Health Interventions and Health Equity: The Example of Measles Vaccination in Bangladesh

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DESPITE REMARKABLE IMPROVEMENTS in health and life expectancy in all countries over the last half-century, significant within-country differentials in health status and survival persist. As a consequence, the issue of health inequity, defined as "inequalities in health status, risk factors, or health service utilization between individuals or groups, that are unnecessary, avoidable, and unfair" (World Health Organization 1998: 4), has emerged as a major policy and programmatic concern in the health field over the last decade.

This article explores the potential direct role of health interventions in contributing to greater health equity. Using longitudinal data from the study area of the ICDDR,B: Centre for Health and Population Research, in rural Bangladesh, we examine the impact of a measles vaccination program—an intervention that has been shown to be highly efficacious in improving child survival—on gender and socioeconomic differentials in childhood mortality.

Inequities in child survival in developing countries

Some of the most pronounced health inequities in developing countries have been documented with respect to differential mortality levels during infancy and early childhood. Socioeconomic differentials in infant and child mortality have been consistently demonstrated in studies over the last two decades (Caldwell 1979; Cochrane, Leslie, and O'Hara 1982; Rutstein 1984; Cleland and van Ginneken 1988; Bicego and Boerma 1993). A recent analysis of 20 Demographic and Health Surveys from developing countries, for example, found that mortality risks for children under age five years born to uneducated mothers were on average more than twice as high as risks to children born to mothers with a secondary school education, with this differential most pronounced among children aged 1–4 years (Bicego and Ahmad 1996). Significant differences in childhood mortality risks have been reported for other indicators of family socioeconomic status as well (Bicego and Ahmad 1996; Rutstein 1984). Excess female mortality during early childhood has also been extensively documented, both in terms of absolute differentials in South Asia and selected Middle Eastern countries (D'Souza and Chen 1980; Koenig and D'Souza 1986; Das Gupta 1987; Bicego and Ahmad 1996), and in relative terms, in light of the historical survival advantage of females, in a larger number of developing countries (Hill and Upchurch 1995).

Considerable debate continues over the most effective and cost-effective approaches to reducing inequities in health. Proposed strategies for achieving greater equity include both indirect and direct measures. Prominent among indirect measures are macroeconomic policies—such as progressive taxation and economic growth with income redistribution—and investments in human development—most notably, universal free primary education, increased female education and labor force participation, and improvements in transportation and housing infrastructure (Mills 1998). Among direct measures, health policies and programs such as mandatory child immunization, dietary fortification, parasite/vector control, and enforcement of sanitary practices have played a prominent role in promoting greater equity in health. A second type of direct approach focuses on the health sector itself, through measures such as more equitable health-sector resource allocation, improvement in the quality of health services that serve the poor, and the promotion of universal access to services. We focus here on the direct role of child immunization in contributing to greater equity in child survival.

Child survival interventions and health equity

A small but important body of evidence exists on the potential role of health interventions in reducing socioeconomic differentials in childhood mortality in developing countries. Rosero-Bixby (1985) presented survey evidence of a significant narrowing of socioeconomic differentials in infant mortality rates in Costa Rica from 1965 to 1979, a period that coincided with improvements in the range and coverage of targeted primary health care services in rural areas of the country.[1] Similarly, Cochrane, Leslie, and O'Hara (1982), in their cross-national study, found that as per capita health expenditures rose, maternal education differentials in childhood mortality levels narrowed.

Additional direct evidence comes from a study in Colombia by Rosenzweig and Schultz (1982), which considered household census data in conjunction with municipal-level health information to predict child mortality risks. The authors found that among their urban sample only, significant interaction effects were evident between maternal education and measures of health facility availability in predicting the risks of childhood mortality, indicating that children born to less-educated mothers benefited more from health programs in terms of reduced mortality risks.[2] A longitudinal cohort study from Matlab, Bangladesh similarly found a significant interaction effect between maternal education and residence in the health intervention area, served by an intensive health outreach program.[3] This finding indicates that the Matlab intervention program had a greater effect on the risks of child death for children of uneducated mothers than for children of mothers with at least some education (Muhuri 1995). In one of the few studies with contrary findings, Orubuloye and Caldwell (1975) reported that the presence of modern medical facilities appeared to widen disparities in child loss by maternal education, in their comparison of two Nigerian villages with and without health facilities.

Explanations for socioeconomic differences in the effects of health interventions

The noted effects of child survival interventions on reductions in socioeconomic disparities in childhood mortality can be explained as a consequence of three types of disparities: 1) differences in disease prevalence, 2) differences in personal illness control, and 3) differences in intervention efficacy.

Differences in disease prevalence

The methodological problems associated with assessments of self-reported morbidity are well recognized (Murray and Chen 1992). Such reservations notwithstanding, studies of differential morbidity generally suggest similar levels of disease exposure across socioeconomic groups (Boerma, Sommerfelt, and Rutstein 1991) and by gender (Chen, Huq, and D'Souza 1981).

Differences in personal illness control

Personal illness control refers to the accessibility and coverage of health interventions and individuals' motivation and demand to use these interventions (Mosley and Chen 1984). Socioeconomic differences in use of and access to health services have received considerable attention as a primary determinant of health equity (Peabody et al. 1999). Health interventions that improve access or reduce barriers to preventive and curative health services could be expected to disproportionately benefit economically less-well-off households and families, with consequent greater improvements in child survival.

