunting*: Height and weight were measured for (surviving) children aged 3-36 months at the time of the survey. In this study we examine stunting among children aged 3-23 months.[5] A child is considered stunted if the recumbent length for age is more than two standard deviations below the NCHS/WHO reference median. This measure best reflects past deficits in nutritional intake and deteriorating health status associated with repeated infectious disease.

- *Morbidity*: Information on common symptoms of illnesses among living children in the two weeks preceding the interview were collected. Two morbidity measures are examined: diarrhea in the last two weeks, and cough with rapid or difficult breathing in the last two weeks. The latter is thought to signal pneumonia, while the former may indicate gastro-intestinal infection--both potentially fatal if left without appropriate treatment. The effects of mother's education on morbidity are examined among children aged 1-23 months at survey.

- *Socioeconomic Status*

  Mother's education: Data were collected from the mother in single years of completed education. Three educational levels are considered: none, 1-5 years (basic), and 6 or more years (intermediate, middle or higher) based on the Bolivian education system. *A priori*, each increase in the level of mother's education is expected to reduce the risk of childhood morbidity and mortality--this is called a "dose-specific" effect or response.

  Household Economic Level: The Bolivia DHS survey collected very few data related to the economic status of the household. Only a couple of questions related to household possessions

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[4] Indeed, this is why mortality after the second birthday is not examined at all. Only 15 children died at age 2 to 5 years.

[5] This age range was chosen so that the data would correspond as closely as possible with the age range of the postneonatal period (i.e., 1-23 months) examined in the mortality analysis.

were asked: "Does anyone in your household possess a car? tractor? motorcycle? bicycle?"[6] A child's household was classified as being of higher economic level if one of the motorized vehicles was reported, of lower economic status if all were lacking.

- *Size at birth*: Actual birthweights were not collected in the DHS surveys[7]. However, mothers were asked if at birth their children were very small, smaller than average, average, larger than average or very large. Other studies have shown that these data can be used to single out low birthweight babies (Moreno and Goldman, 1990; DaVanzo et al., 1984).

- *Family Formation Pattern (Bio-demographic Variables)*: The length of preceding birth interval, mother's age at birth of the child, birth order, sex of the child, and whether the birth was a singleton or multiple birth are available from the birth history information. First order births are assigned to the birth interval length category of lowest risk (24 months or more), in order to avoid their exclusion from analysis. This approach is similar to that used by Palloni and Millman (1986) and Hobcraft et al. (1985).

- *Breastfeeding*: Information on the duration of breastfeeding for each child born in the last 5 years was collected in the Bolivia DHS survey. A dichotomous variable is constructed to indicate whether the child is still breastfeeding at the beginning of the age-segment (month) of risk. This is the only time-varying covariate used in this study and is applied only in the postneonatal mortality model. The statistical approach to its application is described later.

- *Indicators of Household Exposure to Disease*

  Water and sanitation: Responses to a question on current source of drinking water are classified into "piped" and "non-piped". Responses to a question on current excreta disposal method are divided into "toilet facilities including flush toilets or latrines", and "no facilities."[8] These variables, taken together, are expected to capture some of the variation in household exposure to water-borne enteropathogenic agents, but may also capture variation in the economic condition of the household.

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[6] Most other DHS surveys have collected additional information concerning type of materials used in dwelling construction. It is conceded that, in the case of the Bolivia DHS survey, the available data are insufficient to capture adequately the full range of variation in either disposable income or household wealth.

[7] Sixty percent of Bolivian births occur at home.

[8] The actual questionnaire did not have a code for "no facilities" but had a category for "other facilities", which given the observed distributions is taken to be comprised mainly of "no facilities" responses.

- *Health Service Utilization*

  Maternity Health Services Utilization (MATER): Information concerning use of antenatal services and whether delivery was in a medical institution were used to construct a health service index for neonatal mortality. One point is assigned for each behavior, thus values of MATER run from 0 to 2: LOW = 0, MEDIUM = 1, HIGH = 2. While any observed effect of MATER on survival may reflect specific biological protection, a more general measure of behavioral propensity to use these and other health services is almost certainly captured.

  Global Measure of Health Service Utilization (UTIL): Two pieces of information; (a) knowledge of modern contraceptive methods and (b) knowledge of oral rehydration therapy were used, in combination with the two maternity health services variables, to construct an index that is intended to measure a women's propensity to use health services. One point each was assigned for: use of antenatal care, knowledge of modern contraceptive methods, and knowledge of oral rehydration therapy. Two points were assigned for delivery in clinic. Values of UTIL, used in the postneonatal mortality and morbidity models, thus run from 0 to 5. Inspection of the distribution of UTIL led to the scale: VERY LOW = 0, LOW = 1-2, MEDIUM = 3, HIGH = 4-5.

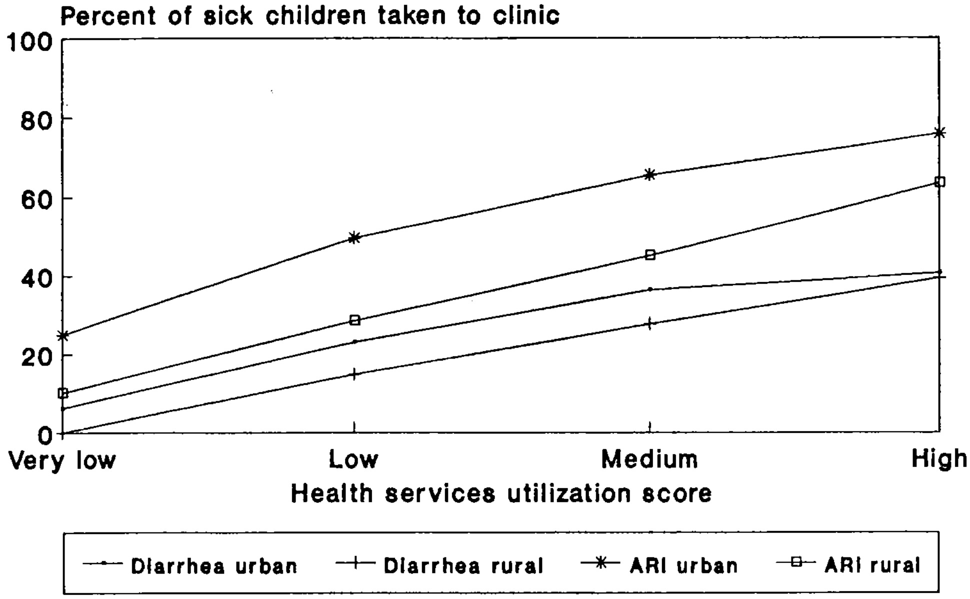
Preliminary work has shown that UTIL performs well as an indicator of general propensity to use services of both a curative and preventive nature. Data on treatment patterns and immunization service use, while not useful in the mortality determinants analysis,[9] have been helpful in assessing the sensitivity of the UTIL index to variations in actual health-seeking behaviors. Figure 2 shows that the percent of children with diarrhea and lower respiratory tract infections taken to the clinic increases markedly with higher UTIL scores in both rural and urban settings. Also, Figure 2 demonstrates that there is a strong positive association between the UTIL score and preventive health services utilization as measured by measles and DPT3 vaccination coverage rates among children aged 12-23 months.

