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Measles vaccination improves the equity of health outcomes: evidence from Bangladesh

David Bishai[a,*], Michael Koenig[a] and Mehrab Ali Khan[b]
[a] *Department of Population and Family Health Sciences, Johns Hopkins University Bloomberg School of Public Health, Baltimore, USA*
[b] *ICDDR, B, Dhaka, Bangladesh*

Summary

Objectives: This paper asks whether measles vaccination can reduce socioeconomic differentials in under five mortality rates (U5MR) in a setting characterized by extreme poverty and high levels of childhood mortality. *Design*: Longitudinal cohort study based on quasi experimental design. *Setting*: Data come from the phased introduction of a measles vaccine intervention in Matlab, Bangladesh in 1982. *Subjects*: There were 16 270 Bangladeshi children aged 9–60 months. *Intervention*: The intervention cohort received measles vaccine. *Main outcome measures*: Socioeconomic differentials in U5MR between the lowest and highest socioeconomic status (SES) quintiles in a cohort of 8135 vaccinated children and a cohort of unvaccinated age matched controls. Mantel–Haenszel rate ratios for the lowest to highest SES quintile were computed. SES was measured by factor analysis of maternal schooling, land holdings, dwelling size, and number of rooms. *Results*: The U5MR ratio of lowest SES to highest was 2.27 (95% CI = 1.62–3.19) in the unvaccinated population and 1.42 (95%CI = 0.94–2.15) in the vaccinated population. The difference between unvaccinated and vaccinated U5MR ratios was statistically significant ($p < 0.10$) and robust across alternative measures of SES. *Conclusion*: Children from the poorest quintile were more than twice as likely to die as those from the least quintile in the absence of measles vaccination. Universal distribution of measles vaccination largely nullified SES related mortality differentials within a high mortality population of children.

Keywords measles vaccine; equity; child survival; Bangladesh

Introduction

Measles vaccination programes in developing countries have been repeatedly documented to be among the most cost-effective public health interventions, costing between $140–$255 (in 1980s dollars) per death averted [1]. Developing country immunization strategies are designed with the hope of distributing services equitably across all social groups [2]. Recognizing that measles vaccination projects are efficient and designed for a fair allocation of services, we sought to ask whether they also improve health outcome equity in the vaccinated population.

We will assess health outcome equity using the rate ratio of the child death rate in the lowest socioeconomic status (SES) quintile to the death rate in the highest SES quintile. A unique data set collected during the introduction of measles vaccine to the Matlab area of Bangladesh will enable us to assess the impact of the intervention on the equity of health outcomes. Because childhood measles is often the gateway into a spiral of

*Correspondence to: Department of Population and Family Health Sciences, Johns Hopkins University Bloomberg School of Public Health, Baltimore, 615 N. Wolfe St., Baltimore, MD 21030, USA. Fax: +410-955-2303; e-mail: dbishai@jhu.edu

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infection, malnutrition, and death for vulnerable children [3], an intervention such as a vaccine which closes this gateway may be one which could reduce socioeconomic differentials in all cause mortality.

Methods

Data

In late 1977, the International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR, B) began a phased introduction of intensive family planning and child health services in four blocks of the Matlab study area. The measles vaccination program was phased in at two of four blocks in the study area from March 1982 to October 1985. Measles vaccination was subsequently introduced in the remaining two blocks in late 1985. Simple logistics and resource limitations in this area made phased introduction of measles vaccine an operational necessity. The presence of a measles vaccination program was the only intervention that differed between the intervention and control areas during the period under study [4]. Vaccination coverage rates in the intervention area went from 0 to 65% within 12 months [5]. The vital events surveillance system recorded deaths and date of death for children in both the intervention and control areas of Matlab. Data on socioeconomic status of each household in Matlab were recorded by the census in 1982.

Each vaccine recipient aged 9–60 between 1982 and 1985 from the early intervention area was matched at random with a child from the late intervention area who was born in the same month and year and who survived at least until the date of vaccination of the vaccine recipient. Matches were found for a total of 8135 of the original 9133 children eligible vaccine recipients. More details about the data set are available elsewhere [5–7].

Table 1 describes the means and standard deviations of the variables used in the study.

Statistical analysis

SES was measured by using either a raw sum or the first principal component that emerged from factor analysis of Maternal Schooling, Land Holdings, Dwelling Size, and Number of Rooms [8]. Robustness was checked by serially deleting one of the four above factors and repeating the mortality comparison.

