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INTERPRETATION OF RELATIONS AMONG MORTALITY,
ECONOMICS OF THE HOUSEHOLD, AND THE HEALTH ENVIRONMENT

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INTERPRETATION OF RELATIONS AMONG MORTALITY,
ECONOMICS OF THE HOUSEHOLD, AND THE HEALTH ENVIRONMENT

1. Introduction: Issues and Evidence on the Causes and Consequences
of Variation in Mortality

Recent mortality declines in low income countries are often thought to stem from narrowly focused innovations in public health technology. If this were true, it might be reasonable to interpret simple associations between health, morbidity, and mortality, on the one hand, and behavioral and personal welfare outcomes, on the other, as prima facie evidence that these outcomes were the consequence of variation in mortality. For example, if regions experiencing declines in mortality reported increasing labor productivity and rising wage rates, it might be inferred that improvements in health contributed to these economic developments.

But I would like to consider the possibility that a household's endowments, including the skills of its members and the healthiness of its environment, interact in as yet poorly understood ways to determine social and economic differentials in mortality and changes over time in the general level of mortality. If this more complicated view of the process determining mortality proves substantially correct, and in particular if family resources and purposive behavioral patterns explain a statistically significant share of differences in the incidence of mortality in low income populations, then the job of disentangling the consequences of mortality change from the causes of that change promises to be a most difficult one. In such a two-way causal relationship, the separation of

the cause from the effect requires a statistical basis for identification, which may only exist when unusual circumstances are responsible for perturbing mortality rates over time or displacing social and economic differentials in mortality without altering other environmental conditions or economic endowments of persons. The central issue is whether a significant share of the systematic variation in mortality across households, and perhaps across other social, economic and regional groupings of the population, can be understood in terms of purposive behavior of these groups constrained by their health environment, their physical endowments, and their human resources? If this explanatory framework proves useful, it then becomes more difficult to infer from standard cross sectional data how mortality variation affects other personal characteristics, personal welfare, and indicators of social performance.

The paper is organized as follows. Section II proposes a taxonomy of possible sources of the mortality change. Section III states the economic framework for explaining variation in child health investments and the consequent incidence of child mortality. An examination of conventional data from the 1973 Census sample from Colombia is reviewed in Section IV in order to illustrate a methodology for the study of social and economic differentials in child mortality ratios and to suggest the usefulness of the economic approach to this problem. A highly tentative discussion of the consequences of mortality differentials and change is presented in Section V. Section VI reassesses the justification for this approach to the study of variation in a couple's child mortality that seeks to estimate the effects of both parental education and market

endowments, and eventually can be used to quantify the effects of community policies to enhance maternal and child health.

II. Sources of Mortality Change

Several sources of change in mortality are outlined below. Depending on interactions among the public health system, the market system, and the household sector, it may be more or less difficult to infer how the individual or society is affected by mortality differentials across social and economic groups at one point in time, or by changes in mortality over time within appropriately defined groups.

A. Public health activities may reduce the exposure of all individuals to disease, without substantially changing personal economic resources, relative prices, or individual behavior. Personal welfare and behavior change as individuals experience less disease, which is assumed to occur independently of personal characteristics or behavior. In this instance, the reduction in mortality is exogenous to individual behavior; the improvement in health resulting from public health activities can be studied without extensive analysis of the demand for health at the individual or household level. Smallpox or malaria eradication may be an example.

B. More common are public health activities that subsidize the cost of preventive and curative medical services, information, and supplies. They thereby encourage people to utilize these inputs with the anticipated result of reducing mortality. These interventions are often treated as though they were exogenous to the community and individual served,

but they generally are not. The geographic distribution of public health activities is conditioned by political, social, and economic factors, and may even reflect the communities' preferences for and priorities among health and social services. At the individual level, the subsidized services are sought differentially by individuals who command different amounts of economic resources, exhibit different abilities, and have acquired different educational advantages. Health clinics, family planning activities, home hygiene and health education extension activities all fall in this category of interactive process involving both nonmarket subsidies and the characteristics of the demanders of health care. Evidence that the level of services provided by such public health activities is associated with change in mortality or other individual or community outcomes is a weak basis for inferring that the particular public health activity has caused these changes.

The responses of individuals and families to changes in market mediated signals can be decomposed into those originating in incomes, prices, returns on investment in survival, and productive efficiency, that together influence the expected incidence and pattern of mortality.

C. Increases in income or command over economic resources systematically influence the level and pattern of allocation of money expenditures, and more generally income affects the underlying allocation of time among leisure, nonmarket work, and market work activities. These systematic shifts in revealed demands associated with income can be portrayed by the framework suggested by Engel (1895); these income conditioned demand functions have direct and indirect repercussions for health and mortality.

Direct outlays on health services increase with income -- perhaps in some instances more than proportionately. Indirectly, expenditures on food, clothing, shelter, and sanitation can reduce mortality (Wrigley, 1969), whereas other forms of consumption -- of tobacco and alcohol, for instance -- can increase mortality. It has been argued that the control of many infectious diseases and pneumonia has recently widened wealth related mortality differentials in some low income countries. Yet as degenerative diseases, such as cancer and those of the heart, became increasingly important causes of death in high income countries in this century, the risks of mortality, with some exceptions, appear to have become less strongly associated with material wealth and possibly more closely linked with consumption patterns and levels of education (Fuchs, 1974; Antonovsky, 1967; and Vallin at this conference). Evidence on this score, though, is fragile in the high income countries, and highly speculative in low income countries. No new techniques are required for study of private demand patterns and health outcomes. These relationships may be estimated from cross sectional household survey data on mortality, health, time allocation, income and expenditure patterns. The infrequency of death suggests the need for large samples, however, and experimentation may be needed to improve instruments for eliciting reliable retrospective information on the incidence of mortality among household members such as own children, and among relatives, such as siblings (Hill and Trussell, 1977; Brass, at this conference).

D. Relative market prices may also account for differences in private behavior that influences mortality. The measurement of these

price differences across households at one point in time and within households over time may call for innovative research methods. It has been common to stress the opportunity value of time required to avail oneself of medical services in high income countries (Acton, 1973). These time costs are undoubtedly important in a poor country as well, where trained health workers are scarce and transportation systems are often primitive. Changes in the value of services can also be viewed as a change in its relative price. For example, a five mile trek with a sick child to a village clinic might not have repaid a mother's effort in many poor countries before the advent of antibiotics. Similarly, medical advice on methods of birth control might not have been of substantial value before the 1960s when the IUD and pill first became widely available throughout the world.

E. Changes in the expected returns on investment in survival may also affect how people allocate their time, expenditures, savings and investments. With an increase in the value of time (reflected in rising wage rates), there is also an increase in the return on investments in reducing morbidity and enhancing health. As life expectancy increases, so do the returns on all forms of human capital investments: basic nutrition, schooling, health care, vocational training and migration. Employers who share the costs of and returns on investment in specific training might also be expected to increase their commitments to vocational training for their workers as the prospects that an individual will die or will be unable to work decrease. Similarly, as the need to spread risks due to frequent mortality becomes less important,

investments can become more concentrated in the smaller nuclear family, rather than be dispersed in the extended family.

If the nature of the development process and associated technical change alters the mix of employment opportunities for men and women, this is reflected in wage rates received by them in the open labor market. Where women's wages are relatively higher compared with men's, the returns on investment in survival should be more favorable for girls relative to boys, and the intrafamily allocation of resources would reflect this differences in returns to survival by sex. The labor market may thereby affect the consumption and investment resources provided to boys and girls within the family (Schultz, 1979). These intra-household allocations of resources among children may in turn affect the health, future productivity, and survival prospects of men and women.

F. Finally, the people's skills may influence their capacity to deal with exposure to the risks of mortality, given subsidized public health services, personal income, market prices, and the returns to survival. For lack of a better term, economists refer to these skills as enhancing the efficiency of the individual in producing "good health" (Grossman, 1972). The most common hypothesis in this regard is that certain basic levels of schooling permit people to produce for themselves better health without increasing their expenditure of time and market goods, and thereby to reduce their risks of mortality. As in other forms of behavior where education is thought to enhance the market and nonmarket productive capacity of the individual, these gains can be

divided into a static increase in output per hour of work and a dynamic gain in allocative efficiency in dealing with an environment where inputs and prices are subject to change (Welch, 1970; T.W. Schultz, 1975). In the case of mothers -- and perhaps fathers -- this efficiency in nonmarket production of health may be assumed to extend to their children's prospects for survival as well as their own. This presumes that the survival of offspring is always good for parents, although this is moot (Scrimshaw, 1978).

Attribution of Mortality Declines Among Sources

The orthodox interpretation of declining mortality rates in the low income world is set forth by Stolnitz (1955, 1956, 1965, 1975) in a series of articles beginning almost 25 years ago and reiterated by Demeny (1965) and Arriaga and Davis (1969). Stolnitz argues that the evidence of widespread declines in mortality in countries at very different levels of development and experiencing different rates of growth suggest that the socioeconomic setting is of minor significance in explaining what has occurred, and that credit should be given to international and national applications of new public health technology. In other words, the mortality transition is due largely to changes in public health techniques that have not relied upon changes in economic conditions and individual behavior. He restated his viewpoint ten years later: "Mortality trends are remarkably neutral with respect to economic events -- Economic misery as such is no longer an effective barrier to the vast upsurge in survival opportunities in the underdeveloped areas" (Stolnitz, 1965). Though this remains the common view, growing doubts

are emerging that we can as yet attribute the decline in death rates to any particular cause or set of causes.

Investigations of differences in death rates across countries also cast doubt on the accepted view that declines in mortality have occurred independently of economic development in low-income countries. Investigations have widely confirmed that across countries at one point in time per capita income is negatively associated with age-specific death rates. But as in many economic relationships, affluence is subject to diminishing returns when linked to death rates or the expectation of life at birth. Preston compares the nonlinear relationship between life expectation at birth and per capital income in constant 1963 dollars. Using mostly high income countries in 1930 and a more representative sample of countries in 1960, Preston fits the pattern of mortality by income level in each year to a general logistic function. The difference between the two curves for 1930 and 1960 can then be interpreted as a structural change in underlying conditions other than incomes. Clearly, the curve has shifted upwards and given the same average income level the average inhabitant of a middle or upper income country has gained greater longevity in this 30 year period. Only 10 to 25 percent of the growth in life expectancy for the world as a whole of 12.2 years between 1930 and 1960 is accounted for by the growth in per capita income (Preston, 1976a). In a subsequent exercise with a larger sample for 1940 and 1970, Preston (1976b) accounts for about half of the increase in life expectancy in low income countries from 1935-1939 and 1965-1970, as estimated by WHO to be 17.6 years, by controlling for literacy and per capita calorie

consumption, as well as per capita income. Adding education as a continuous variable and including other systematic determinants of mortality may, therefore, reduce even more the structural shift in the life expectancy function that remains unaccounted for over time across countries (Rodgers, 1974; Chao, 1979). Regardless, it would be unwise to conclude that the remaining residual shift is due to any one factor such as "public health technological change" rather than a host of unobserved factors and systematic errors in measurement.

To demonstrate that technical advances -- insecticides, antibiotics, and new preventive and curative public health techniques -- have in fact caused the astonishingly rapid decline in mortality, requires that these factors be quantified and studied in conjunction with mortality declines. At the very least, the orthodox view of Stolnitz needs a thoroughgoing reevaluation. All sources of mortality change need to be studied together, including increases in education (especially mother's), men's and women's wages, nonearned income, changes in relative prices, and returns to survival, and local public health activities and services. Mortality is still relatively high among infants and preschool aged groups in low income countries, and it is among this group that increasing analysis of socioeconomic differentials in mortality may shed light on which environmental constraints are responsible for the much higher levels of child mortality in specific areas of the Third World.¹

¹The magnitude of mortality differentials among classes also suggests an additional indicator of how unequally health and welfare are distributed among persons in this period of rapid improvements. A slogan popularized in recent years is to assure all the world's population of its basic needs by the year 2000, among which health is central. Aside from national estimates of infant mortality and life expectancy, little attention has yet been directed to the hard task of determining who bears the high mortality levels and whether there is a more efficient way to help reduce mortality among the disadvantaged than to raise directly their income and/or education.