Table 1 gives a summary of mortality rates, stunting and morbidity prevalences, and distributions of births by mother's educational level and level of health services utilization.[10] It is worth remarking here that while early child mortality, linear growth faltering, and low levels of education and health service utilization appear to be more common in rural Bolivia than in the towns, urban/rural differentials in diarrheal and respiratory illnesses are negligible.

[9] Treatment data were collected only for living children who were ill around the survey date.

[10] Notice that analyses of childhood morbidity and stunting involve a subset of children examined in the mortality analyses.

Figure 2
Curative Services Use by Health Services Utilization Score



Immunization Coverage (12-23 months) by Health Services Utilization Score

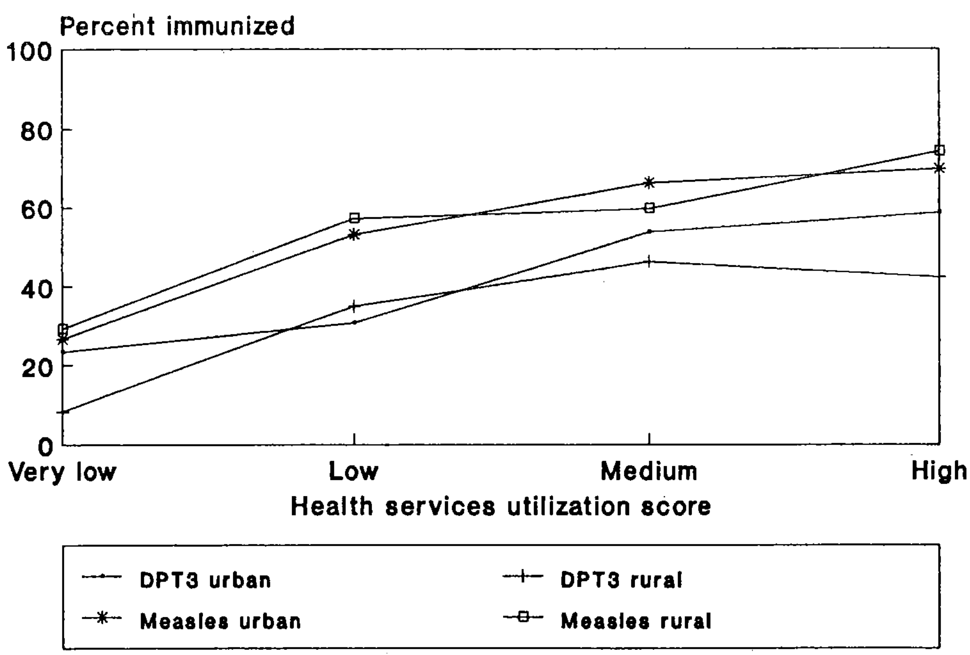


TABLE 1

Neonatal and postneonatal (1-23 months) mortality rates, prevalence of stunting, diarrhea and respiratory illness, and percentage distribution of children by mother's level of education and use of health services, Bolivia DHS 1989.

	REFERENCE CHILDREN	URBAN	RURAL
NEONATAL MORTALITY	All live births in last 5 yrs	.025	.040
POSTNEONATAL MORTALITY	All live births in last 5 yrs surviving the 1st month	.066	.095
Number of observations (live births)		3061	2696
STUNTING	3-23 months old at survey	23.7%	36.8%
Number of observations		915	799
DIARRHEA in last 2 wks	1-23 months old at survey	39.5%	41.2%
Number of observations		1137	978
RESP. ILLNESS in last 2 wks	1-23 months old at survey	28.9%	28.2%
Number of observations		1163	1010 *
EDUCATION of MOTHER	All live births in last 5 yrs		
None		8.8%	30.4%
Basic (1-5 yr)		37.3%	55.0%
Intermediate or higher (6+)		53.9%	14.6%
UTILIZATION INDEX (UTIL)	All live births in last 5 yrs		
Very low		4.0%	20.1%
Low		25.3%	52.9%
Medium		12.8%	11.4%
High		57.8%	15.6%

* Numbers differ between diarrhea and respiratory illness due to differences in the number of missing values and "don't know" responses.

Basic Statistical Model

Six dependent variables are examined in this study: use of health services, neonatal mortality, postneonatal mortality, stunting at the time of the survey, diarrhea in the last two weeks, and symptoms of respiratory illness in the last two weeks. Except for postneonatal mortality, all were analyzed as dichotomous outcomes using the logistic regression model:

$$\ln \frac{(q_i)}{(1-q_i)} = b_0 + b_i X_i \text{ , or}$$

$$\text{logit } q_i = b_0 + b_i X_i \text{ ,}$$

where q_i is the probability of the outcome given the array of independent measures, X_i; and where b_0 is a constant and b_i represents a series of unknown coefficients to be estimated via maximum-likelihood (Hosmer and Lemeshow, 1989). In the case of postneonatal mortality, we use a Cox hazards regression model, obviating the exclusion of a large number of children born within 2 years of survey.[11] The form of the model is,

$$\ln \frac{h(t)_i}{h_0(t)} = b_i X_i \text{ ,}$$

where $h(t)_i$ is the predicted hazard or mortality risk at age (month) t for an individual with the array of covariate values, X_i, $h_0(t)$ is the underlying and arbitrary hazard at age t, and b represents the regression coefficients estimated by the partial-likelihood method of Cox (1972). All covariates, except breastfeeding status[12], are fixed across ages 1 to 23 months.