Variation in use of child survival interventions, according to individual and familial socioeconomic status, has been documented in a wide range of studies. In their comprehensive review, Cleland and van Ginneken (1988) noted the strong positive association between maternal education and use of modern preventive health care, and the somewhat weaker association with curative health services.[4] The positive association between maternal education and use of preventive child and maternal health services is well documented with respect to antenatal care and both child and maternal tetanus immunization (Sommerfelt and Piani 1997; Streatfield, Singarimbun, and Diamond 1990; International Institute for Population Sciences and ORC Macro 2000; Bicego and Boerma 1993). Other studies have also found a positive relationship between maternal education and use of curative care facilities (Gage, Sommerfelt, and Piani 1996), including treatment for fever or respiratory problems (Boerma, Sommerfelt, and Rutstein 1991), as well as a propensity among educated mothers to take sick children for care earlier in the course of illness (Levine et al. 1991). An analysis of DHS data documented the relative disadvantage of female children in receiving treatment for acute respiratory infections (Hill and Upchurch 1995).[5] Studies from Bangladesh and India have also documented the relative disadvantage of female children with respect to health care provision, finding significant gender differences in rates of treatment for diarrhea (Chen, Huq, and D'Souza 1981; Rahaman et al. 1982) and acute respiratory infections (Pande 1999), the purchase of drugs from pharmacies (Hossain and Glass 1988), and immunization status (Bhuiya et al. 1995; Pande 1999).

Differences in intervention efficacy

Given equivalent access to services, it is possible that health interventions may differentially influence the survival prospects of children based on their prior health or nutritional status. A review of the literature underscores the significant shift in thinking that has taken place over the past two decades concerning the potential variability in intervention effects.

Initial work on the question of differential intervention efficacy, known as the "replacement mortality hypothesis," posited that socioeconomic and cultural factors were likely to attenuate the impact of preventive or curative health technologies on improvements in survival, placing more vulnerable children at continued elevated risk of death from other causes. Children "saved" from death by one intervention were thus likely to continue to be at high risk of morbidity and mortality from other causes, with the result that longer-term improvements in child survival associated with a specific intervention might be negligible (Kasongo Project Team 1981; Mosley 1985).

Subsequent refinement of the child survival framework introduced the concept of frailty, whereby a specific childhood morbidity may contribute to death not only directly, but indirectly as well, by producing more frail "survivors" who are at higher risk of dying from subsequent morbidity (Mosley and Becker 1991).[6] An implication of frailty, as the authors noted, is that certain preventive interventions—most notably, vitamin A therapy or measles vaccination, both of which prevent specific debilitating diseases—could be expected to result in significant demographic impact through improved survival of children. Resulting mortality reductions from these interventions might extend substantially beyond those expected from the direct effects of these conditions alone, through the indirect effects of these interventions in reducing frailty, thus preventing subsequent deaths from other causes. Subsequent simulation models that incorporated the concept of frailty illustrated the importance of this factor and correspondingly the importance of interventions that reduced frailty, both for diarrheal disease–related mortality (Black and Becker 1995) and for overall levels of mortality during early childhood (Becker and Black 1996).

A recognized limitation of this earlier work on models of frailty was its assumption of fixed frailty distributions across population subgroups (Mosley and Becker 1991). A more recent elaboration of the frailty model has explicitly recognized and introduced the concept of socioeconomic heterogeneity in frailty (and in intervention coverage). Model simulations that incorporated socioeconomic heterogeneity in frailty demonstrated mortality reductions that were significantly higher than produced by models in which frailty factors were assumed to be uniform across groups (DeBay 2000). In the only known study presenting individual-level empirical evidence on this issue, a measles vaccination study in Haiti found that vaccination had a pronounced effect on survival among socioeconomically less advantaged children,[7] but a negligible effect on mortality risks for socioeconomically more advantaged children (Holt et al. 1990).

Our interest here is to explore further the issue of differential intervention efficacy and its implications for health equity. We ask whether the most vulnerable children may actually benefit disproportionately from a child survival intervention in terms of improved survival prospects. Using longitudinal data from the Matlab study area in rural Bangladesh, we explore whether the Matlab measles vaccination program—an intervention that has been shown to be particularly efficacious in improving child survival—may have also influenced prevailing socioeconomic differentials in subsequent mortality risks. The specific question we address is whether more vulnerable children—within the context of rural Bangladesh, female children and children from poorer families—disproportionately experience improved survival following measles vaccination.

Setting and data

The data come from the Matlab study area of the International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B). Since 1966, the ICDDR,B has maintained a system of continuous surveillance of vital events in Matlab. The demographic data collected from this system are unique among developing countries, in terms of both the size of population under surveillance (now numbering more than 200,000 people) and the duration of surveillance, now almost three decades. The population of the Matlab area remains largely low income and agrarian, typical of much of rural Bangladesh. Subsistence agriculture, largely consisting of rice cultivation, and fishing remain the dominant sources of economic livelihood for a majority of the population. Landholdings remain small, with some indications that functional landlessness has increased for rural Bangladesh as a whole in recent decades (Cleland et al. 1994). Although there have been significant increases in education, especially among females, education levels remain very low; a 1990 survey in Matlab found that more than 60 percent of reproductive-aged women had received no formal schooling, and only 5 percent had completed eight or more years (Koenig et al. 1992).