III. An Economic Framework for Interpreting the Determinants of Mortality

Several working hypotheses simplify the discussion and as preliminary generalizations do not seem at odds with reality. First, it is assumed that mortality and morbidity are influenced, subject to substantial seemingly random variability, by an individual's stock of "health capital". When mortality is reduced, therefore, one expects to observe some tendency for morbidity to decline. Measured in terms of "sick days", morbidity reduces the time a person can work in market and nonmarket activity. It is also believed that morbidity reduces the intensity of work that an individual can sustain during healthy (i.e., not sick) days. People also like to live and live a healthy life. The total private gain, therefore, includes the utility that an individual derives directly from a reduction in morbidity (and expected mortality) in addition to the effect of the morbidity-mortality reduction on his capacity to undertake work and the productivity of that work. In this taxonomy, persons seek to reduce morbidity (and mortality) both for its benefits as a consumer good and as a producer good. Since in both instances the allocation of resources to the production of "better health" involves the current sacrifice of market income and opportunity costs for a stream of future benefits, the process is appropriately treated as an act of investment in a durable stock of "health capital" (Mushkin, 1962; Grossman, 1972).

The second working hypothesis is that all parents value positively the health and survival of their own children. It is not essential for my purposes whether parents are assumed to treat children as simple extensions

of themselves and invest accordingly in the health capital of their children as they do in their own health capital, or alternatively, that parents are motivated to invest in the health of their children in order to transfer resources (with returns) over the life cycle, such as to provide parents with support in their old age. What I wish to exclude is the general practice of using child mortality as a device to regulate reproductive potential. Some couples confronted by reproductive performance in excess of their demands, may be expected to attach a negative value to an additional birth. Infanticide is too well documented as a historic institution in diverse cultural settings to presume that child neglect is never socially tolerated as a population control measure (Scrimshaw, 1978). Nonetheless, though child mortality may occasionally enter into the family planning strategy of some segments of a population, it is assumed here, for simplicity, that child health and survival are sought by the representative parent, even though limited resources constrain the pursuit of this and other lifetime goals.

The Determinants of Health and Mortality

Two types of health determinants can be distinguished: (1) the household's marketable endowments and (2) the characteristics of the household's environment that define the expected health that market and home resources can produce. The household is the unit of analysis because this unit coordinates the consumption of and investment in children, and accomplishes intergenerational transfer of resources and culture that is the core of the family and the foundation of the society. The endowments of the household refer to economic resources evaluated

at their marginal product, converted to common units as a flow of services or income return. Land and material wealth are valued at their market rental rates, whereas the rental value of the labor of household members working in the market is the wage rate. This market wage is generally equated to the shadow value of time in nonmarket activities; this is achieved by varying the allocation of time between market and nonmarket activities, for while the market wage is independent of hours worked in the market, the shadow value of time in nonmarket activities is a diminishing function of hours worked in nonmarket pursuits.

Since market prices may differ across households that operate in geographically separated markets, these transfer prices belong among the set of variables that define the real market value of the household's endowments. The more comprehensive shadow price of goods and services involves both a pecuniary cost of expenditure on market goods and an opportunity cost of time that is required to consume or use the market good or service (Mincer, 1963; Becker, 1965). For example, the market price of medical services may be the same across households, but their time (access) prices may vary according to the household's location with respect to the network of private health workers and public clinics. Public subsidies to medical supplies and services may thus affect relative prices of medical inputs facing private households differentially, depending on the household's location and its alternative sources of supply.

If a family member does not work in the market labor force, no market rate or rental value of his labor endowment is observed. All

that one can directly infer is that the market wage rate currently offered to the individual is less than the shadow value of his time employed in nonmarket activities. There are methodological problems in inferring what the value of the nonmarket worker's labor is worth (Heckman, 1974, 1979; Schultz, 1975, etc.). Suffice it to say that a systematic factor responsible for elevating the individual's nonmarket productivity above that offered in the market is the household's other endowments that complement the individual's productive talents, such as land, livestock, housing, and the purchasing power of the wages of other household members. Since these other endowments of the household are included among the determinants of health, they should provide, in combination with an imputed market wage offer, a satisfactory if not ideal basis for capturing variation across households in the shadow value of the time of persons outside of market labor force.

The second group of factors that fixes the capacity of the household to achieve, on average, better health for its members, include the exposure to disease and the efficiency of the household in coping with that risk. In the first case, disease exposure might be affected by public health programs that eradicate or markedly reduce the incidence of a specific disease, such as smallpox or malaria. As in the first source of mortality change discussed in Section II, such a reduction in exposure benefits all persons equally without individual expenditure of time or goods or modification in behavior. The "environment" in which health is produced has been altered, in this case, by an investment in what economists call a "public good", hence, one person's realization of

this health benefit in no way reduces the benefit enjoyed by another.

Conversely, public investment projects may spread disease to populations that were heretofore unexposed. The Aswan dam in Egypt is said to have spread schistosomiasis, and the British-built canals and transport system are implicated in the diffusion of virulent forms of malaria from Burma throughout the subcontinent of India in the late 19th century. Such changes in disease exposure are for the most part outside of the individual's short run control. But in the longer run, migration to escape disease infested districts and the development of prophylactic behavior modifies the population and the prevalence of the disease. Persisting regional variation in disease associated with public programs will embody endogenous components, due to private choice of residential location and adoption of preventative measures.

A second source of variation in exposure to disease is attributable to innate geography and climate. Technology can modify the health effects of such environmentally fixed conditions, however. As in the previous example, permanent variation in the healthiness of the natural environment leads to interregional migration and differential population growth until other compensating factors begin to offset the greater health risks. The productivity of labor in agriculture may increase in unhealthy areas as the land-labor ratio increases due to relative outmigration, or simply people may prefer to live in a warmer, if nonetheless less healthy, environment. If such compensating variation underlies the regional distribution of populations, one can imagine that people who have a preference for market income relative to health

might come to represent a larger fraction of that population living in an unhealthy but high wage region.

London during the 17th and 18th centuries might have fit this example (Wrigley, 1969). If only the most hardy migrated to London, the unhealthiness of the London environment would have been understated by its excess mortality compared with the surrounding areas. Alternatively, those that migrated to London may have been least inclined to invest in their health and most inclined to earn a higher income and spend it on immoderate consumption (of gin) resulting in a heightened mortality. In this second example of migrant selectivity, the excess mortality of London would have overstated the innate unhealthiness of London's physical environment. Without more information on the nature of the selectivity of migration and the compensating variation in other attributes of the region, persistent patterns of mortality associated with the physical environment of regions can be treated as only a first approximation for the "effect" of the environment on mortality. Even when the endowments of the household are also identified as suggested above, and held constant statistically, regional variation in mortality may be difficult to attribute to a particular set of factors.

The last factor determining mortality is the efficiency of the household in producing "health." In combining market inputs and the time of household members one expects to find cross-sectional variation in the efficiency of households in investing in the survival of their members. The trait most commonly associated with such efficiency in market and nonmarket activities is education and the stock of knowledge that schooling

is thought to transmit. Since the market wage rate reflects education's effect on market productivity and the opportunity cost of time of those working in the labor force, the effect of education on mortality holding constant for the market wage suggests whether education enhances a person's time-efficiency in health production by more or less than education increases the efficiency of labor in market production (Grossman, 1972, 1976). If its impact were proportionately the same, education would be "neutral" in its technological effect on the individual's allocation of time to health investments.² If the production of health were intensive in its use of market goods relative to own-time, increasing a person's education while holding their wage constant could cause a substitution away from the production of health and consequently increase mortality. Any such tendency would be at least partially offset by the increased consumption demand for health associated with the rise in full (market and nonmarket) income. Regardless, it is not possible to predict from economic theory alone the sign of the education effect on health, holding market wages constant.

Combining the various determinants of the health stock of children in a nuclear family, we obtain the following general function expression:

²Since it is often observed that mothers invest more of their time in child care than fathers, one might expect that a mother's education exerts a stronger effect on child health than that of the father. But the neutrality hypothesis does not rely on the magnitude of time allocated to child health care time more than it does the productivity of time in the market.

$$M_{ij} = M(W_{fi}, W_{mi}, V_i, P_{ij}; H_j, R_j, E_{fi}, E_{mi}) \quad i = 1, \dots, n \quad (1)$$

$$j = 1, \dots, m$$

where M_{ij} refers to the ratio of the number of children dead to the number of children born alive to the i^{th} mother of a specific age residing in region j , W_{fi} and W_{mi} are the market wage offers to the mother and her husband, respectively, V_i is a vector of assets in the physical wealth of the mother's household, and P_{ij} is a vector of market and time prices facing the household, H_j is a vector of public health inputs in region j per potential recipient, R_j the region's physical health environment, and E_{fi} and E_{mi} are the educational attainment of the mother and her husband.

As important as are these primary sources of variation in mortality, it is equally important that jointly determined behavioral decisions of the couples not be included in estimating such a mortality function using standard statistical techniques.³ For example, the fertility of the mother probably exerts some effects on the prospects for child survival, at least in high fertility populations. But child mortality is also implicated as a stimulant to fertility, through the formation of mortality expectations that influence the age at which childbearing begins and the pace at which it thereafter proceeds to provide a hedge against the generally perceived force of mortality, and also through a tendency for actual child deaths to induce a replacement response,

³See Goldberger and Duncan's (1973) collection of structural equation studies in the social sciences. I am proposing here that mortality shares a common origin in the household demand system and thus must be treated as a simultaneously determined equation along with labor force behavior and fertility.

involving potentially both biologically autonomous and behaviorally motivated processes (Schultz, 1969, 1976). Without a clear basis for identifying one relationship from the other, and thus separating the effect of fertility on child mortality from the reverse causation, there is no way to include fertility as a conditioning variable among the determinants of mortality without introducing bias (Goldberger and Duncan, 1973). The coefficient estimates for the other factors conditioning mortality -- household endowments, efficiency, and regional conditions -- also cease to be consistent estimators of the causal impact of these factors on mortality if the jointly determined fertility variable is included among the mortality determinants.

The maternal age at marriage, the age at first birth, and indeed the timing of all of the woman's births provide relevant information on the period of time over which her children have probably been exposed to mortality risks. Comparisons of child death ratios across individuals with distinctly different childbearing patterns may, therefore, diverge markedly from comparison of conventional age-standardized death rates for their children. But if such information on the timing of childbearing is used to condition directly the child death ratio, namely as a right-hand-side explanatory variable in the equation (1) explaining the observed child death ratio, the equation is again subject to simultaneous equation bias. The onset of childbearing is closely related to completed fertility and jointly determined with child health investments and will be undoubtedly stochastically linked with variation in health outcomes across couples. To understand the impact of economic

or environmental factors on child mortality it is hard to know what it means to "hold constant" for the life cycle timing of births.

If one cannot directly include the level of fertility or the timing of births as explanatory variables in the equation accounting for variation in the child death ratio across couples, this information should still be used to improve the measurement of the dependent variable -- child mortality as an indicator of child health. Although most procedures, such as those pioneered by Brass (Brass and Coale, 1968; Hill and Trussell, 1977), were developed as an analytical tool for the estimation of mortality levels from aggregate data sources, they should prove suitable for adjusting the observed child mortality ratios of individual couples in order to analyze sources of variation in mortality across a population.