Independent measures are reference parameterized, with the theoretically low-risk category serving as reference. The maximum-likelihood estimate of b is interpreted as the difference in the predicted log odds (or log hazard) of the outcome between those with a particular higher-risk characteristic and those with the reference characteristic. Exponentiation of b, thus, provides an estimate of the relative odds (or relative hazard) associated with that characteristic. In the case of postneonatal mortality, the estimated relative

[11] Children born within two years of the survey are censored before reaching their second birthday (i.e., before completing the 1-23 month period of observation). Hazards regression includes the survival experience of censored cases up to their age at censoring.

[12] In the case of breastfeeding, essentially two down-weighted observations are created that represent one child's experience before and after complete weaning. For instance, if a child stopped breastfeeding at 9 exact months of age and died (or was censored alive) at 18 months, two half-weighted 9-month "exposure cells" are created that indicate breastfeeding and survival to 9 months and non-breastfeeding and survival through the next 8 months and then death (or censoring) in the last month of observation.

hazard can be viewed as a scalar which raises or lowers (depending on the sign of b) the underlying hazard uniformly (or proportionately) throughout the age range 1 to 23 months.[13]

Model Estimation and Inference

Since our primary interest is to estimate effects of introducing the intermediate variables on the relationship between mother's education and child health endpoints, we do not attempt to identify the most parsimonious model that fits the data. Rather, we follow the change in the coefficients for education, related to the addition of key intermediate variables, to draw inference on intervening mechanisms. The process of model estimation is thus related to the causal/temporal ordering of factors implied in the analytical framework (Figure 1) and represented in the generalized sequence of equations:

Equation 1 $\quad \text{logit } q_1 = b_0 + b_1X_1,$

Equation 2 $\quad \text{logit } q_{1,2} = b_0 + b_1X_1 + b_2X_2,$

Equation 3 $\quad \text{logit } q_{1,2,3} = b_0 + b_1X_1 + b_2X_2 + b_3X_3,$

.
.
.

Equation k $\quad \text{logit } q_{1,2,3,k} = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + \dots b_kX_k,$

where equation 1 includes only household socioeconomic factors (including maternal education); equations 2 and 3 add proximate determinants other than health service utilization (e.g., family formation variables, breastfeeding, exposure variables); and equation k adds the indicator of health service utilization. The importance of individual elements of the model is assessed by a change in the model log-likelihood associated with the addition of that variable(s):

$$-2\,(MLL_k - MLL_{k-1}) \qquad X^2 \text{ (\# degrees of freedom)}$$

For instance, the change in the log-likelihood upon adding the utilization index (3 dummy variables for 4 levels of use), when compared against a X^2 distribution (with 3 degrees of freedom) indicates the probability of observing the parameter estimates under the null hypothesis that $b = 0$.

Small size at birth is employed as a control variable in morbidity and mortality models and is entered into

[13] While the proportionality assumption is never fully satisfied with real data, sharp departures or changes in the direction of covariate effects with increasing age will tend to mask or attenuate true effects. Checks on proportionality of hazards across the age range 1-23 months were accomplished by inspecting covariate level-specific survival curves and plots of ln(-ln(s(t))) versus ln(t), where s(t) equals the survival function at age t. In no case were time(age)-varying effects large enough to alter the substantive conclusions drawn from our estimated models of postneonatal mortality.

the system of equations immediately after the socioeconomic factors. This approach facilitates the interpretation of findings by helping to separate in-utero effects from postnatal effects. Sex of child and the occurrence of multiple births are also included as controls in all regressions.

Results Using Data from the Bolivia DHS Survey

Maternal Education and Health Services Utilization

The presentation of parameter estimates of the relationship between education and health services use focuses on the dependent measure, UTIL.[14] In this analysis, categories of UTIL representing low and very low use are collapsed to form the one dichotomous variable (HSERV), where HSERV = 1 for low use and HSERV = 0 for greater use. These logistic regressions included a control for age of the child at the time of the survey.

Results for the urban and rural models were similar, very pronounced and dose-specific effects of low maternal education on low-use of health services (see Table 2). The odds of low-use among children of uneducated women were 17 times (urban) and 18 times (rural) greater than for children of women with at least 6 years of education.[15]

Maternal Education, Health Services Utilization, and Child Survival

Neonatal Period. The results concerning neonatal risk (see Table 3) are markedly different for urban versus rural subsamples. In the rural setting, education is strongly related to neonatal survival but only if the mother has at least 6 years of education. Children of women with less than 6 years of education are about three times more likely to die than children of women with at least 6 years of education. Addition of more proximate variables (many of which are significant determinants in their own right) does not appreciably change the education coefficient. In particular, the maternity health services utilization index (MATER) does not appear to mediate the relationship between education and neonatal mortality.

In the urban setting, a small (marginally significant) effect of education on neonatal mortality is completely erased upon introduction of proximate determinants, especially MATER. Evidence that health services use

[14] Parameter estimates obtained using MATER (maternity health services utilization index) as the dependent variable are similar (see Appendix 1) to those presented in Table 2.

[15] The conversion of a ratio of odds to a ratio of risks or probabilities is a one to one affair only when the dependent measure is relatively rare. In this case, where "low-use" is quite common, especially in the rural setting, the odds ratio metric substantially overestimates the risk ratio. For this reason, the observed changes in the education coefficients upon introduction of the family formation variables should not be over-interpreted as they represent quite small changes in the relative probabilities of low-use.

TABLE 2

Relative odds of LOW health services use associated with explanatory variables. Urban and Rural Models.