In late 1977, an innovative family planning and maternal and child health services program was introduced by the ICDDR,B in half of the Matlab study area: the intervention area. The other half was retained as a comparison area, with the ICDDR,B maintaining demographic surveillance but offering only limited curative services for diarrheal disease; services were restricted to the more limited range provided by the government program. In the intervention area, additional health interventions have been phased in over time, including expanded immunization coverage, diarrheal disease management, nutrition intervention, vitamin A distribution, antenatal and maternity care, and management of acute respiratory infections (Koenig and Strong 1995). The quasi-experimental design of the Matlab program and the fact that interventions were added over time make it possible to assess the joint as well as individual effects of selected child survival interventions, including measles vaccination, on survival.

In March 1982, measles vaccination was offered to all children aged nine months and older in two of the four blocks of the Matlab intervention area, according to a pre-established design of phased introduction of this intervention (Phillips et al. 1984; Koenig and Strong 1995).[8] Measles immunization coverage rates rose rapidly to 60–70 percent of all children aged nine months to two years in these two blocks (Koenig et al. 1990). Measles vaccination was introduced in the remaining two intervention area blocks in late 1985. A detailed record-keeping system recorded on a fortnightly basis the vaccination status and dates for all children under age five years in the intervention area. Previous analysis showed that these two areas had almost identical levels of early child mortality in the period immediately preceding the introduction of measles vaccination (Koenig et al. 1990).

For the present study, all children aged 9–60 months in the initial two intervention blocks who received measles vaccination from March 1982 through October 1985 were eligible for inclusion. These children were randomly matched with unvaccinated children of similar age from the remaining two blocks of the intervention area who were born during the same month and year and who survived at least through the date of vaccination of their matched vaccinee.[9] Of the original 9,133 vaccinated children, 8,135 were successfully matched with controls from the remaining two blocks, resulting in a final analysis cohort of 16,270 children aged 9–60 months. The remaining 998 vaccinated children without matches were excluded from the analysis; separate analysis showed that these excluded vaccinees were similar to retained cases in terms of their socio-demographic characteristics and subsequent mortality experience. All children were followed from the date of vaccination of the vaccinee of the matched pair (aged nine months or higher) until death, out-migration from the study area, the attainment of 60 months of age, or until the closing date of the present study (October 1985).[10] Given censoring of data as a result of differing observation periods for children due to different entry ages into the study and different lengths of follow-up, we employ life-table and proportional hazard regression techniques for our analysis.

Previous analyses have demonstrated the powerful effect of the Matlab measles vaccination program in reducing childhood mortality. A case–control study of 536 child deaths (aged 10–60 months) and 1,072 sex-age matched controls that occurred in the Matlab intervention area between 1982 and 1984 reported measles vaccination to be associated with a 36 percent lower risk of death (Clemens et al. 1988). Similarly, a cohort study using the same data set as the present study found that vaccinated children aged 9–60 months experienced as much as a 46 percent lower risk of death (Koenig et al. 1990). The potential differential impact of measles vaccination on child survival according to individual and familial characteristics, however, remained until now an unexplored issue.

Results

Figures 1 through 3 show life table results of the mortality experience of children over time according to measles vaccination status, by sex, household dwelling size, and mother's education. The strong effect of measles vaccination on reductions in childhood mortality risks is evident. Differences in cumulative mortality risks (Figure 1) are statistically significant for both sexes.[11] The importance of gender itself is also evident, with female children experiencing substantially higher mortality risks relative to male children and greater absolute reductions in mortality risks with vaccination. In essence, vaccinating female children against measles provides them with the same survival chances as unvaccinated male children.

FIGURE 1 Cumulative risk of death by vaccination status and sex: Matlab intervention area, 1982–85

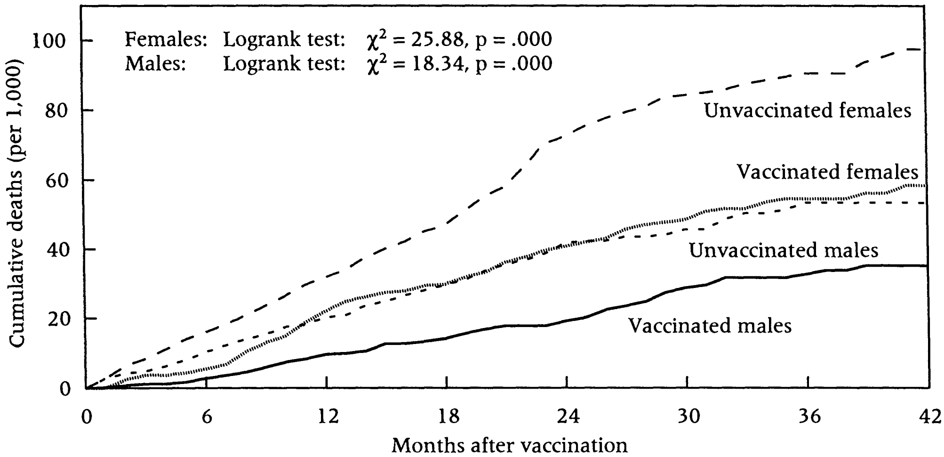


Figure 2 presents similar life table results according to measles vaccination status and household dwelling size, an indicator of family economic status in rural Bangladesh. It is apparent from this figure that among the poorest group of children (dwelling size of 200 sq ft or less), the impact of measles vaccination is most pronounced, with vaccinated children experiencing markedly lower subsequent mortality risks relative to unvaccinated children. This differential persists among children of intermediate economic status (dwelling size of 201–400 sq ft), with the differences in cumulative mortality risks statistically significant for both the poor and average economic status groups. Among children of higher economic status (defined as a dwelling size exceeding 400 sq ft), however, measles vaccination makes little difference in terms of subsequent survival, with mortality risks that are low for both the vaccinated and unvaccinated groups and a statistically nonsignificant difference.[12]