Given knowledge of a population's life table values for age and sex-specific mortality rates, the observed child death ratio can be normalized (divided) by the "expected" child death ratio based on the years of exposure the woman's births have potentially experienced.⁴ Procedures designed to perform this adjustment on retrospective indicators of child mortality have proceeded in several directions (Palloni, 1979),

⁴I have used elsewhere (Schultz, 1978b) a simple normalization of the actual incidence of child mortality by the expected incidence given the mother's age assuming that her births were distributed according to the average national age pattern (rural and urban fertility schedules were distinguished in Colombia from the census file itself). This normalization divides the child death ratio by a nonlinear transformation of mother's age. In the Colombian case considered in this paper, the inclusion of a linear age variable on the right hand side of the equation eliminated the effect of the normalization. Work is underway using information on the open birth interval, which for younger women may be used to perform a Brass-like exposure adjustment. It is, of course, precisely for these younger women (under age 30) for whom the adjustment of the child death ratio is most urgently needed.

but adapting these methods to the analysis of individual data is only beginning (Schultz, 1978b). Unfortunately, in the empirical section that follows, the available Colombian census data contain no information on maternal age at marriage or age at first birth. Holding constant for individual year of age for the mother may mitigate this problem, but for example, among younger women the association between their education and their child death ratio undoubtedly overstates (negatively) the association between their education and their conventionally measured age-specific child death rate. It is presumed, of course, that better educated women of the same age began their childbearing later, on average, and their children have, therefore, had fewer years to survive than the children of less educated women. This bias, however, may be moderate for women over age 30, and, one might hope, negligible for women over age 40.

The inability to adjust the child death ratios for duration of exposure in the empirical example that follows does not imply that such an adjustment is unnecessary. It is imperative that we develop improved methods for measurement of mortality from individual retrospective questions if we are to increase our knowledge of the determinants of mortality in the cross section, and thereby improve our basis for projecting and directing mortality changes over time. In order to normalize retrospective longitudinal mortality ratios it may be convenient to employ an externally generated "model" life table or an independently estimated national life table for one particular year. A more satisfactory procedure might extract from the sample's own information on mortality a smoothed estimate of the schedule of exposure-specific retrospective mortality rates for births. This internally generated normalization factor will then embody both secular changes in mortality levels and structure that occur over time and cultural specific patterns of recall

error that often enter into retrospective responses of this form. It seems likely, however, that plausible differences in life table levels and differences in the age patterns of mortality would not change the normalization procedure sufficiently to change substantially the estimates of the child mortality ratio equation (1). Unfortunately, adjustment for differences in the average duration of exposure of each woman's births to mortality might well modify the illustrative results for Colombia by a more substantial margin, at least for women under the age of 30.

The nature of the dependent variable in the household mortality function is not normally distributed, being discrete and distributed conditionally on the number of children ever born. The statistical techniques suitable for the analysis of such a dependent variable are not well established.⁵ Even when the own-child mortality rate is considered on the right hand side of a fertility equation, there are problems (Williams, 1977). As in all multivariate analyses, the functional form of $M(\cdot)$, the scaling of the endowment variables, and the specification of the technology shifting factors will change the empirical patterns that are found in any particular set of data. Much experimentation in these issues of empirical specification remain to be undertaken, for I know

⁵Since the dependent variable is confined to the unit interval, and appears to be an aggregation of sibling "dosage response" curves within the family, it is natural, if not altogether justified, to rely on the common biometric models such as the logit or probit. The explanatory results reported in Section IV, however, are based on ordinary least squares estimation of linear models. Later work will entail considering more appropriate estimation methods. Given the size of the census samples examined here, it is unlikely that strong findings from the linear model would be qualitatively altered by only a nonlinear transformation of the dependent variable. Other statistical issues of how to remove the conditional relationship with fertility, however, may possibly change the nature of our findings.

of no analysis that jointly considers a combination of household and regional information in the study of household variation in child mortality. Any such exercise can only consider women with births who have defined experience of child mortality. In order to evaluate the characteristics of the husband, the exercise is also limited to women who are currently married with husband present. Appendix Table D indicates how these criteria reduce the size of working samples in reference to a Colombian census file. Few census or survey samples include information on varieties of wealth and fewer include any information on regional market prices or wage rates. Finally, regional information on public health activities and services and the geographic health environment are infrequently examined in studies of interregional variation in mortality, holding constant for the household economic endowments and education of the people in those regions. With this long term research strategy in mind, the next section reports some preliminary tabulations and regressions analyzing unadjusted child mortality ratios calculated from the 1973 Colombian census four percent sample.

IV. Household Determinants of Child Mortality: An Empirical Example

The October 1973 Colombian Census of Population and Housing collected information on children ever born, now living, interval since last birth, personal monthly income, age, education, residence, and so on (DANE, 1978). I am currently engaged with Mark Rosenzweig in the collection of municipality information as wage rates, education and health programs, public health infrastructure, and geographical characteristics of the health environment. The empirical findings reported here

are based on only a preliminary examination of the census sample of 860,000 persons, sorted into husband-wife households in which the wife has had at least one child. Appendix D-1 shows the proportion of all women of a specific age and residential area who are included in this subsample of the census file. Many younger women with at least one child are not currently living with a husband. Some women are also dropped from the sample for not responding to the fertility question, and other analysts of these data have treated these women as having had no children. This controversial treatment of the nonrespondents does not influence us, since child mortality is not defined for this group in either case. The requirement that the husband report his monthly income restricts the working sample by about 10 to 20 percent, but to consider couples for whom both husband and wife report income would drastically reduce the size of the sample, because of the low rate of market labor force participation among married women in Colombia. When community level information on public programs, infrastructure, and climate are also included in the child mortality equation (1), the resulting coefficients on the household education and income variables examined here are likely to change. The existing literature and theory does not inform one, however, as to what changes are to be expected when a more complete specification of the child mortality equation is actually estimated.

The data are first examined by means of extensive tabulations of the child mortality ratio (children dead to children ever born), by the educational attainment of husband and wife, by mother's age and rural/urban residence. These are reported in the upper panel of

appendix tables A-1 to A-12. Virtually all husbands are in the labor force and some four-fifths report monthly income. Since the husband's income and schooling are highly correlated, the lower panel of the appendix tables reports the cross tabulation of husband's income and wife's education. Although the large number of cells defy a simple summary, it is evident that wife's education is strongly associated with child mortality, particularly in urban Colombia.

The second stage in the analysis is to simplify the full tabulations to a more comprehensible set of regression equations by sequentially testing whether the restriction that the effect of a specific factor is additive rather than fully interactive with the other factors. Certain categories are retained for stratification where the effects of factors did not appear comparable or simply additive across categories. Accordingly, rural urban differences are always highly significant and full stratification is retained throughout by mother's age and rural/urban residence. Dummy variables are defined, as in the tabulations, for four ordered levels of education (excluding "other" which appeared to include persons with some secondary schooling in urban areas and some primary schooling in rural areas and six ordered levels of income (omitting non-responses)). The regressions again confirm the strong association between child mortality and parental education, but less of a relationship with income, except perhaps in the urban areas. The pattern of income effects are frequently nonmonotonic, the two lowest income groups (under 600 pesos per month) generally report a higher than average child mortality rate and the two highest income groups (over

1800 pesos per month) frequently report a lower than average level of child mortality, at least in urban areas.

Converting the discrete education or income classes to continuous variables allows a single regression coefficient to summarize the average relationship between child mortality and the entire range of the variable. Elasticities are reported to facilitate comparisons across age groups and between urban and rural populations for whom the child mortality variable (and education and income) are substantially different (see appendix tables A-1 through A-12). The partial association between the mother's and father's schooling and child mortality is reported in Table 1 conditioned only on the wife's age. The reported elasticity represents the proportionate change in child mortality that is associated with a proportionate change in the determining variable, where the relationship is evaluated at the means of the variables for the specific age and residence subsamples. The level of statistical significance associated with the underlying regression coefficient on which the elasticity is based is indicated by the number of asterisks. The underlying regressions are reported in Appendix Table C-1.

In urban areas of Colombia both the education of husband and wife are associated with a reduction in child mortality. Before age 30, the elasticity with respect to the wife's education exceeds the elasticity of the husband's, but for the later age groups they vacillate in relative magnitude. The overall magnitude of the elasticity estimates is large, however, and greatest among young women. For example, in the 30-34 age group, a twenty percent increase in the education of husband

Proportionate Response of Child Mortality Rate
to a Proportionate Variation in the Years of Schooling
of the Mother and Father: Colombia 1973^a

| Age of Mother | Urban | | Sample Size | Rural | | Sample Size |
|---------------|----------------------------|--------------------|-------------|----------------------------|--------------------|-------------|
| | Elasticity with Respect to | | | Elasticity with Respect to | | |
| | Mother's Schooling | Father's Schooling | | Mother's Schooling | Father's Schooling | |
| 20-24 | -.20** | -.054** | 4984 | -.066** | -.024** | 2896 |
| 25-29 | -.53** | -.19** | 7067 | -.15** | -.098** | 3602 |
| 30-34 | -.32** | -.37** | 6692 | -.16** | -.081** | 3421 |
| 35-39 | -.27** | -.37** | 6360 | -.034 | -.11** | 3472 |
| 40-44 | -.24** | -.24** | 4830 | -.073** | -.083** | 2661 |
| 45-49 | -.18** | -.26** | 3469 | -.059* | -.063* | 1961 |
| 50-65 | -.21** | -.20** | 4267 | -.018 | -.042* | 2802 |

* Coefficient statistically different from zero at 5 percent level
(1 tailed test: $t > 1.65$)

** Coefficient statistically different from zero at 1 percent level
($t > 2.33$)

^a Age of mother is held constant in linear regression including years of education of mother and father. Sample is restricted to couples reporting education and husbands reporting positive income.

Source: Schooling elasticities are obtained by multiplying the regression coefficient on schooling in Table C-1 by the ratio of the sample average years of schooling to the sample average child mortality ratio.

and wife, or about one additional year, is associated with a combined 14 percent reduction in child mortality from 5.8 to 5.0 percent. An adjustment of the child mortality ratio for the timing of births would presumably reduce the magnitude of this association, but its persistence into later ages indicates the bias is probably not substantial after age 30 in urban areas.

In the rural areas the relationship is weaker; for example, in two age groups the mother's education is not significantly related to child mortality, and the magnitudes of the elasticities are at most half the size of those in the urban areas, and occasionally as small as a fifth of the urban levels. In the 30-34 age groups in the rural areas the level of education is 1.9 years for both sexes, less than half that in the same age group in urban areas, and child mortality is 11.6 percent or twice the urban level. A 20 percent increase in schooling in the rural population is associated with a 5 percent reduction in child mortality to about 11.0 percent. The absolute and the relative impact of parental education on child mortality in the rural areas appears weaker than in the urban populations of Colombia.

The next question one may ask is whether the strength of the husband's (and perhaps wife's) education association with child mortality is only a proxy for income, that permits the household to purchase more market health inputs as well as afford to allocate more time to child care, despite its possibly greater opportunity cost. Inclusion of husband income with both spouse continuous education variables in the child mortality regressions does not change the results in Table 1. Only

in the urban 40-44 age group and the rural 50-65 age group is the continuous observed husband's income variable statistically significantly different from zero at the five percent level, and in the older rural group the sign of the husband's income effect is perversely positive. Neither education elasticity changes with the inclusion of the husband's income variable in the regression.