URBAN MODEL - 29% very low or low use among 3050 children

Variable	Category	Eq 1	Eq 2
EDUCATION	None	17.99 ***	17.20 ***
	1-5 years	5.73 ***	5.35 ***
ECONOMIC CLASS	Low	1.90 ***	1.85 ***
AGE OF MOTHER	< 20 years		1.99 ***
	>= 35 years		0.69 ***
BIRTH INTERVAL	< 24 months		1.22 *
BIRTH ORDER	First		0.53 ***
	6 and over		1.49 ***
Change in model chi-square		636.7	50.7
p-value		0.000	0.000

RURAL MODEL - 71% very low or low use among 2687 children

Variable	Category	Eq 1	Eq 2
EDUCATION	None	16.49 ***	18.52 ***
	1-5 years	4.79 ***	4.96 ***
ECONOMIC CLASS	Low	3.18 ***	3.22 ***
AGE OF MOTHER	< 20 years		1.14
	>= 35 years		0.79
BIRTH INTERVAL	< 24 months		1.30 **
BIRTH ORDER	First		1.01
	6 and over		1.01
Change in model chi-square		434.7	10.3
p-value		0.000	0.068

* p < .10; ** p < .05; *** p < .01.
- Health service use is considered "low" for the two lowest levels of use on a four level scale (see text).
- All models control for twin status and age of the child at survey.
- Initial model -2 log-likelihood: Urban = 3677.5, Rural = 3132.5

TABLE 3

Relative odds of neonatal mortality associated with explanatory variables. Urban and Rural Models. Results of logistic regression.

URBAN MODEL - 77 neonatal deaths of 3037 live births

		Gross	Eq 1	Eq 2	Eq 3	Eq 4
EDUCATION	None	1.84 *	1.69	1.54	1.35	0.93
	1-5 years	1.42	1.38	1.30	1.17	0.89
ECONOMIC CLASS	Low		1.73	1.85	1.81	1.69
SIZE AT BIRTH	Very small			3.46 ***	3.47 ***	3.34 ***
AGE OF MOTHER	< 20 years				1.54	1.37
	>= 35 years				1.03	1.09
BIRTH INTERVAL	< 24 months				1.81 **	1.78 **
BIRTH ORDER	First				0.86	0.98
	6 and over				1.55	1.50
MATERNITY SERVICES	None					2.18 **
	Medium					2.18 **
Change in model chi-square			2.3	17.2	9.4	8.2
P-value			0.13	0.000	0.09	0.02

RURAL MODEL - 103 neonatal deaths of 2676 live births

		Gross	Eq 1	Eq 2	Eq 3	Eq 4
EDUCATION	None	3.23***	3.12 ***	3.02 **	3.67 ***	3.29 ***
	1-5 years	2.78**	2.71 **	2.70 **	2.84 **	2.62 **
ECONOMIC CLASS	Low		1.71	1.51	1.60	1.51
SIZE AT BIRTH	Very small			4.40 ***	4.10 ***	4.05 ***
AGE OF MOTHER	< 20 years				1.17	1.17
	>= 35 years				.65	.66
BIRTH INTERVAL	< 24 months				2.12 ***	2.11 ***
BIRTH ORDER	First				1.57	1.59
	6 and over				1.14	1.14
MATERNITY SERVICES	None					1.29
	Medium					1.02
Change in model chi-square			0.3	32.1	15.3	1.0
P-value			0.33	0.000	0.009	0.61

* p < .10; ** p < .05; *** p < .01.
- All models control for twin and sex (except gross effect model).
- Initial -2 log-likelihoods: URBAN = 707.7, RURAL = 877.1.

is mediating the relationship between education and neonatal survival is thus lacking altogether in the rural model, and suggestive but not compelling in the urban model. The fact that there exists a smaller gross effect of education on neonatal survival in the urban areas of Bolivia than in the rural areas may indicate that broader physical access to services in towns tends to render personal assets less important in determining real access and use.

Postneonatal Period. Table 4 gives the results for the postneonatal period. Recall that these models differ from those for the neonatal period in three respects. First, breastfeeding status and the exposure to disease indices are introduced into the system of equations before the utilization index. Second, sensitivity of the utilization index (now, UTIL) is enhanced with the use of two additional variables, knowledge of modern contraception and knowledge of oral rehydration therapy. Third, a Cox hazards regression is used to estimate covariate effects.

Like neonatal mortality, postneonatal mortality in urban areas is not very sensitive to variations in mother's education. In contrast to the neonatal period and contrary to common logic, it is among children of women with 1-5 years of education that postneonatal mortality is highest. An explanation involving selective underreporting of deaths among uneducated women appears untenable given the pattern of results for the neonatal period, a period during which underreporting would seem most likely. Health services use appears to play a role in mediating the effect of maternal education on postneonatal mortality.

Interpreting the results from the rural postneonatal model is considerably less straightforward. As with the neonatal period, survival during the postneonatal period is more sensitive to the effects of maternal education in the rural setting than in the urban setting. Yet, some interesting and contrasting patterns of effect mediation emerge within the system of equations. The results of the hazard regressions indicate that both risk-lowering and risk-elevating behaviors are associated with higher maternal education. In equations 3 and 4, inclusion of breastfeeding and family formation pattern variables result in amplification of the education effect. This is because rural women with more education tend to adopt riskier patterns of breastfeeding and family formation than do less educated women (i.e., "too early" weaning and shorter birth intervals). In equations 5 and 6, inclusion of household exposure and health services use variables causes the education coefficient (exponentiated) to move towards the null value of 1. Less education, as expected, is associated with higher risk exposure conditions and lower health services use. Much of the gross education effect remains, however, unexplained.

To this point we have shown that (1) mother's education is strongly related to use of modern health services in both urban and rural milieux, (2) mother's education is more strongly associated with both neonatal and postneonatal survival in the **rural** than in the urban setting, (3) health services use in large part explains the weak relationship between education and mortality in urban areas during both the neonatal and

TABLE 4

Relative hazards of mortality between 1 and 23 months of age associated with explanatory variables. URBAN and RURAL models. Results of Cox hazards regressions.