Figure 3 presents life table results for another indicator of socioeconomic status, mother's education. For the large group of uneducated women, a substantial differential in mortality is evident between vaccinated and unvaccinated children. Among children born to mothers with limited education (1–5 years), this mortality differential by vaccination status persists, although it narrows slightly. The differences in mortality risks for both of these groups are statistically significant. Only among the very small group of children born to mothers with higher levels of education (6+ years) is a substantial narrowing of mortality risks evident, with the difference in mortality risks no longer statistically significant.

FIGURE 2 Cumulative risk of death by vaccination status and household dwelling size: Matlab intervention area, 1982–85

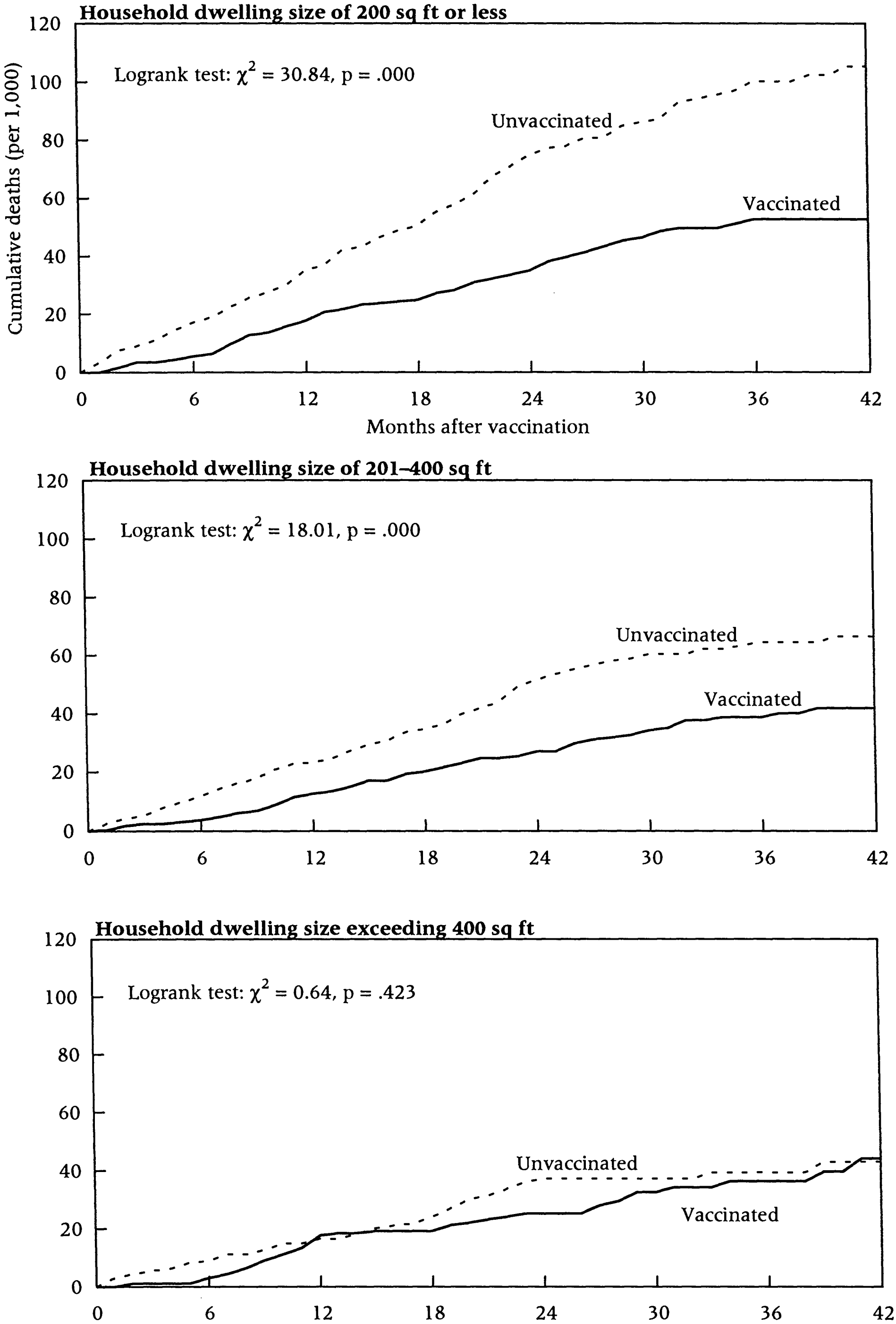
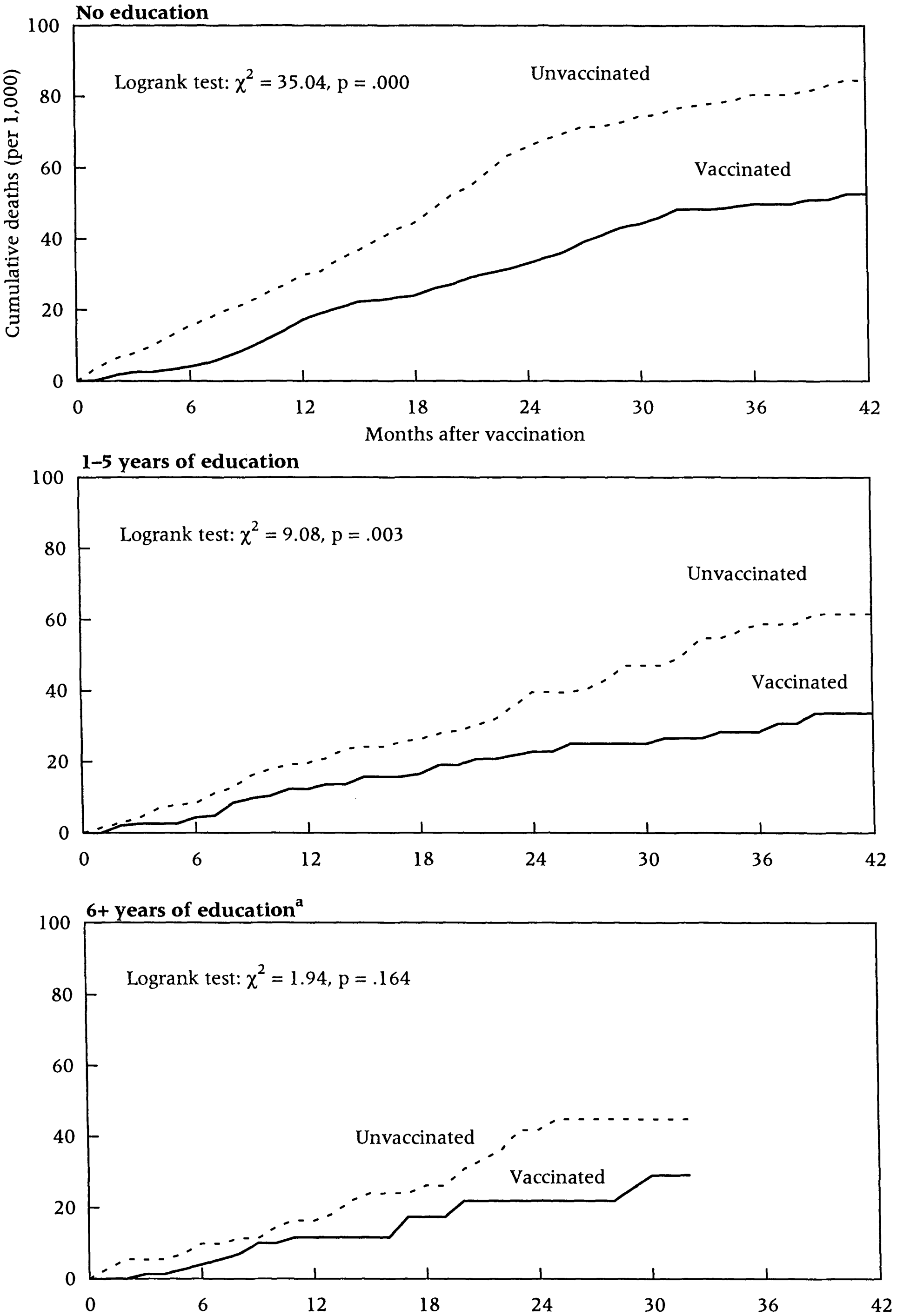