Does this puzzling lack of a relationship between income and child mortality reflect errors in measurement of income, or the transitory variation in monthly incomes that might be weakly associated with a slowly accumulated investment stock such as child health? Would a more permanent life-cycle measure of the husband's income or the market wage offers available to the wife be more closely associated with long run child health investment decisions? A standard procedure in the microeconomic analysis of household behavior is to estimate an auxiliary regression predicting the wage level of men and women separately based on their years of schooling, S , post-schooling experience (age-schooling-7), X , and experience squared, X^2 , and characteristics of the regional labor market in which they work, R (Schultz, 1975).

$$\ln W_i = \alpha_0 + \alpha_1 S + \alpha_2 X + \alpha_3 X^2 + \sum_{j=4}^{m+4} \alpha_j R_j + \epsilon_i \quad (2)$$

$$i = 1, 2, \dots, n$$

where $\ln W_i$ is the natural logarithm of monthly income in pesos of the i^{th} person, for whom $R_j = 1$ if they reside in the j^{th} labor market and $R_k = 0$, for $k \neq j$. Deviations in individual logarithmic wages from

that explained by schooling, postschooling experience and region embody the effects of many omitted variables, errors of measurement and functional form. This disturbance, ϵ_1 , is here assumed to be a random normally distributed error of constant variance.

These auxiliary income equations have been fit by ordinary least squares to individual income responses reported in the Colombian census sample by men and women in urban and rural areas separately. This and other specifications of the income generating function are discussed in Fields and Schultz (1977). As reported in appendix tables B-1 through B-4, these simple income equations account for from 22 to 70 percent of the logarithmic variance in individual incomes in various age, sex and regional subpopulations, which is a somewhat higher proportion explained than is generally found in similar studies of incomes in the United States (Fields and Schultz, 1977).

These estimated income equations are then employed to predict a "permanent" logarithmic income or market wage offer, $\hat{\ln W}_1$, for all husbands and wives in our sample depending on their sex, schooling, post-schooling experience and region of residence, where the $\hat{\alpha}$'s are the ordinary least squares estimates of equation (2):

$$\hat{\ln W}_1 = \hat{\alpha}_0 + \hat{\alpha}_1 S_1 + \hat{\alpha}_2 X + \hat{\alpha}_3 X^2 + \sum_{j=4}^{m+4} \hat{\alpha}_j R_j.$$

This permanent logarithmic wage is imputed to persons regardless whether they worked in the market labor force or reported an income in the census. The child mortality ratio is then regressed against the imputed logarithmic wages for husbands and wives and the elasticity of

the mortality ratio with respect to this measure of permanent income is reported in Table 2. The underlying regressions are reported in appendix Table C-2. In the first row of Table 2 the regression includes only a control for the age of mother, whereas the second row reports the calculated elasticity when four levels of educational attainment of the mother and of the father are also introduced into the regression as dummy variables. The second specification attempts to determine if the imputed permanent wage is only picking up the strong effect of education on wages. The potential effect of the market wage is statistically identified by the inclusion of R_j , namely 22 departmental labor market dummy variables in the male wage equations and 3 or 4 regional labor market dummy variables in the female wage equations.

According to the results in Table 2, the wage effects represent more than the effect of education. Although the inclusion of education sometimes reduces the estimated wage elasticities, occasionally it also increases them, as for urban mothers age 35-39 and urban fathers age 40-44. The effect of permanent income differences on child mortality is much less notable in the Colombian rural population, and here the association with the women's market wage is the more relevant factor depressing child mortality. As with the education elasticities which tended to be of roughly the same magnitude for mothers and fathers after age 30, the imputed wage elasticities in the urban samples are distinctly larger for women than men before age 30, and roughly comparable thereafter. In the rural population, the mother's wage elasticity is generally larger than that for the father, however. The rural mother's education elasticity also exceeds the father's up to the age of 34.

The imputed wage variable is based on the continuous years of schooling

Proportionate Responses of Child Mortality Rate

to a Unit Variation in the Logarithm of Parent Monthly Imputed Wage Rates:

Colombia 1973^a

| Age of Mother and other controls | Urban | | | Rural | | |
|-------------------------------------|-------------------------------|------------------|----------------|-------------------------------|------------------|----------------|
| | Elasticity with Respect to | | Sample Size | Elasticity with Respect to | | Sample Size |
| | Mother's Wage | Father's Wage | | Mother's Wage | Father's Wage | |
| 20-24 | | | | | | |
| without education | -.850** | -.313** | 5705 | -.366** | -.132 | 3457 |
| with education ^b | -.837** | -.220 | 5705 | -.347** | -.0694 | 3457 |
| 25-29 | | | | | | |
| without education | -.687** | -.167** | 8073 | -.195** | -.0596 | 4334 |
| with education ^b | -.635** | -.143 | 8073 | -.137** | -.0423 | 4334 |
| 30-34 | | | | | | |
| without education | -.400** | -.389** | 7665 | -.167** | .0243 | 4144 |
| with education ^b | -.345** | -.470** | 7665 | -.115** | .0609 | 4144 |
| 35-39 | | | | | | |
| without education | -.472** | -.330** | 7399 | -.0892** | -.0417 | 4318 |
| with education ^b | -.564** | -.236** | 7399 | -.0359 | -.0025 | 4318 |
| 40-44 | | | | | | |
| without education | -.344** | -.270** | 5804 | -.142** | .0258 | 3279 |
| with education ^b | -.333** | -.423** | 5804 | -.158** | .0598 | 3279 |
| 45-49 | | | | | | |
| without education | -.287** | -.286** | 4309 | -.128** | .141** | 2485 |
| with education ^b | -.283** | -.344** | 4309 | -.126** | .185** | 2485 |
| 50-65 | | | | | | |
| without education | -.199** | -.218** | 4776 | -.0135 | -.0187 | 3226 |
| with education ^b | -.111* | -.144** | 4776 | -.0089 | .0044 | 3226 |

* Coefficient statistically different from zero at 5 percent level (1 tailed test: $t > 1.65$)

** Coefficient statistically different from zero at 1 percent level ($t > 2.33$)

^a Age of mother is held constant as in Table 1 but sample not restricted to husband's reporting incomes.

^b Four educational levels are represented by dummy variables for husband and wife, as well as age of the mother.

Source: Divide coefficient on imputed logarithmic wage variable in Table C-2 by mean child mortality ratio in the sample in Tables A-1 through A-12 to obtain elasticities without education. Underlying regressions with education dummies are not reported.

information, whereas education is controlled in the second set of mortality equations in Table 2 at four discrete levels.

A more serious problem is posed if the regional identifying variables in the wage equation also affect directly the health environment. If health conditions differ by region for reasons other than income level, the wage imputation model estimated here may not be properly identified. To decompose parent education's impact on child health into market and non-market components requires that we obtain another basis for identification. Unanticipated shifts in regional income levels might perform this function. Exogenous changes in output prices (e.g. coffee) or development of new industries (e.g. drugs) could alter incomes and not health conditions. But data are lacking on prices and output of coffee or drugs by region. It may be noted, however, that regional income differences are relatively greater in rural than in urban areas (Tables B-1 to B-4), whereas in rural areas male wage variation at least, is not associated with child mortality ratios.⁶

Returning to the problem of measurement of education in the wage and mortality equations, the child mortality equation is reestimated conditional on both parents' imputed (logarithmic) wages and years of schooling (continuous), and summarized in Table 3 (and C-3). Recall that the permanent imputed wage reflects in addition to age and education also the level of wages in the regional labor market (see Tables B-1 through B-4). The male wage functions are estimated within the urban and rural

⁶ There are additional problems which cannot be remedied with these data and methods. Very few mothers with husbands present actually work in the Colombian rural labor force and report monthly incomes. The weakness of the estimates for the rural population may, therefore, reflect this shortcoming of the approach and data. Also the census does not provide information on hours worked last month which could be used to convert the reported monthly income into the more appropriate hourly wage variable. Variation in hours worked is likely to be more substantial for women than for men, and may be particularly serious for rural women who may be periodically drawn out of the household by harvest fluctuations in labor market demand for daily agricultural workers. One also expects that the unobserved variable "hours worked" is not unrelated to the household's endowments. This probable correlation between the measurement error embodied in the measured wage and the other explanatory variables would bias the estimates of the parameters to the wage function and hence distort the estimates of the mortality equation.

**Proportionate Responses of Child Mortality Rate
to Proportionate Changes in Parent Imputed Wages and Schooling**

| Age of Mother | URBAN | | | | RURAL | | | |
|------------------|---------|---------|-----------|---------|---------|--------|-----------|----------|
| | Wage | | Schooling | | Wage | | Schooling | |
| | Mother | Father | Mother | Father | Mother | Father | Mother | Father |
| 20-24 | -3.08** | -.252 | 1.77** | -.073 | -.346** | .0284 | .0086 | -.129** |
| 25-29 | -2.38** | -.0081 | 1.53** | -.173 | -.154** | .0023 | -.0606 | -.106** |
| 30-34 | -1.13** | -.609** | .586** | .197 | -.100** | .0672 | -.0865** | -.0834** |
| 35-39 | -1.66** | .0391 | .912** | -.335** | -.0193 | .0130 | -.0447 | -.0937** |
| 40-44 | -.796** | -.350** | .354* | .0639 | -.175** | .100* | .0609* | -.119** |
| 45-49 | -1.04** | -.058 | .618** | -.198* | -.151** | .209** | .0402 | -.0863** |
| 50-65 | -.0373 | .0891 | -.221** | -.129* | .0194 | .0025 | -.0222 | -.0461** |

* Coefficient statistically different from zero at 5 percent level
(1 tailed test: $t > 1.65$)

** Coefficient statistically different from zero at 1 percent level
($t > 2.33$)

^a Age of mother is held constant in linear regression including years of education of mother and father. Sample is restricted to couples reporting education and husbands reporting income.

Source: Divide coefficient on imputed logarithmic wage variables reported in Table C-3 by the sample mean mortality ratio from Table A-1 through A-12 to obtain wage elasticities. Schooling elasticities are obtained by multiplying the coefficients on years of schooling in Table C-3 by the ratio of the sample average years of schooling over the sample average of the child mortality ratio.

subpopulations by age groups, allowing for levels to vary across the 23 department regional markets. For women the smaller sized samples undoubtedly contribute to the lower joint statistical significance of regional wage differences, and thus for women only five traditional urban regions are distinguished and four rural regions.

In urban areas, relatively high wages for men and particularly for women are associated with lower child mortality. This is interpreted as the effect of market income on the demand for child health. One percent higher market wages for women age 30 to 49 is associated, averaged over ages, with a 1.2 percent lower child mortality rate. However, if that increase in wages were due to an increase in the education of the mother the "wage" effect is half the magnitude, leading to only a .6 percent decline in child mortality.⁷ Why should the partial elasticity of child mortality with respect to a mother's education be positive?

To understand the sign of the direct effect of a mother's education in urban areas, it is necessary to also consider women's labor force behavior. The market wage exerts its effect on household endowments only for those in the labor force, and education in Colombia is positively associated with labor force participation, even when conditioned on market wage opportunities. More educated mothers are drawn into the labor force, given what can be observed regarding their market wage opportunities and those of their husbands. This finding suggests that the nonpecuniary benefits

⁷This is approximately equal to the magnitude of the simple relationship between education and child mortality summarized in Table 1

of market work compared with nonmarket work increase proportionately more rapidly than do wages as the education of the mother increases. This labor force effect of a mother's education accounts for the positive direct effect of a mother's education on child mortality. The tendency of more educated mothers to allocate a greater proportion of their time to market work leads to a deterioration in child health, holding constant for their wage rate. A larger model that also accounts for women's labor force participation decisions (Schultz, 1978a) is required to trace out adequately the manner in which the educated mother's enhanced market productivity contributes to her reduction in home time, and increase in market income, which have offsetting effects on the incidence of child mortality.