URBAN MODEL - 156 deaths among 2955 survivors of neonatal period

		Gross	Eq 1	Eq 2	Eq 3	Eq 4	Eq 5	Eq 6
EDUCATION	None	1.52	1.44	1.41	1.36	1.42	1.27	0.92
	1-5 years	1.81***	1.77 ***	1.76 ***	1.68 ***	1.75 ***	1.66 ***	1.41 *
ECONOMIC CLASS	Low		1.33	1.34	1.37	1.42	1.34	1.27
SIZE AT BIRTH	Very small			1.34	1.30	1.26	1.30	1.28
AGE OF MOTHER	< 20 years				1.10	1.10	1.07	1.03
	>= 35 years				0.61 *	0.60 *	0.59 *	0.61 *
BIRTH INTERVAL	< 24 months				2.45 ***	2.39 ***	2.45 ***	2.38 ***
BIRTH ORDER	First				1.28	1.24	1.25	1.28
	6 and over				1.61 **	1.61 **	1.60 **	1.56 **
BREASTFEEDING	Not at start of interval at risk					1.49 *	1.59 **	1.63 **
WATER SUPPLY	Not piped						1.08	1.02
SANITATION	No facilities						1.39 *	1.29
UTIL	Very low							2.38 **
	Low							1.62 **
	Medium							0.89
Change in Model Chi-square			13.10	1.31	30.83	3.35	15.02	10.79
P-value			0.004	0.236	0.000	0.063	0.002	0.013

RURAL MODEL - 170 deaths among 2566 survivors of the neonatal period

		Gross	Eq 1	Eq 2	Eq 3	Eq 4	Eq 5	Eq 6
EDUCATION	None	1.93 **	1.93 **	2.05 **	2.24 **	2.58 **	2.19 **	1.78 *
	1-5 years	1.81 **	1.78 **	1.86 **	1.87 **	2.09 **	1.88 **	1.58
ECONOMIC CLASS	Low		1.23	1.21	1.27	1.28	1.28	1.15
SIZE AT BIRTH	Very small			1.42	1.33	1.27	1.30	1.31
AGE OF MOTHER	< 20 years				1.24	1.25	1.20	1.29
	>= 35 years				1.05	1.06	1.13	1.10
BIRTH INTERVAL	< 24 months				2.51 ***	2.47 ***	2.49 ***	2.43 ***
BIRTH ORDER	First				1.15	1.13	1.10	1.13
	6 and over				0.84	.83	.85	.83
BREASTFEEDING	Not at start of interval at risk					2.70 ***	2.77 ***	2.99 ***
WATER SUPPLY	Not piped						1.29	1.24
SANITATION	No facilities						1.25	1.19
UTIL	Very low							1.84 *
	Low							2.10 **
	Medium							1.54
Change in Model Chi-Square			6.90	1.72	30.93	15.91	5.7	5.5
P-value		0.075	0.170	0.000	0.128	0.128	0.139	

* p < .10; ** p < .05; *** p < .01, Initial -2 log-likelihood: URBAN = -1204.7, RURAL = -1299.9
- all models control for twin status and sex of the child.

postneonatal periods, but appears to only partially mediate the effect in the rural setting during the postneonatal period and not at all during the neonatal period and (4) in the rural milieu, both postneonatal risk-lowering and risk-elevating behaviors are associated with maternal education.

Maternal Education, Health Services Utilization, and Stunting

The following is an examination of the effects of maternal education and health services use on stunting among children aged 3 to 23 months at the time of the survey. A child is considered **stunted** if the height-for-age index is two or more standard deviations below the median for the NCHS/WHO reference population. Stunting is thought to reflect chronic malnutrition and repeated bouts with infectious disease. The age of the child at the time of the survey is used as a control in all baseline models.

A finding common to both urban and rural Bolivia is that children of more educated women are much less likely than children of less educated women to suffer stunted growth (see Table 5). In the rural setting, these effects appear to be more pronounced than in the towns and the substantial education effect can only in part be explained by intermediate variables, UTIL in particular. The education effect in urban Bolivia on the other hand, while somewhat weaker than in the rural areas, is almost completely explained by the proximate determinants. The results indicate that variables reflecting household exposure to disease account for a large portion of the effect, while use of health services accounts for much of the remainder.

In sum, the results show that children of less educated women suffer much more commonly from stunting (in both urban and rural areas) than children of educated women. The education effect can be traced in the urban setting in part through health services use, but more importantly through factors reflecting household exposure to disease. In the rural milieu, where an even stronger education effect was observed, less than half of the effect can be traced to proximate determinants--health services use being the most important mediating factor.

It was previously suggested that omission of dead children from analysis of the determinants of stunting may introduce bias related to selectivity. Appendix 2 shows the results of the stunting models for all children (including dead children) in the cohort born 3-23 months before the survey, and under the extreme assumption that all of the dead children would have been stunted at the time of the survey, had they survived. Although the education effects on stunting appear to be slightly greater in the rural model and slightly less in the urban model (compare with Table 5), no changes in the level or pattern of estimates has occurred that would suggest that serious biases are operative.

TABLE 5

Relative odds of stunting (<-2 SD) at ages 3-23 months associated with explanatory variables. Urban and rural models. Results of logistic regression.

URBAN MODEL - 217 of 915 children stunted

		Gross	Eq 1	Eq 2	Eq 3	Eq 4	Eq 5
EDUCATION	None	2.77***	2.49 ***	2.43 ***	2.15 **	1.37	1.02
	1-5 years	2.35***	2.21 ***	2.20 ***	2.05 ***	1.63 **	1.36
ECONOMIC CLASS	Low		1.96 **	1.99 ***	1.92 **	1.67 *	1.59
SIZE AT BIRTH	Very small			1.64 *	1.70 **	1.81 **	1.83 **
AGE OF MOTHER	< 20 years				0.83	0.78	0.76
	>= 35 years				0.64	0.68	0.70
BIRTH INTERVAL	< 24 months				1.23	1.31	1.34
BIRTH ORDER	First				0.89	0.91	0.94
	6 and over				1.72 **	1.66 **	1.65 **
WATER SUPPLY	Not piped					1.19	1.14
SANITATION	No facilities					2.51 ***	2.35 ***
UTIL	Very low						2.10 *
	Low						1.56 *
	Medium						1.88 **
Change in model chi-square			7.2	3.4	9.2	27.4	8.1
P-value			0.007	0.06	0.10	0.000	0.04