FIGURE 3 Cumulative risk of death by vaccination status and mother's education: Matlab intervention area, 1982–85



[a]At 32 months after vaccination, the numbers of children in the two groups are below 25.

Multivariate analysis

We next consider the results of proportional hazard regression analyses, which permit us to control for the effects of other confounding factors that may be related to both vaccination status and childhood mortality, and to test the statistical significance of interaction effects between vaccination status and individual characteristics of interest. The two continuous variables in our model, mother's education and household dwelling size, have been centered— i.e., subtracted from a constant value—to reduce collinearity among covariates. In addition, for the household variable, we used log values to reduce existing skewness to the right caused by very high values. Interaction terms were created by cross-tabulating vaccination status (0 = vaccinated, 1 = unvaccinated) with sex (0 = male, 1= female), mother's education, and log of household dwelling size. Our outcome variable is defined as 0= survived, 1= died. The specification of our model is as follows:

$$h(t) = h_0(t)exp(\alpha X + \beta' Y + \gamma' Z)$$

where $h(t)$ = hazard rate at time t, h_0= baseline hazard;
X = vaccination status
Y = the vector of socioeconomic and demographic covariates
Z = two-way interaction of vaccination status with a socioeconomic covariate, with α, β, γ's associated coefficients.

The first column of Table 1 shows the hazard ratios from a model without interaction effects. The results support previous findings concerning the strong effect of measles vaccination on childhood mortality, with unimmunized children facing a 76 percent higher risk of subsequent mortality (corresponding to a 43 percent reduction in risk for immunized children). Female children, children from Muslim families, and those from households of lower socioeconomic status all experience significantly higher risks of subsequent mortality. The effects of birth order are nonsignificant, and the effect of mother's education just fails to attain statistical significance.