In the rural areas, the elasticity of child mortality with respect to the mother's market wage is consistently negative, as anticipated but only about one-tenth the magnitude of that estimated for the urban population. One might interpret this difference as implying that the marginal effect of market income on child survival is much larger in the urban sector than in the rural, even after one has taken into account the fact that urban wages are 50 percent greater than rural wages.⁸ The husband's wage effect on child mortality is generally insignificant except at the later ages when it is perversely positive in sign. On the other hand, the father's education exerts a consistent negative effect on child mortality at all ages. Given the lower premium for educated male labor

⁸ Analysis of rural Indian household survey data also found little correlation between measures of household income and wealth and the level of child mortality.

in the rural sector compared with the urban sector,⁹ the nonmarket productivity effect of education may exceed that offered in terms of the market wage for rural men. In the rural areas the mother's schooling is not consistently related to child mortality, exhibiting a negative relation at age 30-34 and a positive relation at age 40-44. The lower level of labor force participation of women in the rural sector suggests again the need to explicitly incorporate information on women's labor force behavior and explain this allocative decision jointly with that of child health and survival.

Conclusions and Qualifications

The substantial declines in mortality in the Third World recorded in the last three or four decades are often attributed to public health interventions that are assumed to be quite independent of economic development and the personal distribution of resources. Achievements in public health are consequently treated as belonging to the first source of mortality change that is only weakly related to (1) modifying individual behavior, (2) increasing private economic resources, (3) reducing shadow prices of health inputs, and (4) increasing returns on investments in human capital and survival itself. These four other sources of mortality decline also warrant study in combination with public health measures, using multivariate statistical techniques. Otherwise, we are unlikely

⁹The coefficient on years of education in the estimated income function represents an approximate measure of the internal rate of return to schoolings if a number of assumptions are maintained (Mincer, 1970, 1974). As can be seen from appendix Tables B-1 and B-3, men obtain a return on schooling in urban areas approaching 20 percent, but they obtain a return on schooling of only about half that level in rural areas.

to progress in understanding the determinants of mortality in low income countries. Mortality analysis framed at the household level shifts the primary focus of study to how families allocate limited resources to achieve multiple objectives, one of which is to invest in the health and survival of its members.

Educational attainment of mothers is closely linked to differences in child mortality (Arriaga, 1979, see also Behm and Caldwell's papers at this conference). But is this relation due to positive assortative mating that occurs in most societies that yields a positive correlation between a wife's education and her husband's education, wage rate, and income? Even when these characteristics of the husband are held constant by statistical techniques, is the remaining inverse relation between a mother's education and the mortality of her offspring due to the effect of schooling on the mother's market productivity and wage that indirectly contribute to the reduction of child mortality by increasing the household's general command over market goods and services? Or is the effect of the mother's education due to her increased nonmarket productivity, and specifically her capacity to invest more efficiently in her offspring's survival, given her endowments of market income and time for child care?

The data examined here for Colombia in 1973 suggest that in urban areas the market productivity effect of the mother's education appears a stronger factor in decreasing child mortality than is the nonmarket efficiency effect of the mother's education. Where women's wages are greater, given their age and education, child mortality is lower. The converse may be true in rural Colombia, where women's wages are less

strongly associated with child mortality, whereas the mother's education is inversely associated with child mortality. But the rural evidence should be approached with caution, for only a small and perhaps unrepresentative fraction of rural Colombian women participate in the market labor force and report wages. Other information at the community level on rural wages will be needed to improve our confidence in this aspect of the analysis of rural child mortality.

The selective nature of internal migration poses an additional complication. In Colombia the rate of migration from rural to urban areas is high (Schultz, 1971); migration may be a source of bias in estimating the mortality determinant equation for I have stratified on rural and urban populations as though they were distinct, closed, exogenously determined populations. Migration in Colombia from rural to urban areas selects the better educated and within education groups may draw forth those most inclined to work in the market labor force, to delay marriage and the onset of childbearing, and to opt for a reduction in lifetime fertility. Hence, those that are observed to have migrated may have made a sequence of choices not unrelated to gaining improved access to health inputs (lowering their shadow prices) and to obtaining an increased wage for their labors. Migrants may also be more (or less) efficient in using these health inputs and market income to reduce mortality among their offspring. It is not now possible to disentangle how the selective process of migration, that accounts for who resides in my rural or urban samples, would alter the parameter estimates presented above, but it seems likely that long run response elasticities

will be affected when this source of selectivity bias is taken into account properly (Heckman, 1979; Olsen, 1979).¹⁰

The final issue in the empirical analysis of mortality determinants that needs reiteration is the explicit omission of fertility as a determinant of child mortality. A large literature has documented the cross-sectional positive association between child mortality and fertility at the family level and at areal aggregate levels. Interpretation of this association remains controversial, however (Preston, 1975; Schultz, 1969, 1976, 1978, 1978b). Child mortality affects the demand for fertility both through modification of what parents expect child mortality to be in the future which encourages hedging demand ex ante, and through inducement of replacement demand ex post, after a child's death. Infant mortality may also influence fertility by altering the potential biological supply of births in the same direction as the demand variation. Although the evidence is less adequate, it seems intuitively reasonable to anticipate that a portion of the simple association between child mortality and fertility is attributable to the reverse causal sequence, namely,

¹⁰ A simple descriptive investigation with these Colombian census data suggests that rural-urban migrants have a somewhat higher child mortality level the shorter their duration of current residence, taking account of their current location, income, education and age. But other parameters in the mortality equation did not prove particularly sensitive to the inclusions of this crude additional migration variable. Similar variables were defined in the CELADE 1963 urban Latin American PISPAL surveys, but they did not even suggest a consistent tendency across the seven major cities for rural-urban migrants to experience more child mortality than native city born residents (see Schultz, 1978b). More work along these lines may help to clarify how the cumulative health effects of past residential environments distinctly affect current or past health indicators, given current endowments and location.

for high fertility and short birth intervals to reduce child health and survival prospects by straining the economic resources of the family and reducing the time a mother has per child (and perhaps by reducing her health and productivity as well). In the empirical analysis of child mortality determinants, the examination of fertility requires a statistical basis for identifying the distinct effect of fertility on child mortality; in other words, some additional information is required on an exogenous variable that affects fertility but exerts no effect directly on child mortality. Having an identifying restriction, permits one to infer how independent variation in fertility works its distinct effect on child mortality. Such a variable might be the cost of contraception, or perhaps endemic regional diseases that reduce reproductive potential involuntarily through premature sterility, or randomly allocated local family planning activity that reduces the access and information cost of modern birth control. Until such a variable is available, it is not possible to "partial out" how much of the total "unconditional" effects on child mortality of parental wages, education and region operate through variation in fertility, and how much of these effects operate more directly on child mortality. Lacking a basis for such an identifying restriction in these Colombian census data, the empirical results reported here are derived from unconditional demand equations which embody both direct and indirect influences of the exogenous conditioning variables (Goldberger and Duncan, 1973).

V. Mortality as a Determinant of Household Behavior and Social Welfare

What consequences stem from a change in mortality? Three simplifying assumptions are useful to consider this question and neglect exceptions that, though they may occur, are nonetheless relatively unimportant. The first working assumption is that age-mortality schedules shift in the same direction at all ages. Thus, I shall neglect the possibility that a reduction in mortality at one age is associated with an increase in mortality at another age. One can imagine two situations which might generate this uncommon pivoting in age-mortality schedules. Preserving life at one age may open it to additional risks at a later age; for example, heart surgery on an infant's congenital heart defect may reduce early infant mortality at the cost of increasing heart related problems among these same children at later ages. Though this is a logical possibility, the multifaceted nature of medical technological progress is likely to achieve reductions in mortality at those later ages from other risks that would numerically offset the increased risks due to complications experienced by the beneficiaries of the infant therapies. Thus, age specific mortality rates for a cohort would generally decline together, though certainly not at the same rate across ages. I am less confident that the same statement could be defended for degenerative diseases that represent a growing share of deaths after middle age.

A second reason for pivoting of age-mortality schedules might be traced to concurrent, though I would argue distinct, developments in environmental conditions and consumptions patterns. Rising incomes may contribute to more alcohol consumption and more reliance on transportation

by automobiles. Reduced childhood mortality purchased by costly advances in medical technology may parallel increased adult mortality from cirrhosis of the liver and accidental deaths. In this second case, one is reluctant to attribute the adult rise in mortality to the expensive medical technology that achieved the decline in childhood mortality. With these possible exceptions in mind, the working hypothesis maintained here is that age-mortality schedules shift regularly up or down, due to changes in medical knowledge, practices, and incomes. If this is true, returns to human investment must increase at all ages as mortality declines.

The second working assumption is that average morbidity and health shift in the same direction as does mortality, or mortality is an ordinal indicator of good health. Moreover, good health is assumed to yield a direct personal welfare gain and enhances the potential productivity of human time and effort. This second assumption is consistent with the general perception of health status but may be a better or worse approximation in different circumstances. The link between the incidence of mortality and health status of a population may at times appear to be imperfect, such as where debilitating disease is infrequently the direct cause of death, or conversely, where sudden loss of life from epidemic disease does not extract from survivors a commensurate loss of vitality. Nonetheless, the assumption as a general rule simplifies discussion here. More detailed future research may refine this relationship for different causes of disability and death, and by different underlying economic and

geoclimatic preconditions.¹¹

A third working assumption is that the aggregate derived demand for labor in productive units is elastic. One could imagine that the demand for final goods is inelastic, and the possibilities of substituting labor for capital are sufficiently limited that an increase in the productivity of labor exceeded productive requirements and required the wage rate per productive unit of labor to decline by a larger proportion than the general decline in mortality had increased the productive units of labor available to each person. In this extreme case, the wage received per person would fall. The increased effective supply of labor released by the general decline in mortality, holding the physical labor supply behavior of individuals constant, would reduce per capita labor income. The subsequent discussion assumes, I think realistically, that the derived demand for productive units of labor is not inelastic in the long run span of a human's lifetime.

With these three working assumptions in mind, it is clear that general reductions in mortality increase the current "value of time" to individuals. It is also clear that the expected value of time in the

¹¹In studies of U.S. health determinants it was initially argued that mortality was an inadequate and rough measure of "health," and the lack of association between mortality and the consumption of health services (except for infant mortality) was, therefore, not a satisfactory indication that increasing these health services would not improve markedly health status. But more refined analyses based on six indicators of ill health (cholesterol levels, varicose veins, high blood pressure, abnormal electrocardiograms and x-rays, and unfavorable periodontal index) reconfirm the earlier inability to find a direct interregional association between the availability or use of health resources and improved health outcomes by age. (Newhouse and Friedlander, 1977; Newhouse, 1968).

future increases, increasing the expected future wealth of the individual to the extent that the improvement in longevity is viewed as permanent (Schultz, 1976). The current "value-of-time effect" can be interpreted as a current increase in the shadow price of leisure, which encourages individuals to demand less leisure now or work more, holding constant income or wealth. But the enhanced value of current and expected future time also augments the individual's human wealth, and this expected "wealth effect" is generally thought to increase the demand for leisure as it erodes the incentive to work. One cannot predict on theoretical grounds alone, therefore, whether the general decline in mortality will lead to an increase or decrease in current hours of work or hours worked over an individual's lifetime. But the ambiguity in the direction of mortality's effect on "effort" does not signal an ambiguity in the private economic value of a decrease in mortality, which must be positive under almost any assumption regarding preferences. Since one cannot predict by economic theory alone whether decreased mortality will encourage people to work more or less in the market, or to retire sooner or later over their lifetime, it becomes impossible to predict confidently whether per capita market incomes will increase or decrease purely as a consequence of the mortality decline. One can predict, nevertheless, that the productivity of labor per unit time worked will rise and hence the wage rates, and that the returns to human capital investments will increase but not necessarily relative to the return on physical capital investments. Patterns in the empirical literature on labor force behavior provide more guidance, however, on what one might reasonably expect to find if mortality were to experience a general remission.

