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Abstract

The reduction in mortality in this century is as important a watershed for the world as was the industrial revolution. Econometric studies of household sample surveys in contemporary low income countries provide a new basis for estimating causal relationships linking nutrition, mortality, morbidity, and productivity. Improvements in health are also being related to changes in wages, time allocation, fertility and personal incomes, while dealing with both the simultaneous determination of health and income, and certain sources of measurement error. Hypotheses confirmed by microeconometric studies of the determinant of child mortality and fertility are then reexamined with intercountry regressions that seek an explanations for cross sectional and time series variation in child mortality and total fertility rates from 1972 to 1988. Although country aggregate data have clear limitations, they confirm many recent findings of household analyses. Women's education is the powerful engine of demographic change, promoting the decline in child mortality and fertility, while slowing population growth. Factors that permit higher levels of calorie consumption per capita, given a country's education and income, are associated with lower levels of child mortality. Combining micro and macro data sources and methods of analysis improves our impressionistic knowledge of the determinants of this century's mortality decline. Progress on this front will provide a firmer basis for modeling fertility behavior, and thus a deeper understanding of the episode of rapid population growth that has marked this century.

KEY WORDS: Mortality, Fertility, Development

The reduction in mortality in this century is perhaps the most far reaching change achieved in the world since the onset of the industrial revolution. What do we know about this improvement in health, and how it has affected labor productivity, resource use, and personal behavior. There is little agreement on what caused mortality to decline gradually in Europe from 1750 to 1875, before there were effective medical treatments for most serious infectious diseases. This century's decline in mortality in low income countries is not much better understood, theoretically or empirically, than the earlier European experience. Plausible hypotheses, however, are plentiful. Real per capita income has increased markedly in many low income countries and new public and private health technologies are believed to provide more affective curbs on infectious and parasitic diseases (Samuel Preston, 1980). Empirical tests of these hypotheses remain indecisive, because most analysis is of aggregate data. More promising are econometric studies of household sample surveys in contemporary low income countries, that can deal with both the simultaneous determination of health and income and certain types of errors in measurement. Causal relationships are being estimated with these new methods, and exogenous variation in household constraints are being linked to nutrition, mortality, morbidity, and productivity. Predictable improvements in health are beginning to be related to wages, market labor supply, fertility, and personal income.

I. Secular trends in mortality and population growth

There has been a marked convergence in the length of human life between the rich and poor countries of the world in the second half of this century. From 1950 to 1990 the United Nations has estimated that life expectancy at birth, a

summary measure of age specific mortality, increased in industrially advanced countries (high income) from 66 to 75 years, or by nine years, whereas in the rest of the world (low income) it increased more than twice as much, by 21 years from 42 to 63. Latin America was the healthiest low income region in 1950, and life expectancy still increased 16 years in this forty year period, whereas in South East and East Asia life expectancy grew 26 years from 44 to 70. In South and West Asia it increased 20 years from 40 to 60, whereas in Africa the least progress was made with it increasing from 38 to 54 years. The declines in infant and childhood mortality were particularly dramatic, as in the high income countries after 1900. This decline in mortality is by definition the predominant cause for the increase in population growth rates in the low income world from .7 percent per year around the turn of the century to a peak growth rate of 2.4 percent in 1970-75. After 1970 the variance in birth rates across low income countries widened, with sharp declines registered in Latin America and East and South East Asia. More slowly declining mortality and fertility have left population growth rates stable or falling only slowly in South and West Asia, and in Africa there is little evidence of an overall tendency for birth rates to begin their decline.

II. Causes of Mortality and Morbidity

Analysis of mortality requires that deaths are measured for a representative population, for which conditioning exogenous characteristics are known, including age and sex. Surveys often question women concerning their births and the survival status of their children. Demographers have concluded that these retrospective responses are a reasonably reliable basis for estimating the level of child mortality. No similar scheme has proven fully satisfactory

for analyzing the determinants of much less frequent adult mortality.

Studies in many disciplines have found that a strong inverse relationship exists between the mother's schooling and the incidence of mortality among her children. Child mortality ratios are also generally higher for rural, low income, and agricultural households. In simple bivariate relationships, an extra year of schooling of the mother is associated with a 5 to 10 percent reduction in her child mortality (Susan H. Cochrane, et al., 1980; Barbara Mensch et al., 1986).

Access to health and family planning facilities have also proven to be statistically significant predictors of lower child mortality ratios in some studies, but they explain much less than maternal education (Mark Rosenzweig and T. Paul Schultz, 1982; Duncan Thomas et al., 1990). To estimate the effect of household income (expenditures per adult) on child mortality, the method of instrumental variables is preferred, because income embodies the woman's labor supply behavior that is simultaneously determined with her time available for child care. It is common to find that increments in income are associated with decreases in child mortality, but with diminishing returns.