In Models 2 through 4, interaction terms for the joint effects of measles vaccination status and gender, household dwelling size, and mother's education, respectively, have been added. The interaction effect for gender/vaccination status (Model 2) does not attain statistical significance. Although, as shown in Figure 1, the *absolute* decline in mortality risks with measles vaccination for female children may exceed that for male children, the *proportional* declines in mortality are comparable for both sexes, hence the absence of significance for the interaction term. Model 3 of Table 1 shows that that interaction term between vaccination status and household dwelling size is statistically significant. Although the bivariate results in Figure 3 suggested a similar interaction effect between vaccination status and mother's

TABLE 1 Proportional hazard analysis of the effects of measles vaccination on childhood mortality: Matlab intervention area, 1982–85

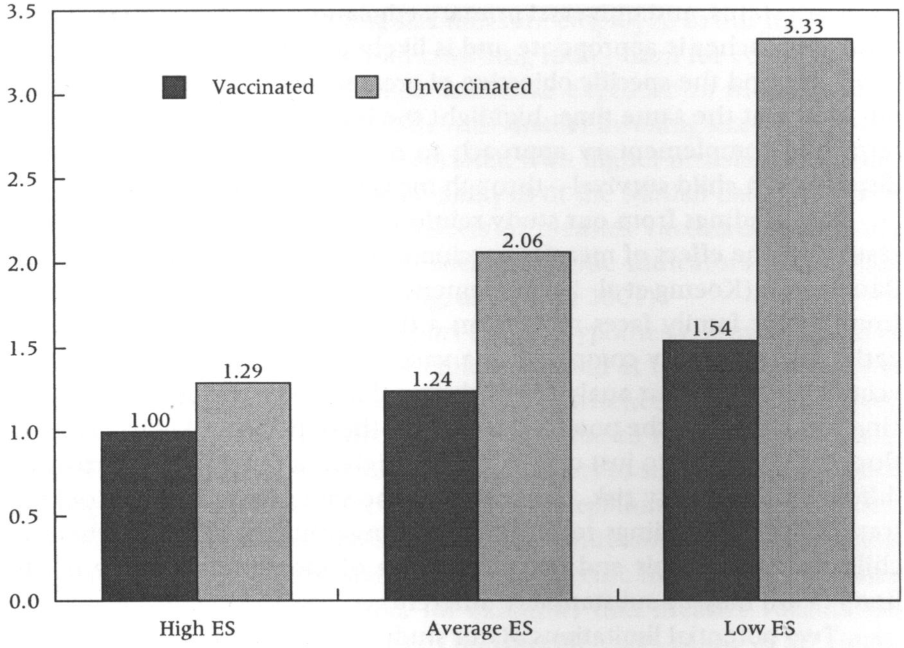
Covariates	Model 1	Model 2	Model 3	Model 4
Main effects				
Vaccination status				
Vaccinated	1.00	1.00	1.00	1.00
Unvaccinated	1.76 (1.48, 2.08)**	1.79 (1.36, 2.36)**	1.29 (0.94, 1.77)	1.37 (0.95, 1.97)
Birth order				
1	0.82 (0.67, 1.01)	0.82 (0.67, 1.01)	0.82 (0.67, 1.01)	0.82 (0.67, 1.01)
2–6	1.00	1.00	1.00	1.00
7+	1.31 (0.97, 1.78)	1.31 (0.97, 1.77)	1.31 (0.97, 1.77)	1.31 (0.97, 1.77)
Mother's education (years) (factor per 1-year increase)	0.98 (0.95, 1.00)	0.98 (0.95, 1.00)	0.98 (0.95, 1.00)	0.98 (0.95, 1.00)
Religion				
Muslim	1.00	1.00	1.00	1.00
Hindu	0.57 (0.45, 0.74)***	0.57 (0.45, 0.74)***	0.57 (0.44, 0.73)***	0.57 (0.44, 0.73)***
Sex				
Male	1.00	1.00	1.00	1.00
Female	1.75 (1.48, 2.07)***	1.79 (1.35, 2.37)***	1.76 (1.48, 2.08)***	1.75 (1.48, 2.07)***
Log household dwelling size (m^2)	0.61 (0.52, 0.71)***	0.61 (0.52, 0.71)***	0.75 (0.59, 0.96)*	0.61 (0.52, 0.71)***
Interaction effects				
Sex by vaccination status				
Unvaccinated female		0.97 (0.68, 1.38)		
All other		1.00		
Vaccination status by dwelling size				
Unvaccinated			0.71 (0.52, 0.96)*	
Vaccinated			1.00	
Vaccination status by mother's education				
Unvaccinated				0.96 (0.92, 1.01)
Vaccinated				1.00

n = 16,246 observations. Statistical significance: * p<0.05; ** p<0.01; *** p<0.001. Coefficients are expressed as hazard ratios with 95 percent confidence intervals given in parentheses.

education, this interaction just fails to attain statistical significance in the multivariate analysis (Model 4 of Table 1).