Table 1. Sample totals, proportions, and means

Variable	Full sample		Vaccinated		Unvaccinated	
	Obs	Mean or % (SD)	Obs	Mean or % (SD)	Obs	Mean or % (SD)
Children	16 270		8135		8135	
Deaths	593		218		375	
Total person years (PY)	30 854		15 588		15 266	
Proportion died	16 270	3.64%	8135	2.68%	8135	4.60%*
Mortality rate (per 100PY)		1.92%		1.40%		2.45%
Proportion vaccinated	16 270	50.00%	8135	100.00%	8135	0.00%
Proportion female	16 270	48.18%	8135	47.72%	8135	48.64%
Maternal schooling (years)	15 962	1.65 (4.34)	7997	1.95 (4.37)	7965	1.97 (4.32)
Land owned (acres)	16 270	16.68 (78.37)	8135	17.11 (82.48)	8135	16.25 (74.03)
Dwell size (100 sq. ft)	15 967	3.01 (1.94)	7921	3.03 (20.10)	8032	2.99 (1.87)
Number of rooms	16 270	1.33 (0.85)	8135	1.36 (0.89)	8135	1.31 (0.81)
Age of mother	16 269	25.74 (6.66)	8135	25.69 (6.60)	8134	25.80 (6.73)

*Denotes $p < 0.05$ for comparison between vaccinated and unvaccinated groups using z-test for proportions.

The full sample of 16 270 children was sorted into quintiles according to the SES variable. The mortality rate in the lowest quintile was divided by the mortality rate in the highest quintile to form a rate ratio.

Mortality rates were computed as deaths divided by person years observed in each group. Mantel–Haenszel rate ratios for the lowest to highest SES quintile were computed and variance estimators for the Mantel–Haenszel rate ratios were computed. A Wald statistic was used to test the null hypothesis that the rate ratio was uniform in both the vaccinated and unvaccinated populations.

Results

With the full principal component model of SES, the rate ratio was 2.27 (95% CI = 1.62–3.19) in the unvaccinated population indicating that children from the poorest quintile were more than twice as likely to die as those from the least poor quintile. In the vaccinated children, the rate ratio was 1.42 (95%CI = 0.94–2.15). The Wald test rejected the null hypothesis that the rate ratio was uniform across the vaccinated and unvaccinated populations at the $p < 0.10$ level. Figure 1 indicates that the results were robust across the different models of SES that were used.

To ease interpretation of the SES index Table 2 monetizes the size of the resource differences between the lowest and highest SES quintile. Table 2 can be used to estimate the magnitude of costs that would be associated with a hypothetical mortality equalization project that addressed underlying SES inequalities by directly equalizing the assets of the poorest and the least poor.