Empirical Labor Supply Responses of Men and Women

Prime aged males are noted to participate fully in the market labor force, generally 95 percent from age 25 to 55, with the proportion being somewhat higher in rural than in urban areas and higher in low income than in high income countries. This demographic group also reports a tendency in high income countries to reduce their hours of work per week as incomes rise. For example, U.S. manufacturing statistics report a decline from 60 hours per week in 1890 to 40 hours after the Second World War, whereas German statistics indicate the work week was 82 hours in 1825 and recently reached 40. Household level studies of labor supply in the U.S., Brazil, India, the Philippines and Colombia often find evidence of a backward bending labor supply response for husbands with respect to their own wage, and little response to their wife's wage opportunities.

This empirical evidence suggests that one might reasonably anticipate prime-aged males to respond to an upward shift in the productivity of their time and that of their wives by reducing slightly their labor force participation, particularly at the end of their lifetime. They also may reduce somewhat their hours of market work when participating. Hence, if an exogenous decline in mortality occurred, the male labor supply response would probably dampen any evident rise in market production that economists could monitor and aggregate into a conventional measure of gross national product. It also seems likely that schooling would be extended as returns on human capital increased, and this might further reduce measured GNP, though not necessarily reduce a more comprehensive

concept of national income that treated schooling as an investment of current resources in future productive potential.

With currently married women the effect of a decline in mortality might be to increase market participation and even hours worked among participants. This would be implied by household studies of wives that confirm their labor supply elasticity with respect to their own wage (positive) exceeds at most ages their labor supply elasticity with respect to their husband's wage (negative) in absolute value. Thus, an equi-proportional increase in the wages of men and women might be expected to lead to a modest increase in wives working in the market. Here, however, the inadequacy of national accounts that neglect for the most part the woman's nonmarket production can lead one seriously astray. To increase a woman's market production, the household generally sacrifices some nonmarket production, and the welfare of household members need not increase as wives enter the labor force. An example would be where the husband loses his job, and his wife substitutes her time in the market until he regains employment. The case of a general decline in mortality that raises the wages of both husband and wife, however, is clearly an instance of a welfare gain, regardless of observed labor supply responses. Although it may not be clear exactly what the wife's time allocation between market and nonmarket activities signifies, a decline in mortality would probably lead her to increase her time in the market labor force.¹²

¹² There are other reasons, however, to anticipate this result. If decreased child mortality is associated with decreased fertility, the prospects are improved for wives to increase the allocation of time to extra-familial activities in the market. If mortality is lower in urban than in rural areas, we might again be able to attach several interpretations to the pronounced tendency for women to be more heavily engaged in market activities in urban than in rural settings. This is generally the case outside of subSaharan Africa and portions of Malay-influenced Southeast Asia where women hold a predominant role in agriculture. In these latter regions the modern or nonagricultural participation pattern of women might be a better measure of their labor supply.

Survival Effects on Investment in People

The overall level of personal and perhaps social resources allocated to enhance the productivity of the human agent should increase in response to a general decline in mortality. If a good explanation for the varied forms of human capital investments were at hand, one might look for the partial effect of mortality level on child and adult health investments, nutrition and physical development, schooling inputs and achievements, migration and job search, vocational training, career paths that involve more or less on-the-job training, and finally reproductive behavior and the joint decisions of resource intensity or nurture of children. Unfortunately, few of these decisions processes are sufficiently well understood so that the partial correlation with mortality levels at the community or group level would convey any precise meaning. The prediction of economic theory, however, is strong and clear. We should expect those peoples experiencing the most rapid declines in mortality to also be investing more heavily than they have in the past in augmenting labor's productivity. This is a case where the process feeds on itself. An initial exogenous downward shift in mortality increases the incentive to invest in additional health capital along with other activities that accelerate the spread of schooling and fosters increased mobility, that in turn leads the better educated to relocate in urban areas where the level of wages and the returns to schooling are larger. Thus, the decline in mortality may be linked, albeit tenuously, with a host of other fundamental economic and demographic processes that are closely associated with the economic development process as it is unfolding today: schooling, migration, urbanization and decreasing fertility. But what is cause and what is effect?

Empirically Measuring the Consequences of Mortality Variation

A literature is only beginning to document the outlines of how household endowments, public programs and geoclimatic conditions interact to determine mortality rates across households and socioeconomic groups in poor societies. Time series analyses remain for the most part unconvincing in their heroic efforts to allocate mortality declines to various environmental causes (not causes of death). Seen in this light, it is not surprising that measurement of consequences of recent mortality declines is still an open field for conceptual thinking and empirical research. Hence the need now for conferences of this variety, representing diverse viewpoints and bringing to bear on this question different areas of expertise (and ignorance). If variation in mortality or variation in the incidence of a particular disease were independent of the economic means of households and the voluntary economic and demographic behavior of household members (that reflect those means and individual tastes), then it might be acceptable to interpret correlations between mortality or the incidence of disease and economic and demographic outcomes as though these correlations characterized causal relations. A good example is the thoughtful and cautious empirical analysis of Weisbrod (1973) and his associates looking at relationships between the incidence of parasitic diseases in St. Lucia and (1) work, (2) schooling, (3) productivity, (4) infant mortality, and (5) fertility. Even when seemingly better longitudinal data are considered (Weisbrod and Helminiak, 1977), it is still relatively easy to explain the lack of empirical evidence of a link between the incidence (or severity) of disease and economic and demographic outcomes.

But the unrecognized task confronting the Weisbrod project, and many other far less sophisticated undertakings that have sought to show the consequences of mortality or morbidity variation, is to distinguish between the two-way causal mechanisms determining health investments of people in terms of their economic endowments and health environment, and the relationships determining labor supply, savings and investment behavior in terms of health conditions, environment, and endowments. Without a statistical basis for identifying these two sets of relationships, how far can one go? What conditions can one persuasively argue influence health status and yet exert no direct effects on this set of indicators of personal welfare and behavior? There is little reason to be sanguine that such identifying variables are commonly observed in nature.¹³ Perhaps enlisting health scientists will guide us in collecting with increased precision the intensity of such "exogenous" public health interventions as are described in section II (A) that can be treated as wholly independent of individual voluntary behavior and underlying endowments of the household and community. The job remains important, though difficult for me to fathom.

VI. Concluding Comments

The theme of this conference is that mortality differs across social and economic groups, and that these differentials may significantly widen or narrow as overall mortality levels change. How does one proceed to learn what causes these differentials to exist and how these differentials

¹³ This point is made with considerable effect by Kenneth Wolpin and Mark Rosenzweig.

affect the welfare of individuals and families and modify the functioning of a society?

As a novice to the study of mortality, much of my paper has tried to state how an economist might come to this task: How would standard empirical materials be arranged to shed some light on these issues, and where might the theoretical tools of economics help to interpret the empirical regularities that were thus assembled?

I have assumed that a combination of many social and economic factors in addition to public health technology explain cross sectional differentials in mortality and the recent decline in mortality in low income countries. Mortality is a discrete indicator of an individual's stock of health capital, which is in part accumulated over a lifetime as a result of many incremental decisions made first by parents for their child and then by the individual himself and the household of which he or she is a member. Various factors in this process that are predetermined or exogenous to the individual's lifetime decisions upon reaching adulthood can be treated as directly conditioning health investments and resulting mortality. If the factors thought to be relevant to health investments are themselves jointly determined within the household economy, the commonly reported partial correlations from an ordinary least squares regression do not provide a satisfactory (i.e., statistically consistent and unbiased) measure of causal relation. If such jointly determined factors as a wife's labor force behavior, fertility, and age at marriage are excluded from the list of conditioning variables, one may learn much from estimating a multicausal equation that might be called an unconditional

demand equation for mortality. This equation is assumed here to be linear in functional form for convenience, but it may be preferable, for well known biometric reasons, to explore nonlinear estimation techniques such as probit and logit where each individual can be monitored.

In the analysis of the incidence of mortality, one searches for ways to enrich samples in order to increase the frequency of the event being studied. The retrospective evidence commonly available on a mother's experience of child mortality represents an aggregation of mortality experience that has occurred over several years for several children within a similar environment and in a household that is likely to have had a relatively stable economic endowment. Neglecting errors of recall, this unadjusted retrospective own-child death ratio is a better proxy for age-specific mortality levels as the mother outgrows the childbearing period and all of her offspring experience the early periods of greatest mortality. This simple measure of mortality used here could be improved upon, but perhaps without greatly altering the reported results, by dividing actual child mortality by a normalization based on the mother's expected child mortality.

Another reason for considering child mortality is the greater frequency of preschool child mortality in low income countries relative to the incidence in high income countries. This substantial margin of so-called "excess" mortality among young children suggests that these deaths may be potentially responsive to economic and environmental conditions that development policy might affect. Since one is generally able to observe only current conditions and endowments in

conjunction with mortality (or health status), the older the population under study the longer the persons have had to invest in their stock of health and accumulate experiences that will affect their current stock of health and reduce their dependence on currently observed conditions. One might hypothesize, therefore, that mortality among children would be particularly responsive to currently observable economic and medical conditions.

The simple indicator of child health examined in this paper is easily related to observed household characteristics in surveys and census samples, such as to the market income opportunities of the parents, their education, and location. Future work should explore normalizations of the child mortality ratio for exposure duration of the mother's children, and examine community information on program activities, infrastructure and climate as potentially important additional determinants of child mortality. The empirical results summarized in Table 3 could be used to explain the decline in Colombian child mortality in terms of rising wages, educational advance, and urbanization. But such a partial explanation in terms of only household characteristics is no better or worse than those stories that have in the past attributed the modern decline in mortality to a revolution in public health technology. Economic development has also paralleled the decline in mortality and has increased people's control over economic resources and induced them to acquire, through schooling, a set of productive skills that have an undeniable effect on their own health and the health of their children. What remains unclear is the relative role of the mother's and the father's education on child health,

and the way in which parental education actually exerts its effect.

The character of the family and the activities performed by men, women and children within the family should have a great deal to do with how these intrafamily allocations of health investment occur. The determinants of and consequences of child mortality, therefore, are integral parts of the family economy.