RURAL MODEL - 294 of 799 children stunted

		Gross	Eq 1	Eq 2	Eq 3	Eq 4	Eq 5
EDUCATION	None	2.95***	2.93 ***	3.00 ***	3.24 ***	2.81 ***	2.12 **
	1-5 years	1.64**	1.64 *	1.69 **	1.76 **	1.62 *	1.36
ECONOMIC CLASS	Low		1.12	1.12	1.08	1.08	1.00
SIZE AT BIRTH	Very small			1.58	1.49	1.62	1.59
AGE OF MOTHER	< 20 years				0.95	0.99	1.00
	>= 35 years				1.06	0.99	0.99
BIRTH INTERVAL	< 24 months				1.56 **	1.58 **	1.57 **
BIRTH ORDER	First				1.45	1.44	1.43
	6 and over				1.12	1.20	1.27
WATER SUPPLY	Not piped					0.74	0.73
SANITATION	No facilities					1.82 ***	1.71 **
UTIL	Very low						2.81 ***
	Low						1.69 **
	Medium						2.47 ***
Change in model chi-square			0.1	2.5	5.8	9.0	14.4
P-value			0.74	0.12	0.32	0.01	0.002

* p < .10; ** p < .05; *** p < .01 ;
- Initial -2 Log Likelihood: URBAN = 883.5, RURAL = 951.8
- All models control for twins, sex and age of the child at survey date

Maternal Education, Health Services Utilization, and Symptoms of Illness

In reviewing the findings related to determinants of disease prevalence, it should be borne in mind that the accuracy and precision of the dependent measures (on which the validity of these findings hinge) may well vary according to the individual characteristics of survey respondents (e.g., Boerma et al., 1990). While this caveat may also apply to the measurement of mortality and health services use, morbidity measures are particularly sensitive to language ambiguities and subjective interpretations by respondents.

Diarrhea in the Last Two Weeks. The results shown in Table 6 indicate that maternal education is weakly related to diarrhea prevalence (last 2 weeks, children 1-23 months at the time of the survey) in urban areas, while in the rural areas virtually no education effect was observed. In the urban setting, children of women with 1 to 5 years of education were found to be at higher risk of diarrheal illness than those of uneducated women. This may be (1) an actual effect, perhaps related to longer breastfeeding among uneducated mothers, (2) a reflection of greater underreporting (or less recognition) of diarrhea by uneducated mothers, or (3) simply a result of sampling error. In any case, the small education effect is not appreciably affected by entry of any of the proximate determinants, including the index of health services use, UTIL.

Symptoms of Respiratory Illness. Findings regarding symptoms associated with respiratory illness (cough with rapid/difficult breathing in last 2 weeks among children aged 1-23 months) are very similar to those for diarrheal disease (see Table 7). Respiratory disease among rural children is not significantly related to maternal education. In the urban setting, we found higher risk of respiratory illness among children of relatively less educated women, especially those with 1-5 years of education. No mediating effects of the proximate determinants were observed. The lack of an effect among children of uneducated women may be interpreted similarly to the identical pattern observed for diarrheal prevalence, except that the breastfeeding explanation seems less tenable.

In sum, the estimated effect of maternal education on childhood morbidity (1-23 months) in the urban areas of Bolivia roughly parallels in magnitude the effect of education on postneonatal mortality (1-23 months)–a 30 to 80 percent increased odds (or hazards) of poor outcome associated with education levels below 6 years. In contrast, children of better educated women in the rural areas of Bolivia, while experiencing substantially lower risk of postneonatal death, appear to be sick as frequently as children of less educated women.

Discussion

Table 8 summarizes the effects of maternal education on the various health endpoints examined in this study. The estimated odds ratios (or ratio of hazards) are presented for three models: (1) the basic model

TABLE 6

Relative odds of diarrhea(last 2 weeks) at ages 1-23 months associated with explanatory variables. Urban and rural models. Results of logistic regression.

URBAN MODEL - 449 diarrhea cases among 1137 children

		Gross	Eq 1	Eq 2	Eq 3	Eq 4	Eq 5
EDUCATION	None	1.47*	1.36	1.36	1.30	1.31	1.39
	1-5 years	1.76***	1.69 ***	1.69 ***	1.63 ***	1.63 ***	1.63 ***
ECONOMIC CLASS	Low		1.57 **	1.56 **	1.53 **	1.54 **	1.55 **
SIZE AT BIRTH	Very small			.95	.99 **	.98	.98
AGE OF MOTHER	< 20 years				1.25	1.24	1.20
	>= 35 years				.68 *	.68 *	.68 *
BIRTH INTERVAL	< 24 months				.95	.96	.97
BIRTH ORDER	First				.56 ***	.56 ***	.59 ***
	6 and over				1.14	1.13	1.09
WATER SUPPLY	Not piped					1.07	1.06
SANITATION	No facilities					.96	.98
UTIL	Very low						.62
	Low						1.13
	Medium						1.06
Change in model chi-square			6.8	.05	13.6	0.3	3.2
P-value			0.009	0.82	0.02	0.87	0.35

RURAL MODEL - 404 diarrhea cases among 978 children

		Gross	Eq 1	Eq 2	Eq 3	Eq 4	Eq 5
EDUCATION	None	1.04	1.02	1.02	1.10	1.14	1.17
	1-5 years	.96	.95	.96	.97	1.00	.99
ECONOMIC CLASS	Low		1.26	1.26	1.27	1.28	1.30
SIZE AT BIRTH	Very small			1.08	1.06	1.07	1.09
AGE OF MOTHER	< 20 years				0.94	0.94	.94
	>= 35 years				.75	0.75	.75
BIRTH INTERVAL	< 24 months				1.02	1.01	1.02
BIRTH ORDER	First				1.34	1.34	1.37
	6 and over				1.25	1.25	1.23
WATER SUPPLY	Not piped					.93	.93
SANITATION	No facilities					.96	.98
UTIL	Very low						.95
	Low						1.07
	Medium						1.21
Change in model chi-square			0.6	.1	4.1	0.3	1.1
P-value			0.42	0.76	0.53	0.88	0.79

* p < .10; ** p < .05; *** p < .01 ;
- Initial -2 Log Likelihood: URBAN = 1483.8, RURAL = 1310.8.
- All models control for twins, sex and age of the child at survey.