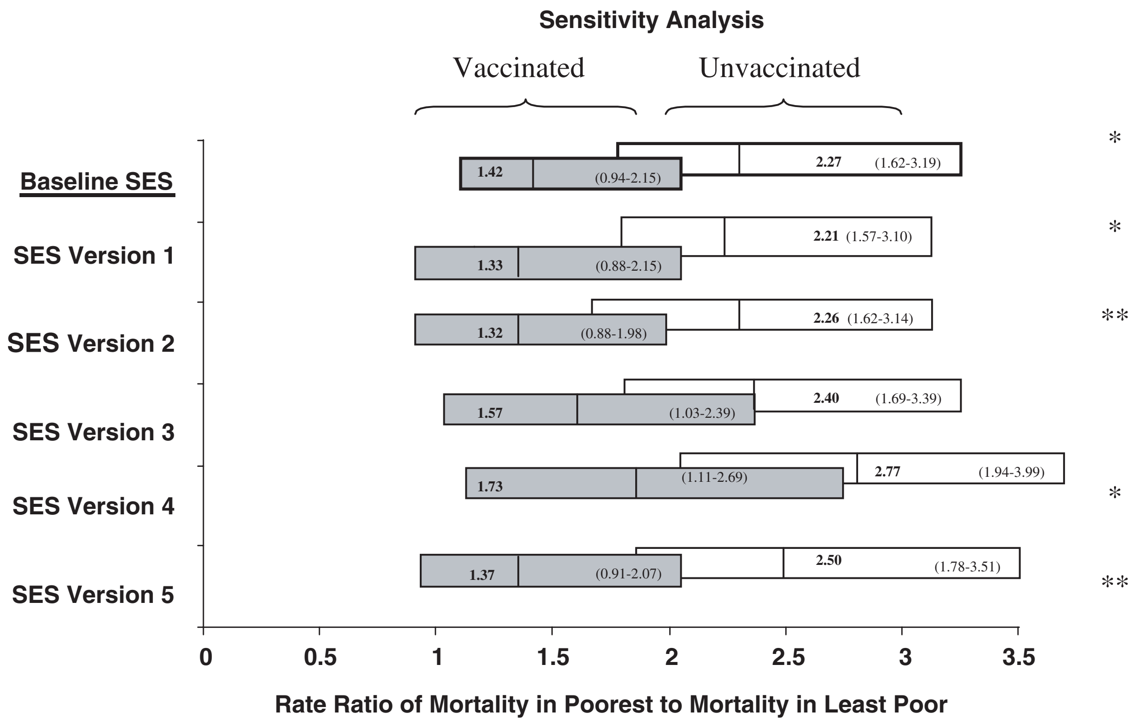

Figure 1. Grey bars above contain the *rate ratio* and 95% confidence intervals of the under five mortality rate (U5MR) in the poorest SES quintile to U5MR in the highest SES quintile based on data from the measles vaccine recipients in Matlab. White bars describe children who did not receive measles vaccine. Six alternative rankings of the SES of the households are displayed. The baseline model is based on principal components of land, maternal education, dwelling size, and number of rooms. Version 1 omits land. Version 2 omits maternal education. Version 3 omits dwelling size. Version 4 omits number of rooms. Version 5 is based on raw sums of all SES variables. The asterisks (** for $p < 0.05$ and * for $p < 0.10$) indicate that the *rate ratio* is significantly different no matter what version of SES is used for the analysis

Table 2. Comparing costs of various strategies to improve health equity by direct distribution of SES determinants to the cost of improving health equity by distributing measles vaccines

Factor	Mean in lowest quintile	Mean in highest quintile	Difference	Unit cost[a]	Cost to equalize this factor for one child ($ per low SES child)
Number of rooms	0.97	2.12	1.15	$1023	$1176
Dwelling size (sq ft)	122	590	468	$10	$4787
Land holdings (acres)	0.85	28.82	27.97	$492	$13 754
Maternal schooling (years)	0.05	3.40	3.35	$54	$181
Measles vaccine receipt				$2.50	$2.50

[a] Unit cost data for dwellings and land in Matlab are based on an informal survey of Matlab field staff conducted by K. Zaman of ICDDR, B on 10 March 2000. Cost of schooling is a conservative estimate because it is based on public expenditures on education per child [11]. Measles vaccine distribution costs are from [1].

Discussion

A limitation of comparing vaccinated to unvaccinated populations is the concern that there was selective uptake of the vaccine in the intervention area. This study does not compare health equity in the intervention *area* to health equity in the comparison *area*. The data that would be required to compare areas is no longer available. One might be concerned that our findings occur simply because we confined our attention to the 60% of (vaccinated) children whose parents had elevated receptiveness to modern health technology and interest in their children's health. In other words, the vaccine itself did not cause the mortality rates to equalize across SES group it was simply a marker for a population where SES mattered less. As partial evidence that the role of self-selection may be limited we note that contraceptive use was similar in these two groups – 28% in the vaccinated and 27% in the unvaccinated controls. This suggests that the groups were comparable in this important measure of receptiveness towards modern health technology and interest in family size. As can be seen in Table 1, there was no statistical evidence that the vaccinated children we studied had different SES indicators than the age-matched controls from the area where vaccine was not available. The relative contributions of self-selection mechanisms and vaccine to the equalization of death rates remain difficult to judge.

Extrapolating from the Matlab area to other settings with lower child mortality or less intensive demographic surveillance may not be warranted. It would appear that in Matlab measles vaccine was not only one of the most efficient health investments, but appears to have been associated with a sharp reduction of SES-related mortality gradients at a fraction of the cost of direct poverty reduction. There was no equity efficiency tradeoff in efforts to reduce mortality with measles vaccine.

Conclusion

Using data from a phased introduction of measles vaccine in Matlab, Bangladesh in 1982 we find that the rate ratios of under five mortality in the lowest to the highest SES quintile differ from 2.27 in an unvaccinated cohort to 1.42 in a vaccinated cohort.

This paper is one of the first to offer evidence that preventive public health interventions could reduce socioeconomic inequity in health. Although there is concern that curative interventions may temporarily worsen health equity [11], our findings suggest that universal measles vaccination in a high mortality, impoverished population of children could be an effective strategy for achieving health equity. Opportunities to improve health equity with measles vaccine still abound. Nearly 30 million children in the world are not receiving vaccinations of any kind [10].

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