PROPORTION OF CHILDREN EVER BORN WHO ARE NOW DEAD
BY RURAL/URBAN, WIFE'S AGE AND EDUCATION
AND HUSBAND'S EDUCATION OR MONTHLY INCOME

| Colombia 1973 URBAN Residents, Wife's Age 20-24 | Wife's Education | | | | |
|---|------------------|-----------------|-------------------|----------------|------------------|
| | None | Some Primary | Some Secondary | Some Higher | All Education |
| <u>Husband's Education:</u> | | | | | |
| None | .1213 | .0896 | .0625 | - | .1036 |
| Primary | .0874 | .0496 | .0249 | - | .0491 |
| Secondary | .0243 | .0290 | .0155 | .0816 | .0222 |
| Higher | - | .0595 | .0217 | .0000 | .0194 |
| <u>Husband's Income:</u> (pesos last month) | | | | | |
| Zero | .1141 | .0826 | .0600 | - | .0814 |
| 1-300 | .1028 | .0964 | .0217 | - | .0915 |
| 301-600 | .0988 | .0474 | .0077 | - | .0527 |
| 601-1000 | .0853 | .0514 | .0328 | - | .0517 |
| 1001-1800 | .0632 | .0406 | .0130 | - | .0335 |
| 1801-4000 | .1514 | .0362 | .0149 | .0400 | .0293 |
| 4001+ | - | .0340 | .0183 | .0135 | .0231 |
| Not reporting | .1294 | .0375 | .0306 | - | .0471 |
| Unknown | .0985 | .0285 | .0316 | - | .0410 |
| <u>Total</u> | .0990 | .0481 | .0194 | .0180 | .0436 |
| Number observations | 505 | 3,420 | 1,685 | 95 | 5,705 |

- less than ten observations in cell

PROPORTION OF CHILDREN EVER BORN WHO ARE NOW DEAD
BY RURAL/URBAN, WIFE'S AGE AND EDUCATION
AND HUSBAND'S EDUCATION OR MONTHLY INCOME

| Colombia 1973 URBAN Residents, Wife's Age 25-29 | Wife's Education | | | | |
|---|------------------|-----------------|-------------------|----------------|------------------|
| | None | Some Primary | Some Secondary | Some Higher | All Education |
| <u>Husband's Education:</u> | | | | | |
| None | .1221 | .0787 | .0997 | - | .0983 |
| Primary | .0982 | .0540 | .0303 | - | .0548 |
| Secondary | .0911 | .0397 | .0238 | .0000 | .0305 |
| Higher | - | .0287 | .0174 | .0264 | .0207 |
| <u>Husband's Income:</u> (pesos last month) | | | | | |
| Zero | .1437 | .0755 | .0281 | - | .0753 |
| 1-300 | .1410 | .0691 | .0299 | - | .0834 |
| 301-600 | .1316 | .0741 | .0765 | - | .0869 |
| 601-1000 | .0925 | .0633 | .0234 | - | .0615 |
| 1001-1800 | .0864 | .0443 | .0241 | - | .0431 |
| 1801-4000 | .0631 | .0346 | .0214 | .0000 | .0284 |
| 4001+ | .0200 | .0440 | .0259 | .0227 | .0290 |
| Not reporting | .1206 | .0556 | .0106 | - | .0548 |
| Unknown | .0949 | .0603 | .0427 | - | .0614 |
| <u>Total</u> | .1076 | .0529 | .0248 | .0211 | .0489 |
| Number observations | 731 | 4,788 | 2,337 | 217 | 8,073 |

- less than ten observations in cell

PROPORTION OF CHILDREN EVER BORN WHO ARE NOW DEAD
BY RURAL/URBAN, WIFE'S AGE AND EDUCATION
AND HUSBAND'S EDUCATION OR MONTHLY INCOME

| Colombia 1973 URBAN Residents, Wife's Age 30-34 | Wife's Education | | | | |
|---|------------------|-----------------|-------------------|----------------|------------------|
| | None | Some Primary | Some Secondary | Some Higher | All Education |
| <u>Husband's Education:</u> | | | | | |
| None | .1253 | .1072 | .0221 | - | .1139 |
| Primary | .1095 | .0639 | .0394 | - | .0658 |
| Secondary | .0886 | .0331 | .0377 | .0467 | .0366 |
| Higher | - | .0276 | .0145 | .0085 | .0136 |
| <u>Husband's Income:</u> (pesos last month) | | | | | |
| Zero | .1077 | .0706 | .0590 | - | .0757 |
| 1-300 | .1310 | .1077 | - | - | .1128 |
| 301-600 | .1505 | .0809 | .0591 | - | .0986 |
| 601-1000 | .1236 | .0737 | .0360 | - | .0780 |
| 1001-1800 | .0998 | .0525 | .0502 | - | .0567 |
| 1801-4000 | .0711 | .0463 | .0331 | .0238 | .0421 |
| 4001+ | - | .0362 | .0219 | .0139 | .0242 |
| Not reporting | .0969 | .0710 | .0511 | - | .0711 |
| Unknown | .0517 | .0697 | .0279 | - | .0581 |
| <u>Total</u> | .1152 | .0617 | .0332 | .0139 | .0595 |
| Number observations | 852 | 4,745 | 1,898 | 170 | 7,665 |

- less than ten observations in cell

PROPORTION OF CHILDREN EVER BORN WHO ARE NOW DEAD
BY RURAL/URBAN, WIFE'S AGE AND EDUCATION
AND HUSBAND'S EDUCATION OR MONTHLY INCOME

| Colombia 1973 URBAN Residents, Wife's Age 35-39 | Wife's Education | | | | |
|---|------------------|-----------------|-------------------|----------------|------------------|
| | None | Some Primary | Some Secondary | Some Higher | All Education |
| <u>Husband's Education:</u> | | | | | |
| None | .1206 | .1288 | .0571 | - | .1240 |
| Primary | .1165 | .0743 | .0514 | - | .0772 |
| Secondary | .0754 | .0391 | .0288 | .0325 | .0341 |
| Higher | - | .0175 | .0205 | .0056 | .0170 |
| <u>Husband's Income:</u> (pesos last month) | | | | | |
| Zero | .1264 | .0954 | .0590 | - | .0990 |
| 1-300 | .1473 | .1140 | .0724 | - | .1233 |
| 301-600 | .1448 | .1191 | .0466 | - | .1240 |
| 601-1000 | .0959 | .0917 | .0280 | - | .0874 |
| 1001-1800 | .0993 | .0642 | .0407 | - | .0651 |
| 1801-4000 | .0710 | .0490 | .0316 | .0758 | .0451 |
| 4001+ | .0956 | .0390 | .0262 | .0053 | .0287 |
| Not reporting | .1480 | .0693 | .0378 | - | .0769 |
| Unknown | .0856 | .0758 | .0800 | - | .0778 |
| <u>Total</u> | .1168 | .0738 | .0335 | .0123 | .0700 |
| Number observations | 1,051 | 4,594 | 1,631 | 123 | 7,399 |

- less than ten observations in cell

PROPORTION OF CHILDREN EVER BORN WHO ARE NOW DEAD
BY RURAL/URBAN, WIFE'S AGE AND EDUCATION
AND HUSBAND'S EDUCATION OR MONTHLY INCOME

| Colombia 1973 URBAN Residents, Wife's Age 40-44 | Wife's Education | | | | |
|---|------------------|-----------------|-------------------|----------------|------------------|
| | None | Some Primary | Some Secondary | Some Higher | All Education |
| <u>Husband's Education:</u> | | | | | |
| None | .1414 | .1357 | .1350 | - | .1386 |
| Primary | .1306 | .0907 | .0579 | - | .0934 |
| Secondary | .0934 | .0716 | .0511 | .0250 | .0595 |
| Higher | - | .0649 | .0370 | .0437 | .0401 |
| <u>Husband's Income:</u> (pesos last month) | | | | | |
| Zero | .1340 | .1094 | .0881 | - | .1150 |
| 1-300 | .1746 | .1378 | - | - | .1502 |
| 301-600 | .1568 | .1336 | .0449 | - | .1373 |
| 601-1000 | .1271 | .1109 | .0651 | - | .1104 |
| 1001-1800 | .1056 | .0823 | .0574 | - | .0818 |
| 1801-4000 | .0919 | .0691 | .0646 | - | .0689 |
| 4001+ | .1256 | .0522 | .0397 | .0368 | .0424 |
| Not reporting | .1513 | .0893 | .0533 | - | .0970 |
| Unknown | .1232 | .1018 | .0659 | - | .1007 |
| <u>Total</u> | .1340 | .0947 | .0517 | .0353 | .0902 |
| Number observations | 946 | 3,568 | 1,240 | 50 | 5,804 |

- less than ten observations in cell

PROPORTION OF CHILDREN EVER BORN WHO ARE NOW DEAD
BY RURAL/URBAN, WIFE'S AGE AND EDUCATION
AND HUSBAND'S EDUCATION OR MONTHLY INCOME

| Colombia 1973 URBAN Residents, Wife's Age 45-49 | Wife's Education | | | | |
|---|------------------|-----------------|-------------------|----------------|------------------|
| | None | Some Primary | Some Secondary | Some Higher | All Education |
| <u>Husband's Education:</u> | | | | | |
| None | .1654 | .1474 | .0741 | - | .1558 |
| Primary | .1468 | .1097 | .0836 | - | .1127 |
| Secondary | .0598 | .0703 | .0545 | .1000 | .0617 |
| Higher | - | .0256 | .0473 | .000 | .0416 |
| <u>Husband's Income:</u> (pesos last month) | | | | | |
| Zero | .1771 | .1122 | .0661 | - | .1247 |
| 1-300 | .1401 | .1599 | - | - | .1514 |
| 301-600 | .1889 | .1453 | .1193 | - | .1592 |
| 601-1000 | .1295 | .1198 | .1035 | - | .1206 |
| 1001-1800 | .1178 | .1040 | .0625 | - | .1003 |
| 1801-4000 | .1007 | .0776 | .0643 | - | .0749 |
| 4001+ | .1799 | .0713 | .0425 | .0413 | .0537 |
| Not reporting | .1904 | .0974 | .0841 | - | .1170 |
| Unknown | .1987 | .1280 | .0884 | - | .1399 |
| <u>Total</u> | .1548 | .1083 | .0617 | .0387 | .1070 |
| Number observations | 782 | 2,683 | 857 | 31 | 4,309 |

- less than ten observations in cell

PROPORTION OF CHILDREN EVER BORN WHO ARE NOW DEAD
BY RURAL/URBAN, WIFE'S AGE AND EDUCATION
AND HUSBAND'S EDUCATION OR MONTHLY INCOME

| Colombia 1973 RURAL Residents, Wife's Age 20-24 | Wife's Education | | | | |
|---|------------------|-----------------|-------------------|----------------|------------------|
| | None | Some Primary | Some Secondary | Some Higher | All Education |
| <u>Husband's Education:</u> | | | | | |
| None | .1008 | .0898 | .0667 | - | .0948 |
| Primary | .0950 | .0733 | .0468 | - | .0762 |
| Secondary | - | .0616 | .0000 | - | .0379 |
| Higher | - | - | - | - | - |
| <u>Husband's Income: (pesos last month)</u> | | | | | |
| Zero | .0924 | .0689 | .0400 | - | .0749 |
| 1-300 | .1244 | .0860 | .0278 | - | .0950 |
| 301-600 | .0885 | .0880 | .0478 | - | .0872 |
| 601-1000 | .1207 | .0667 | .0547 | - | .0779 |
| 1001-1800 | .0917 | .0385 | .0303 | - | .0461 |
| 1801-4000 | .0313 | .0904 | .0147 | - | .0660 |
| 4001+ | - | .0545 | - | - | .0700 |
| Not reporting | .0662 | .0822 | .0000 | - | .0735 |
| Unknown | .0493 | .0433 | - | - | .0446 |
| <u>Total</u> | .0976 | .0763 | .0317 | - | .0800 |
| Number observations | 895 | 2,425 | 136 | 1 | 3,457 |

- less than ten observations in cell

PROPORTION OF CHILDREN EVER BORN WHO ARE NOW DEAD
BY RURAL/URBAN, WIFE'S AGE AND EDUCATION
AND HUSBAND'S EDUCATION OR MONTHLY INCOME

| Colombia 1973 | | Wife's Education | | | |
|--|-------|------------------|-------------------|----------------|------------------|
| RURAL Residents, Wife's Age 25-29 | None | Some Primary | Some Secondary | Some Higher | All Education |
| <u>Husband's Education:</u> | | | | | |
| None | .1205 | .1026 | .0303 | - | .1115 |
| Primary | .1215 | .0821 | .0462 | - | .0882 |
| Secondary | - | .0469 | .0628 | - | .0623 |
| Higher | - | - | .0330 | - | .0222 |
| <u>Husband's Income:</u> (pesos last month) | | | | | |
| Zero | .0970 | .0862 | .0784 | - | .0896 |
| 1-300 | .1189 | .0920 | .0281 | - | .0998 |
| 301-600 | .1233 | .0913 | .0665 | - | .0999 |
| 601-1000 | .1273 | .0813 | .0154 | - | .0902 |
| 1001-1800 | .1291 | .0754 | .0536 | - | .0831 |
| 1801-4000 | .1640 | .0737 | .0962 | - | .0903 |
| 4001+ | - | .0808 | - | - | .0671 |
| Not reporting | .1276 | .0805 | - | - | .0940 |
| Unknown | .1618 | .0709 | - | - | .1012 |
| <u>Total</u> | .1213 | .0857 | .0492 | - | .0945 |
| Number observations | 1,248 | 2,922 | 160 | 4 | 4,334 |

