The Effect of Malaria on Female Educational Attainment: Evidence from Sri Lanka

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Malaria is among the most devastating diseases in the world today, causing 300 million illnesses and between one and three million deaths annually. Forty percent of the world's population is at risk for malaria infection. Roll Back Malaria and the Global Fund to Fight AIDS, TB and Malaria are two of the growing number of international organizations seeking to reduce malaria incidence. While the primary purpose of these organizations is to reduce the pain and suffering associated with the disease, we quantify an important additional justification that has received little attention thus far: the gain in educational attainment.

Recent studies have approached the estimation of the economic costs of malaria in both the Growth literature (e.g. Gallup and Sachs 2001, Sachs 2003) and the Development literature (e.g. Wiseman et al 2003). The growth literature estimates the effect of malaria on GDP per capita and GDP growth, but in most instances the model is not fully identified and no estimates are made regarding the specific channel through which this relationship occurs. In the development literature, estimates are made of the instantaneous effects of the disease. Our study seeks to fill the gap between the two approaches by estimating malaria's direct impact over an individual's lifetime by using micro level survey data to properly identify the effects.

The episode that we use in our study is the almost complete eradication of malaria from Sri Lanka in the early 1960s. The national incidence rate decreased from over 97% in 1935 to 0.0002% in 1963. This public health campaign was exogenous to the individual districts of Sri Lanka and under taken with the specific goal of complete malaria elimination from the island.

We examine in detail one of the most important hypothesized effects of malaria on economic development: its effect on education. Malaria can reduce educational attainment through several channels. Maternal malaria infections can result in pre-mature birth or low birth weight. Both pre-mature birth and low birth weight have been linked with future health problems and cognitive development delays. Increased infant and child mortality raises fertility and, because of "child-hoarding," raises the net rate of reproduction, thus reducing resources available for each child. Expenditure on treatment and foregone employment income reduces resources that can be used for children's nutrition and education. Children may also miss school because they are ill, to care for an ill family member, or substitute for family labor in the labor force. The academic performance of those who are infected, but able to attend school, can be compromised by malaria-induced anemia. Finally, survivors of cerebral malaria exhibit learning impairments and brain damage.

Because the malaria eradication campaign took place during a broad increase in the national level of health and schooling, one cannot simply look at the correlation between the national malaria incidence rate and human capital accumulation. Our source of identification is the interaction between the exogenous national reduction in malaria and the innate geographic and climatic factors that created a heterogeneous disease environment prior to eradication. In the period before eradication spleen rates, a measure of longstanding malaria, in the most severely affected regions were three or more times higher than those in the low intensity regions. The malaria eradication campaign eliminated these regional differences. We examine the difference in changes in human capital between the highly and minimally malarious regions in order to estimate the effect of malaria on human capital accumulation.

Our results would be biased if there were other public health or education measures that were undertaken simultaneous to the malaria intervention. While there were such interventions on a national level, Gray (1974) and Ekanayake (1982) find no systematic differentials in implementation between the regions. Another potential problem would be if pre-eradication differences in malaria among regions were the result of endogenous regional differences in economic development. In such a case, convergence among regions that occurred simultaneous to the malaria eradication would bias the results towards finding a large effect of malaria. Because of the high correlation between the pre-eradication spleen rates and the "Malaria Ecology" measure, an ecological index designed to reflect innate malaria risk calculated by Kiszewski et al (2004), we believe that these pre-eradication rates are based on ecological factors instead of endogenously determined by development.

We combine two different data sources in our estimation: micro level data from the Demographic and Health Survey (DHS) and district level spleen rates from Newman (1965). The DHS survey was undertaken in Sri Lanka in 1987 producing a sample of 5,859 ever married women aged 15-49 at the time of the survey representing 86% of the Sri Lankan population.[1] From this sample, we eliminate all women not born in Sri Lanka and those under who are too young to have completed twelve years of schooling leaving us with 5,843 women. For district level spleen rates, we use the percentage of school-age children with an enlarged spleen on the day of the survey exam. This district level spleen rate is aggregated to the level of a DHS region in order to match each individual in the DHS data with the regional spleen rate at the time of her birth.