To facilitate interpretation of the interaction effect between household dwelling size and vaccination status, Figure 4 shows the relative risks for three values of the continuous household dwelling size variable: "high economic status (ES)," corresponding to the 90th percentile; "average ES," corresponding to the mean; and "low ES," corresponding to the 10th percentile.[13] Vaccinated children from high ES households have been set as the reference category (relative risk = 1.00). On the whole, unvaccinated children from the poorest households experience subsequent mortality risks that are over three times higher than vaccinated children from the high ES

FIGURE 4 Relative risk estimate of the joint effects of measles vaccination and household dwelling size on childhood mortality: Matlab intervention area, 1982–85



households (relative risk = 3.33 versus 1.00). While among high ES households, unvaccinated children experience only a 1.3 times higher risk of subsequent mortality relative to vaccinated children (relative risk = 1.29 versus 1.00), this differential increases to a 1.7 times higher risk for children from average ES households (relative risk = 2.06 versus 1.24), and widens to 2.2 times higher risk among children from the poorest households (relative risk = 3.33 versus 1.54). While unvaccinated children from the poorest households experience mortality risks that are 2.6 times higher than risks for unvaccinated children from high ES households (relative risk = 3.33 versus 1.29), among vaccinated children the differential mortality experienced by the poorest ES households is only about 1.5 times higher than among the high ES households (relative risk = 1.54 versus 1.00). Measles vaccination can thus be seen to exert a pronounced leveling effect upon prevailing economic differentials in childhood mortality risks.

Discussion

As levels of childhood mortality in many developing countries gradually converge to much lower levels, the persistence of inequities in child health and survival is likely to remain as a major concern among health policymakers and planners (Gwatkin 1998). To date, approaches for reducing health inequities have focused primarily on long-term interventions and policies aimed at more equitable economic development, improvements in women's status, and universal primary education. The focus on these structural approaches is appropriate and is likely to yield substantial social dividends beyond the specific objective of greater health equity. The results of our study, at the same time, highlight the importance of a powerful short-term and complementary approach to narrowing existing socioeconomic disparities in child survival—through measles vaccination coverage.

The findings from our study reinforce and extend previously reported results on the effect of measles vaccination on childhood mortality in rural Bangladesh (Koenig et al. 1990; Clemens et al. 1988). An unvaccinated child from a poor family faces more than a threefold higher risk of subsequent early child mortality compared to a vaccinated child from a family of high economic status. Our analysis has shown that the provision of measles vaccination alone has the potential to reduce these risks markedly—from over three times higher to just over 1.5 times higher, a remarkable narrowing of differential mortality risk. Care must, at the same time, be exercised in extrapolating our findings to other developing-country settings, where both child mortality levels and the importance of measles as a cause of childhood death may be substantially different.

Two potential limitations of our study require discussion. The first concerns possible challenges to the validity of our findings arising from selection bias among measles vaccinees. This possibility has been previously considered from several perspectives (Koenig et al. 1990). One potential source of selection bias—that vaccinees may have differed from non-vaccinees in terms of socioeconomic characteristics that differentially influenced subsequent survival—was considered and ruled out.[14] Another potential source of selection bias concerns possible self-selection among vaccinees for better survival relative to unvaccinated children. Previous analysis (ibid.) has shown that even when the possible effects of such selection bias are taken into account—controlling for the possibility that non-vaccination is correlated with an unobservable mortality risk—the impact of measles vaccination on childhood mortality is only slightly diminished.[15] A final possible source of selection bias is that families of vaccinees and non-vaccinees differed in terms of access to and use of other health services and technologies. Measles vaccine was provided independently of other health interventions; the other interventions available in Matlab during the 1982–85 observation period were unlikely to have had a major effect on child mortality rates; and available evidence suggests no differential between vaccinees and non-vaccinees in at least one key health service indicator, contraceptive prevalence.[16] These findings, taken as a whole, provide little support for selection bias in explaining the pronounced improvements in subsequent survival among children who received measles vaccination in the Matlab program.

A second possible limitation concerns the finding of a significant interaction between measles vaccination and household dwelling size, but the absence of a significant effect for mother's education. This raises the possibility that the household dwelling size measure employed in our model may be serving as a proxy for household crowding rather than for economic status per se. Overcrowding and more intensive exposure to measles—presumably more common in households with smaller dwelling size—have been shown in studies elsewhere to be associated with higher measles case–fatality rates (Aaby et al. 1984). Separate analysis of the Matlab data, however, demonstrates that the differential effects of measles vaccination on early childhood mortality remain when socioeconomic indicators other than dwelling size are used (Bishai, Koenig, and Khan 2001).

Our findings provide little support for the hypothesized mechanism of replacement mortality during early childhood; and at least with respect to measles vaccination, they argue against the existence of such an effect. Rather, by saving poorer children from death due to measles or measles-related complications, measles vaccination appears to significantly enhance their long-term survival prospects as well. The explanation of how measles vaccination disproportionately benefits more vulnerable children remains largely unknown, and understanding of the specific mechanisms remains limited. It has been hypothesized, for example, that measles vaccination may stimulate the immune system in nonspecific ways (Aaby et al. 1995). Measles is known to be a devastating illness among children with poor nutritional reserves and can lead to a prolonged vulnerability to infectious illness and frailty, until visceral protein and vitamin A stores are replenished (Bhaskaram 1995). Unresolved questions also remain as to whether the health equity effects reported here are confined to measles vaccination or extend to other child survival interventions as well.