The availability of calories, proteins and certain micronutrients allow a child to grow and fight off infections. Weight and gestational age at birth, height and weight for age are all anthropometric indicators of net nutrition or health that predict survival, reduced chronic illnesses, and subsequent performance in school and labor market. Synergistic interactions can also operate in the reverse direction, with growth retardation being associated with illness, diminished nutritional intake, weight loss, that increase the likelihood of death (R.E. Black, et al., 1984). It is reported that child height by age four is a good predictor of adult height (Raynaldo Martorell and J. P. Habicht, 1986),

which has led some to assume that adult height may be treated as an exogenous determinant of adult labor productivity just as schooling is in a wage function. If long run net nutritional status or health is measured by height, then weight given height is a shorter-run measure of health. Hans Waaler (1984) has shown in a large sample from Norway that when the body mass index (BMI=height in meters/weight in kilograms squared) is less than 21 or more than 29, age specific mortality increases. Analysis has only started of the effect of BMI on adult health and functioning, because of the lack of consensus on how to measure adult health and relate it to economic performance.

III. Consequences of Health and Nutrition on Productivity

Improved health is widely thought to increase the productivity of the human agent. But until recently, this connection has been inadequately documented. The principal problem in measuring the effect of health on productivity is that productivity contributes to income, which allows expenditures to increase on food and other health related inputs. To estimate without simultaneous equation (upward) bias the one-way effect of nutrition and health on labor productivity, some exclusion restriction must be imposed, namely, a variable is known that affects nutrition or use of health inputs but does not otherwise affect individual productivity or household income. Errors in measurement of nutrition and health status may also bias (downward) direct estimates of their effects on labor productivity. John Strauss (1986) first described the problem, and proposed that variation in the community level price of food is suitably correlated (inversely) with food consumption and can serve as the instrument for nutrition. He shows that in Sierra Leone in very low income farm households the predicted availability of nutrition is related to increased farm family labor

productivity. Similar estimates for wage earners in India (Anil Deolalikar, 1988) and Sri Lanka (David Sahn and Alderman, 1988) were subsequently obtained. In Brazil the effects on wage rates of exogenous height and education, and endogenous BMI, calories and proteins per capita are all statistically significant factors for males, whereas for women, height, calories and proteins are generally significant. For example, they find a one percent increase in height is associated with a three percent increase in the wages of males and two percent increase of females, and calories exert a quadratic effect on wages (Thomas and Strauss, 1992).

Short run or acute spells of illness also make individuals less productive by reducing their capacity to work. But there is less consensus on how to measure adult morbidity in a household survey of a low income population, except perhaps among the elderly. Self-reported functional activity limitations (day of work missed) due to illness are admittedly subjective, but may be a satisfactory measure of adult morbidity when they are measured only among wage earners, who forego wages when missing work. Using instrumental variables that include community food prices and health facilities, estimates for male wage earners in Côte d'Ivoire suggest that one day more predicted illness per month is associated with a 15 percent lower wage rate and 14 percent fewer hours worked per year (Schultz and Tansel, 1992).

IV. Consequences of Child Mortality on Behavior

A potentially important behavioral response to the decline in child mortality is a decline in birth rates. If parent demand for surviving children is price inelastic, and the cost per surviving child decreases in proportion to the increase in survival rate, then price theory implies that parents will

respond to a decline in child mortality by reducing the number of births they demand (Schultz, 1981). This result may be strengthened if the decline in mortality extends to later ages, thereby increasing the expected returns to investments in the human capital of children, and these forms of child quality are seen by parents as a substitute for a greater number of children (Gary S. Becker, 1981). Incorporating the parent's aversion to risk and the uncertainty of child mortality is likely to increase further how strongly parents react to changes in death rates. Although a variety of estimation methodologies have been used to assess the response of births to child deaths, a significant positive response is usually found.

V. Cross Country Determinants of Child Mortality and Fertility

The hypotheses confirmed by microeconometric studies of child mortality and fertility can be reexamined with intercountry regressions that seek to explain the national levels of child mortality (deaths through the fifth birthday per thousand live births) and total fertility rates (the number of births a woman would bear if she lived through her childbearing years bearing children at current age-specific rates). These child mortality and fertility rates are estimated for most countries by the United Nations and are combined with income and education data compiled by The World Bank and UNESCO and other data sources. The economic theory of fertility emphasizes the important time input of women to childrearing, and hence the link between women's education, value of time, and the opportunity cost of children. Men's education and value of time should, according to the microeconomic framework, exert a less negative effect on the demand for children. The same pattern of education effects was noted in the empirical literature explaining child mortality, with the mother's schooling

being the most important determinant, presumably because she manages child care and administers the child's food and medical care. Years of female and male adult education are therefore included separately as determinants of child mortality and fertility rates. GDP per adult is controlled as a measure of nonhuman capital income from land, natural resources, and reproducible capital, expressed in equivalent dollars using foreign exchange rates. Urbanization is also included, along with control variables for the country's proportion of three religious groups: catholics, protestants, and muslims.