TABLE 7

Relative odds of respiratory illness (cough with rapid/difficult breathing in last 2 weeks) at ages 1-23 months associated with explanatory variables. Urban and rural models. Results of logistic regression.

URBAN MODEL - 336 cases among 1163 children

		Gross	Eq 1	Eq 2	Eq 3	Eq 4	Eq 5
EDUCATION	None	1.18	1.16	1.14	1.14	1.34	1.43
	1-5 years	1.59***	1.58 ***	1.59 ***	1.55 ***	1.66 ***	1.70 ***
ECONOMIC CLASS	Low		1.08	1.10	1.09	1.16	1.17 **
SIZE AT BIRTH	Very small			1.39	1.43 *	1.38	1.37
AGE OF MOTHER	< 20 years				1.32	1.30	1.30
	>= 35 years				.92	.89	.89
BIRTH INTERVAL	< 24 months				1.05	1.03	1.03
BIRTH ORDER	First				.64 **	.64 **	.64 **
	6 and over				.91	.91	.91
WATER SUPPLY	Not piped					1.12	1.13
SANITATION	No facilities					.66 ***	.67 ***
UTIL	Very low						.78
	Low						.94
	Medium						.99
Change in model chi-square			0.2	2.4	6.6	7.7	.5
p-value			0.64	0.12	0.25	0.02	0.93

RURAL MODEL - 285 cases among 1010 children

		Gross	Eq 1	Eq 2	Eq 3	Eq 4	Eq 5
EDUCATION	None	1.01	1.05	1.05	.99	1.09	1.26
	1-5 years	1.19	1.22	1.24	1.15	1.23	1.29
ECONOMIC CLASS	Low		.61 *	.61 *	.60 *	.61 *	.66 *
SIZE AT BIRTH	Very small			1.39	1.36	1.35	1.41
AGE OF MOTHER	< 20 years				1.31	1.29	1.31
	>= 35 years				.55 ***	0.56 ***	.56 ***
BIRTH INTERVAL	< 24 months				.98	.96	.97
BIRTH ORDER	First				.77	.78	.80
	6 and over				1.90 ***	1.87 ***	1.82 ***
WATER SUPPLY	Not piped					.99	1.01
SANITATION	No facilities					.82	.86
UTIL	Very low						.68
	Low						.89
	Medium						1.22
Change in model chi-square			2.7	1.6	14.9	1.3	4.5
p-value			0.10	0.21	0.01	0.51	0.22

* p < .10; ** p < .05; *** p < .01 ;
- Initial -2 Log Likelihood: URBAN = 1385.1 RURAL = 1197.1.
- All models control for twins, sex and age of the child at survey

TABLE 8

Summary of the effects of maternal education on child morbidity and mortality. Relative odds (or relative hazards) associated with level of maternal education. Reference category is 6 or more years of education.

	Urban		Rural	
	No education	1-5 yrs	No education	1-5 yrs
NEONATAL MORTALITY				
Basic model (1)	1.69	1.38	3.12 ***	2.71 **
Intermediate variables (2)	1.35	1.17	3.67 ***	2.84 **
Health services utilization (3)	.93	.89	3.29 ***	2.62 **
POSTNEONATAL MORTALITY (ages 1-23 mos.)				
Basic model	1.44	1.77 ***	1.93 **	1.78 **
Intermediate variables	1.27	1.66 ***	2.19 **	1.88 **
Health services utilization	.92	1.41 *	1.78 *	1.58
STUNTING (ages 3-23 mos.)				
Basic model	2.49 ***	2.21 ***	2.93 ***	1.64 *
Intermediate variables	1.37	1.63 **	2.81 ***	1.62 *
Health services utilization	1.02	1.36	2.12 **	1.36
DIARRHEA (ages 1-23 mos.)				
Basic model	1.36	1.69 ***	1.02	.95
Intermediate variables	1.31	1.63 ***	1.14	1.00
Health services utilization	1.39	1.63 ***	1.17	.99
RESPIRATORY ILLNESS (ages 1-23 mos.)				
Basic model	1.16	1.58 ***	1.05	1.22
Intermediate variables	1.34	1.66 ***	1.09	1.23
Health services utilization	1.43	1.70 ***	1.26	1.29

(1) Basic model includes controls for economic status, sex and twin status.
(2) Intermediate variables model includes basic model variables, size at birth, and all intermediate (proximate) variables, except the health services utilization index.
(3) As (2) but including the health services utilization index.

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

with education and economic status (controlling for twinning and sex), (2) the model with all intermediate variables except the index of health services utilization (UTIL or MATER) and (3) the model with all intermediate variables including UTIL or MATER.

Rural Areas

The findings of this illustrative analysis indicate that in the rural areas of Bolivia, children of more educated mothers are at a decided advantage in terms of survival prospects and in terms of linear growth (height-for-age), but are no less frequently ill than children of less educated mothers. The education advantage is particularly important during the neonatal period, but extends through the postneonatal period as well.

The intermediate variable that reflects use of modern health services appears to have only a small role in mediating the effect of education on postneonatal survival and has no role at all during the neonatal period. The results of the rural stunting model were very similar to the results of the postneonatal mortality model. Taken together, these findings suggest that **unmeasured** education-conditioned health behaviors surrounding the time of illnesses–including direct curative action (or non-action), and perhaps also patterns of feeding during and following illness–may play the dominant role in effecting the relationship between education and postneonatal mortality in the rural milieu. A hypothesis consistent with these findings is that formal education among rural women in Bolivia has resulted in decreasing use of certain traditional and harmful treatment practices (e.g., withholding fluids during diarrhea). Shorter breastfeeding among more educated women, on the other hand, tends to attenuate the education advantage.