Our results provide further impetus to the already compelling argument to accord universal measles vaccination coverage very high priority within child survival programs (Olive, Aylward, and Melgaard 1997). Despite the demonstrated potential for measles vaccination to improve survival, a continuing paradox in South Asia and elsewhere is that the children most likely to benefit from this preventive health technology are the least likely to receive it. Recent national surveys indicate that measles vaccination coverage rates range from 70 percent in Bangladesh (Mitra et al. 1997) to as low as 50 percent and 42 percent in Pakistan and India, respectively (National Institute of Population Studies 1992; International Institute for Population Sciences and ORC Macro 2000). These levels mask significant variation in coverage by socioeconomic status, with levels substantially lower among children of uneducated mothers than among children of mothers with secondary school or higher education—63 percent versus 88 percent in Bangladesh, 44 versus 82 percent in Pakistan, and 36 versus 83 percent in India (ibid).[17]

In the search for new approaches to improving child health and child survival in developing countries, attention has largely focused on the development of new child survival technologies and interventions. This emphasis has resulted in a tendency to overlook existing interventions that have been proven to be highly effective in reducing childhood mortality, but that often remain only partially and inequitably implemented. Measles vaccination represents one such intervention. Despite significant progress over the last decade, measles still accounts for almost 10 percent of all deaths among children under age five years globally (World Health Organization 1995), or as many as 1 million deaths per year (Centers for Disease Control and Prevention 1997). As of 1998, there were at least ten countries where measles vaccination reached less than 50 percent of eligible children, and over 25 countries where coverage was less than 80 percent, despite its relatively low cost of under US$0.50 per dose.

The results of this study underscore the need for developing special strategies and targeted approaches for reaching the most disadvantaged children. Intensive community-based outreach programs, such as the Matlab intervention program, have been shown to be highly effective in reaching larger numbers of at-risk children with both preventive and curative services. Our findings provide a strong rationale for the large number of governmental and voluntary agencies concerned with issues of economic and social equity to become more directly and actively engaged in programs such as measles vaccination. Such engagement would provide a more immediate complement to long-term social and economic development in the effort to achieve health equity goals.

Notes

This study was made possible by support from the ICDDR,B: Centre for Health and Population Research, in Bangladesh, and the Global Forum for Health Research, based in Geneva. The authors gratefully acknowledge the contribution of Renée Rees to the statistical analysis, and the research assistance of Arzum Ciloglu, Heidi Park, and Karima Saleh. Saifuddin Ahmed, Stan Becker, and Henry Mosley provided helpful comments on earlier drafts.

1 The ratio of infant mortality among children of less-educated mothers (four or fewer years of schooling) versus better-educated mothers (seven or more years of schooling) declined from 3.7 to 2.1 in Costa Rica during this period.

2 Rosenzweig and Schultz used data on the number of clinics or hospital beds per capita to reflect the shadow price of child health. They did not directly address the link between health facility use and health outcomes.

3 An earlier analysis of gender and child mortality using the same data, however, failed to provide support for the thesis that presumably more vulnerable female children benefited more from the intensive Matlab intervention program. See Muhuri and Preston (1991).

4 Other pathways through which mother's education may contribute to improved child survival include its effect on child nutritional status and domestic child care practices.

5 Hill and Upchurch (1995), however, failed to find a significant association between gender and immunization status, and indeed found girls to be somewhat advantaged compared with boys with respect to treatment for diarrhea.

6 Evidence for this comes from a study by Hull, Williams, and Oldfield (1983) in Gambia, which reported significant delayed mortality from measles for up to nine months after the initial infection.

7 Defined as children of mothers who were illiterate, had no knowledge of oral rehydration therapy, and had birth intervals of less than 24 months.

8 At the time of the field intervention, the positive impact of measles vaccination on childhood mortality had not been conclusively established. See Kasongo Project Team (1981) and Aaby et al. (1981).

9 See Koenig et al. (1990) for a detailed description of the study design and analysis.

10 During the observation period 3.3 percent of vaccinees and 5.1 percent of non-vaccinees out-migrated from the Matlab study area. The closing date of the data set (October 1985) coincides with the time when measles vaccination was introduced in the remaining two blocks of the intervention area.

11 The statistical test used to compare cumulative risks of survival in Figures 1–3 was the Logrank test. Similar results were obtained when the Wilcoxon test was employed.

12 We selected dwelling size as a readily interpretable indicator of economic status. We examined multiple alternative indexes of economic status based on factor analysis and found that our results were robust across all specifications of economic status (Bishai, Koenig, and Khan 2001).

13 The specific values of the household dwelling size variable are as follows: 90th percentile (well off) = 545 sq ft; average = 256 sq ft; and 10th percentile (poor) = 120 sq ft.

14 The intensive outreach program in Matlab, in which door-to-door visits were made to administer measles vaccination to children, greatly reduced the possibility of self-selection among vaccinees. Moreover, the proportional hazard analysis we present controlled for any residual differences between vaccinees and non-vaccinees in important socio-demographic characteristics.

15 An earlier analysis that incorporated the effects of selection bias found only a modest reduction in the effect on childhood mortality—from 46 percent to 40 percent (see Koenig et al. 1990).

16 The health interventions available in the Matlab area prior to and during the measles vaccination trial were tetanus toxoid for mothers, antenatal care, oral rehydration therapy, and family planning (Koenig and Strong 1995). The first two interventions are unlikely to have affected mortality during ages 9–60 months; the mortality impact of oral rehydration therapy is open to question, and contraceptive use rates at that time among families of vaccinees and non-vaccinees were virtually identical—27 and 28 percent (Koenig et al. 1990).

17 Similar socioeconomic differentials in coverage were evident for other child vaccinations as well.

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