Although there are no comparable prices across countries for nutrients or the stability of prices over space and time within countries, FAO estimates calories consumed per capita. Calories might be expected to vary, given the population's education, income and urbanization, because of trade and pricing policies that cause divergences between domestic and international food prices, as well as perhaps in response to government policies that supplement (or frustrate) private markets in food. A quadratic function in calories per capita is expected to influence child mortality. Calories are not included as a direct determinant of fertility. Child mortality is hypothesized to be a determinant of fertility, but both are likely to be affected by many of the same unobserved factors that impact on the household, and thus child mortality would be correlated with the fertility error. The null hypothesis that child mortality is exogenous is rejected by the Wu-Hausman test at the $p<.002$ level, and the method of two stage least squares is therefore used to estimate the effect of child mortality on fertility.

The price of only one contraceptive is available for 62 low income countries in 1988, the oral steroid. An alternative measure of family planning program activities is available for more countries, but it is more likely to be

endogenous since it includes supplies of contraceptives which are demand driven. For a more complete description of the data sources and full presentation of the regression findings, see Schultz (1993).

Several findings are relevant to this paper. First, women's education is the most significant determinant of child mortality. At the sample mean, a one year increase in women's education is associated with a 5 percent decline in child mortality. Calories are the second most important determinant of child mortality, exhibiting the expected nonlinear effect, with the benefits of additional average calories per capita ceasing at 3400 calories per day, more than two standard deviations above the sample mean of 2450 calories in these 62 low income countries. Income measured by foreign exchange rates, adult male education and urbanization were not statistically significant determinants of child mortality. Physicians per capita and indicators of the supply of water and sanitation facilities were also insignificant and excluded from the final model.

Fertility is most significantly related to the endogenous (or exogenous) child mortality rate. A decline in one child death is offset by about one fewer birth. Male education is associated with higher levels of fertility and female education with much lower fertility, conditional on the level of child mortality. Fertility is lower in urban areas and higher when the price of oral contraceptives is higher. The elasticity of fertility with respect to the price of this single form of contraceptive is, however, only about .05 .

The same cross sectional regression can be fit to earlier years, but no oral contraceptive data are then available for most countries. Using the alternative indicator of family planning activities, regressions estimated for 1972, 1982, and 1988, are consistent with the findings reported here. The association between family planning programs and fertility is negative as

expected, but a standard deviation increase in family planning accounts for only a 4 percent decline in fertility. Half of the total effect of female education on fertility appears to be occurring because educating women lowers child mortality, which is in turn positively associated with fertility.

During the period 1972 to 1988 the average education of women in this sample of countries increased about three years, and according to the 1988 estimates, this gain is associated with a 18 percent reduction in child mortality. An important feature of modern economic growth is the tendency for women's education to catch up to the levels attained by men, and this trend has been shown here to be related at the level of the family and nation with declines in child mortality as well as fertility. Calories per capita increased only 7 percent in our sample, but even this advance is associated at the sample mean with a 10 percent decline in child mortality. The slow and uneven progress to improve nutrition in the low income world should not be undervalued as an instrument for reducing mortality. Moreover, micro evidence points to the accumulating importance of nutrition and control of disease, not just in affecting child survival, but in raising adult weight, and eventually height, and thereby augmenting the productivity and welfare of men and women.

VI. Conclusions

Country aggregate data have clear limitations. Some of the figures for child mortality and fertility are estimated indirectly from periodic surveys and interpolated to the particular year studied. More work is needed to improve the data for such cross country comparisons. But the aggregate data nonetheless confirm many of the recent findings of micro level analyses. Women's education is the powerful engine of demographic change, promoting the decline in child

mortality and fertility, while slowing, on balance, population growth. Factors that permit higher levels of calorie consumption per capita, given the country's education and income, are associated with lower levels of child mortality. Although calorie availability in the low income world has improved in the 1970s by .9 percent per year and in the early 1980s by 1.1 percent, much of this has been due to the rapid increase in agricultural output in China. Calories per capita in Africa, for example, declined by .7 percent per year in the early 1980s (FAO, 1987; Table 2.6). At least among those countries with the lowest levels of nutrition, gains can be important for further child mortality declines and the subsequent decline in fertility. Combining micro and macro data sources and methods of analysis promises to improve our sketchy understanding of the determinants of this century's mortality revolution. Progress on this front will provide a stronger basis for modeling fertility behavior, and thus a more complete analysis of the population explosion of our era.

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