Less can be said about the neonatal period: there appear to exist various **unmeasured** behaviors related to higher educational level (i.e., other than greater use of antenatal and delivery services) that greatly improve the chances of early childhood survival.

Urban Areas

Looking at the results for the urban population, very different conclusions emerge. First, maternal education has a much weaker influence on child survival during the first two years than was observed in the rural setting. It was suggested that this may be related to less variation among urban women with respect to real access to health services or, similarly, with respect to physical access to services not constrained by individual characteristics.

Differences in disease prevalence related to educational level were shown to be of roughly the same magnitude as education-related differences in postneonatal survival. One interpretation of this finding is that behaviors related to disease prevention may be predominantly operative in effecting the education advantage in urban centers. That a large part of the gross education effect on postneonatal survival (1-23 months) and chronic undernutrition (3-23 months) is explained by differences in the use of health services and household exposure to disease, lends further support to the hypothesis that modern health behaviors related to disease prevention and, perhaps, better weaning diet, are key in affording the children of more educated women a better chance at survival.

A more specific interpretation can be made concerning the effect of maternal education on neonatal survival. The pattern of results suggests that, in urban centers, education-related differences in survival can be explained in large part by differences in the use of modern medical services--namely, antenatal and delivery services.

Prospectus

This analysis will be extended to data from several DHS surveys conducted between 1986 and 1989. Certain features of the analytical framework, as described here, may require modification due to variations across countries in the availability of data related to particular elements of the framework. For example, more detailed information on economic status of the household is available in most of the other DHS surveys but in some surveys data on respiratory illness are not available. The analytical framework and methods of the study will, however, remain essentially intact. Because of sample size limitations, we may choose to pool data from the same geographic region (e.g., Mali and Senegal).

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APPENDIX 1

Relative odds of low health services use (see below for definition of "low") associated with explanatory variables. Urban and Rural Models. Results of logistic regressions.

URBAN MODEL - 25% low use among 3050 children

Variable	Category	Eq 1	Eq 2
EDUCATION	None	13.33 ***	12.86 ***
	1-5 years	5.49 ***	5.14 ***
ECONOMIC CLASS	Low	2.17 ***	2.12 ***
AGE OF MOTHER	< 20 years		1.95 ***
	>= 35 years		0.66 ***
BIRTH INTERVAL	< 24 months		1.26 **
BIRTH ORDER	First		0.49 ***
	6 and over		1.42 ***
Change in model chi-square		532.4	52.6
p-value		0.000	0.000

RURAL MODEL - 65% low use among 2687 children

Variable	Category	Eq 1	Eq 2
EDUCATION	None	10.83 ***	11.00 ***
	1-5 years	3.94 ***	3.87 ***
ECONOMIC CLASS	Low	3.31 ***	3.35 ***
AGE OF MOTHER	< 20 years		1.17
	>= 35 years		0.78 *
BIRTH INTERVAL	< 24 months		1.17
BIRTH ORDER	First		0.83
	6 and over		1.16
Change in model chi-square		371.8	9.4
p-value		0.000	0.093

* p < .05; ** p < .01; *** p < .001.
- Health service use is considered "low" when neither prenatal nor delivery services were used by the mother. This is equivalent to a score of 0 for the variable MATER.
- All models control for twin status and age of the child at survey.
- Initial model -2 log-likelihood: Urban = 3423.4, Rural = 3458.5

APPENDIX 2

Relative odds of stunting at ages 3-23 months OR death by survey date associated with explanatory variables. Urban and rural models. Results of logistic regressions.

URBAN MODEL - 307 stunted or dead of 1005 children born 3-23 before survey

		Eq 1	Eq 2	Eq 3	Eq 4	Eq 5
EDUCATION	None	2.22 ***	2.18 ***	1.97 **	1.33	0.94
	1-5 years	2.11 ***	2.10 ***	1.92 ***	1.60 ***	1.29
ECONOMIC CLASS	Low	1.92 ***	1.94 ***	1.90 ***	1.66 **	1.61 **
SIZE AT BIRTH	Very small		1.74 **	1.86 ***	2.04 ***	2.02 ***
AGE OF MOTHER	< 20 years			1.12	1.08	1.06
	>= 35 years			0.65	0.70	0.71
BIRTH INTERVAL	< 24 months			1.54 **	1.64 ***	1.62 ***
BIRTH ORDER	First			0.77	0.80	0.83
	6 and over			1.82 ***	1.71 ***	1.75 ***
WATER SUPPLY	Not piped				1.17	1.10
SANITATION	No facilities				2.29 ***	2.17 ***
UTIL	Very low					2.33 **
	Low					1.73 ***
	Medium					1.64 **
Change in model chi-square		9.2	5.5	19.9	29.0	10.8
P-value		0.002	0.019	0.001	0.000	0.013

RURAL MODEL - 372 stunted or dead of 877 children born 3-23 before survey

		Eq 1	Eq 2	Eq 3	Eq 4	Eq 5
EDUCATION	None	2.90 ***	2.97 ***	3.38 ***	2.82 ***	2.12 ***
	1-5 years	1.80 ***	1.81 ***	2.01 ***	1.81 ***	1.53 *
ECONOMIC CLASS	Low	0.99	0.96	0.96	0.94	0.88
SIZE AT BIRTH	Very small		1.91 **	1.78 **	1.92 **	1.86 **
AGE OF MOTHER	< 20 years			0.91	0.95	0.95
	>= 35 years			1.08	1.09	1.11
BIRTH INTERVAL	< 24 months			1.84 ***	1.87 ***	1.86 ***
BIRTH ORDER	First			1.66 **	1.61 *	1.61 *
	6 and over			1.00	1.07	1.13
WATER SUPPLY	Not piped				0.81	0.78
SANITATION	No facilities				1.93 ***	1.80 ***
UTIL	Very low					2.64 ***
	Low					1.60 **
	Medium					2.13 ***
Change in model chi-square		.0	6.4	12.9	11.5	14.1
P-value		0.98	0.01	0.024	0.03	0.003

* p < .10; ** p < .05; *** p < .01.
- Initial -2 Log-likelihood, URBAN = 912.7, RURAL = 958.2
- All models control for twins and age of the child at survey.