Using these combined data we estimate the following equation:

$$educ_{ijt} = \beta_0 + \beta_1 spleenrate_{jt} + X_{ijt}'\beta_2 + \varepsilon_{ijt}$$

where $educ_{ijt}$ is the measure of individual educational attainment of person i born in region j at time t, $spleenrate_{jt}$ is the spleen rate in region j at the time of the respondent's birth t, and X_{ijt} is a vector of additional controls: being born in a city, regional level dummy variables, and a full set of birth year dummy variables. The errors are assumed independent across sample points, but are allowed to be correlated within them. Because of data limitations, we are unable to identify a respondent's place of birth if they no longer live in the village or city of their birth; we estimate the model for both the entire sample and those who remain in their city or village of birth.[2] Our direct education measures of interest are completed years of schooling and being able to read a newspaper or letter easily. Regressions are run separately for each measure. Our estimates appear in the first four columns of Table 1. The marginal effects of the spleen rate on the dependent educational attainment variables are negative and significant with the exception of column (4) where we look only at those who have remained in the same village or city their entire lives.

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[1] The eastern coastal belt and northern provinces were excluded due to civil disturbances.
[2] Individuals will not appear in the non-mover sample if they remain in their region of birth, but live in a different village or city. While we would like to include them in the non-mover sample, we are unable to distinguish them from those respondents who moved across regions.

Table 1 - Effects of Malaria Eradication								
Dependent Variable:	Educational Attainment		Can Read a Letter or Newspaper Easily		Percentage of Births Alive at Age 5		Number of Births by Age 30	
Sample:	Full	Non-Movers	Full	Non-Movers	Full	Non-Movers	Full	Non-Movers
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Regional Spleen Rate in Year of Birth	-3.971 (0.801)***	-4.018 (1.647)**	-0.263 (0.096)***	0.002 (0.212)	-0.411 (0.184)**	0.041 (0.409)	2.172 (0.511)***	2.859 (1.009)***
Observations	5,843	2,086	5,843	2,086	4,185	1,471	4,053	1,372
Pseudo R^2	0.02	0.02	0.06	0.06	0.04	0.06	0.02	0.03

Notes: All regressions include a full set of year of birth and region dummy variables and a dummy variable for being born in a city. Coefficients in columns (3) and (4) are marginal effects from probit regressions; the other coefficients are marginal effects from tobit regressions. Robust standard errors in parentheses (* significant at 10%, ** significant at 5%, *** significant at 1%).

The estimated effects of malaria's effect on the two direct measures of human capital are large. The coefficient in column (1) indicates that reducing the spleen rate from 100% to 0% in a region would increase years of completed education by 3.97 years. The maximum national spleen rate during the period under study was 28.4% in 1937. Eliminating malaria from this point would result in an increase in years of schooling of 1.13 years. In our DHS sample, average years of education rose from 4.60 for women born 1937-1940 to 6.77 for women born 1954-1957. Thus, the virtual elimination of malaria was responsible for 52% of the increase in female education. At the regional level, the result is similar. In the irrigated dry zone, the most intensely malarial of the regions, the spleen rate averaged 55.8% from 1937-1940; based on our estimates, elimination of malaria from this level would increase education 2.21 years. Average education in the irrigated dry zone in our sample increased from 3.12 years to 7.20 years, with malaria accounting for 54% of this increase. Doing similar calculations based on the marginal effect of the spleen rate on literacy, we find that 40% of the national increase in literacy can be attributed to the elimination of malaria.

We also look at the impact of malaria eradication on measures of child survival and fertility: the percentage of births per woman who survive until age 5 and the total number of births by age 30. We estimate the same model as above, replacing *educ* with the two measures of maternal and child health. The results appear in the final 4 columns of Table 1. Our results for these fertility and survival results are just as striking as those for education. In all models, excepting column (6) which is restricted to those who have lived in the same city or village their entire lives, the results of malaria are significant and of the sign predicted. Reduction of the spleen rate from the nationwide peak of 28.7% to 0% results in an 11 percentage point increase in the percentage of births per woman who survive to age 5. The same reduction in the spleen rate decreases the number of births by age 30 by 0.62.

Our results show that in addition to the reduction in pain and suffering, increased educational attainment is another important justification for malaria eradication. With such a large impact on educational attainment, malaria eradication should be a top public health priority in those areas still afflicted by it. The large gains in education attributed to malaria eradication provide a partial explanation for the low levels of GDP and GDP growth seen in sub-Saharan Africa where malaria continues to be endemic. The spleen rates in Sri Lanka in the 1930s are similar to those seen in endemic malaria regions in Africa. There are obviously other ways to improve educational attainment, and future work will focus on the cost-benefit analysis of malaria eradication versus other interventions that increase education.