- less than ten observations in cell

PROPORTION OF CHILDREN EVER BORN WHO ARE NOW DEAD
BY RURAL/URBAN, WIFE'S AGE AND EDUCATION
AND HUSBAND'S EDUCATION OR MONTHLY INCOME

| Colombia 1973 RURAL Residents, Wife's Age 30-34 | Wife's Education | | | | |
|---|------------------|-----------------|-------------------|----------------|------------------|
| | None | Some Primary | Some Secondary | Some Higher | All Education |
| <u>Husband's Education:</u> | | | | | |
| None | .1406 | .1315 | - | - | .1360 |
| Primary | .1371 | .0998 | .0545 | - | .1062 |
| Secondary | - | .0842 | .0624 | - | .0848 |
| Higher | - | - | - | - | .0000 |
| <u>Husband's Income:</u> (pesos last month) | | | | | |
| Zero | .1150 | .1149 | .1111 | - | .1146 |
| 1-300 | .1333 | .1021 | .0375 | - | .1129 |
| 301-600 | .1533 | .1156 | .0071 | - | .1272 |
| 601-1000 | .1367 | .1084 | .0435 | - | .1146 |
| 1001-1800 | .1725 | .0821 | .0677 | - | .0979 |
| 1801-4000 | .1262 | .1021 | .0302 | - | .0975 |
| 4001+ | - | .0494 | - | - | .0418 |
| Not reporting | .1647 | .1034 | .0702 | - | .1203 |
| Unknown | .1252 | .0921 | - | - | .1035 |
| <u>Total</u> | .1394 | .1066 | .0488 | - | .1156 |
| Number observations | 1,352 | 2,674 | 114 | 4 | 4,144 |

- less than ten observations in cell

Table A-10

PROPORTION OF CHILDREN EVER BORN WHO ARE NOW DEAD
BY RURAL/URBAN, WIFE'S AGE AND EDUCATION
AND HUSBAND'S EDUCATION OR MONTHLY INCOME

| Colombia 1973 RURAL Residents, Wife's Age 35-39 | Wife's Education | | | | |
|---|------------------|-----------------|-------------------|----------------|------------------|
| | None | Some Primary | Some Secondary | Some Higher | All Education |
| <u>Husband's Education:</u> | | | | | |
| None | .1498 | .1347 | - | - | .1441 |
| Primary | .1248 | .1204 | .0650 | - | .1206 |
| Secondary | - | .0779 | .0723 | - | .0804 |
| Higher | - | - | - | - | - |
| <u>Husband's Income:</u> (pesos last month) | | | | | |
| Zero | .1538 | .1109 | - | - | .1303 |
| 1-300 | .1206 | .1304 | .0622 | - | .1254 |
| 301-600 | .1485 | .1280 | - | - | .1366 |
| 601-1000 | .1229 | .1260 | .0731 | - | .1242 |
| 1001-1800 | .1524 | .1062 | .0833 | - | .1146 |
| 1801-4000 | .1390 | .1148 | - | - | .1161 |
| 4001+ | - | .1186 | .0664 | - | .0977 |
| Not reporting | .1624 | .1312 | .0361 | - | .1409 |
| Unknown | .1346 | .1119 | - | - | .1214 |
| <u>Total</u> | .1393 | .1234 | .0729 | - | .1285 |
| Number observations | 1,660 | 2,578 | 77 | 3 | 4,318 |

- less than ten observations in cell

PROPORTION OF CHILDREN EVER BORN WHO ARE NOW DEAD
BY RURAL/URBAN, WIFE'S AGE AND EDUCATION
AND HUSBAND'S EDUCATION OR MONTHLY INCOME

| Colombia 1973 RURAL Residents, Wife's Age 40-44 | Wife's Education | | | | |
|---|------------------|-----------------|-------------------|----------------|------------------|
| | None | Some Primary | Some Secondary | Some Higher | All Education |
| <u>Husband's Education:</u> | | | | | |
| None | .1655 | .1742 | - | - | .1686 |
| Primary | .1691 | .1390 | .1100 | - | .1472 |
| Secondary | - | .0431 | .0536 | - | .0576 |
| Higher | - | - | - | - | - |
| <u>Husband's Income:</u> (pesos last month) | | | | | |
| Zero | .1389 | .1261 | - | - | .1325 |
| 1-300 | .1825 | .1493 | - | - | .1655 |
| 301-600 | .1789 | .1587 | - | - | .1670 |
| 601-1000 | .1878 | .1442 | .1527 | - | .1590 |
| 1001-1800 | .1480 | .1204 | - | - | .1262 |
| 1801-4000 | .1159 | .1457 | .0350 | - | .1287 |
| 4001+ | - | .1727 | - | - | .1377 |
| Not reporting | .1488 | .1617 | - | - | .1547 |
| Unknown | .1801 | .1621 | - | - | .1668 |
| <u>Total</u> | .1669 | .1466 | .0950 | - | .1543 |
| Number observations | 1,404 | 1,815 | 58 | 2 | 3,279 |

- less than ten observations in cell

PROPORTION OF CHILDREN EVER BORN WHO ARE NOW DEAD
BY RURAL/URBAN, WIFE'S AGE AND EDUCATION
AND HUSBAND'S EDUCATION OR MONTHLY INCOME

| Colombia 1973 RURAL Residents, Wife's Age 45-49 | Wife's Education | | | | |
|---|------------------|-----------------|-------------------|----------------|------------------|
| | None | Some Primary | Some Secondary | Some Higher | All Education |
| <u>Husband's Education:</u> | | | | | |
| None | .1922 | .1617 | - | - | .1818 |
| Primary | .1648 | .1542 | .1110 | - | .1566 |
| Secondary | - | .1860 | .0083 | - | .1175 |
| Higher | - | - | - | - | - |
| <u>Husband's Income:</u> (pesos last month) | | | | | |
| Zero | .1656 | .1477 | - | - | .1551 |
| 1-300 | .1825 | .1455 | - | - | .1662 |
| 301-600 | .1807 | .1714 | - | - | .1746 |
| 601-1000 | .2018 | .1633 | - | - | .1743 |
| 1001-1800 | .2487 | .1593 | - | - | .1785 |
| 1801-4000 | .1725 | .1260 | - | - | .1340 |
| 4001+ | - | .1774 | - | - | .1320 |
| Not reporting | .1895 | .1487 | - | - | .1676 |
| Unknown | .1655 | .1794 | - | - | .1710 |
| <u>Total</u> | .1817 | .1564 | .0855 | - | .1662 |
| Number observations | 1,086 | 1,358 | 40 | 1 | 2,485 |

- less than ten observations in cell

| Variable | 20-24 | 25-29 | 30-34 | 35-39 | 40-44 | 45-49 | 50-65 |
|--|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
| Antioquia | .0185 | .106 | .110 | .0597 | .146 | .0835 | .101 |
| Atlantico | .0279 | .0851 | .0271 | -.0203 | -.0165 | .130 | .166 |
| Bogota | -.0113 | .114 | .160 | .0410 | .157 | .0941 | .183 |
| Bolivar | -.0565 | .0293 | -.0607 | -.163 | .0795 | -.0176 | .0489 |
| Boyacá | -.0393 | -.0952 | -.146 | -.346 | -.0933 | -.376 | -.469 |
| Caldas | -.0522 | -.0134 | .0382 | -.208 | .0711 | -.0487 | -.0524 |
| Cauca | -.268 | -.255 | -.270 | -.352 | -.386 | -.354 | -.424 |
| Cesar | .00487 | .199 | -.0402 | -.184 | .0796 | .0157 | .158 |
| Córdoba | -.358 | -.212 | -.103 | -.191 | -.0878 | -.106 | -.185 |
| Cundinamarca | -.177 | -.0480 | -.0938 | -.197 | -.0536 | -.214 | -.0682 |
| Chocó | .158 | .108 | -.132 | -.178 | -.413 | .0723 | .278 |
| Huila | .0212 | -.0826 | -.0793 | -.120 | -.271 | -.231 | -.00005 |
| Guajira | .103 | .0602 | .0936 | -.169 | -.0184 | -.361 | .155 |
| Magdalena | -.203 | .0130 | .0293 | -.240 | -.137 | -.234 | .118 |
| Meta | .102 | .177 | .176 | -.131 | .0750 | .212 | .0994 |
| Nariño | -.473 | -.409 | -.479 | -.606 | -.674 | -.539 | -.767 |
| Norte de Santander | -.137 | -.00176 | -.0213 | -.160 | .111 | -.0412 | .0318 |
| Quindio | -.212 | .0945 | -.0545 | -.183 | -.124 | .00309 | .0319 |
| Risaralda | -.0749 | .149 | .0585 | -.0641 | .0611 | .0177 | -.0170 |
| Santander | -.0563 | .0827 | .0828 | -.00275 | .163 | .134 | .127 |
| Sucre | -.137 | -.158 | .00818 | -.322 | -.163 | -.0714 | -.0935 |
| Valle | -.0231 | .136 | .0532 | -.0229 | .0595 | .0152 | .172 |
| Experience (Years) | .0374 (8.63) | .0576 (13.) | .0549 (9.95) | .0559 (9.43) | .0374 (5.38) | .0345 (4.73) | .0513 (5.64) |
| Experience ² /100 | -.0423 (4.56) | -.0902 (10.) | -.0775 (8.13) | -.0787 (8.68) | -.0532 (5.62) | .0345 (40.) | -.0651 (6.37) |
| Years of Education | .165 (53.) | .171 (62.) | .176 (63.) | .176 (60.) | .166 (47.) | .165 (33.) | .165 (38.) |
| Intercept | 5.79 | 5.55 | 5.55 | 5.61 | 5.88 | 5.93 | 5.38 |
| R ² | .413 | .436 | .458 | .445 | .410 | .417 | .378 |
| S.E.E. | .680 | .728 | .749 | .778 | .808 | .826 | .941 |
| Sample Size | 6069 | 7689 | 6933 | 6395 | 4822 | 3305 | 3815 |
| Joint F-test for Departamentos (degrees of freedom) | 5.72 (22,6044) | 7.62 (22,7664) | 8.02 (22,6908) | 9.09 (22,6370) | 8.11 (22,4795) | 4.73 (22,3280) | 6.99 (22,3790) |

^aThe dependent variable is the natural logarithm of monthly income reported in the 1973 Colombian Census. The estimates are ordinary least squares with t reported beneath continuous variable coefficients, and in the last row is the joint F test of statistical significance for the regional residence effects.

Note: Tolima is omitted department.

| Variable | 20-24 | 25-29 | 30-34 | 35-39 | 40-44 | 45-49 | 50-65 |
|---|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|
| Antioquia | .0902 | .0423 | .135 | .0398 | .281 | .142 | -.0940 |
| Atlantico | .215 | .118 | .187 | .133 | .419 | -.122 | -.424 |
| Bogota | .125 | -.921 | -.555 | .0201 | -.157 | -.0591 | -.931 |
| Bolivar | .217 | -.185 | .321 | .119 | .204 | .278 | .289 |
| Boyacá | -.663 | -.668 | -.675 | -.653 | -.621 | -.767 | -.971 |
| Caldas | .266 | .149 | .268 | .208 | .405 | .505 | .0346 |
| Cauca | -.215 | -.668 | -.332 | -.486 | -.199 | -.395 | -.553 |
| Cesar | .547 | .454 | .467 | .511 | .168 | .444 | .151 |
| Córdoba | -.0245 | -.0534 | .0771 | -.0567 | .138 | .0331 | -.179 |
| Cundinamarca | -.206 | -.264 | -.152 | -.288 | -.175 | -.376 | -.350 |
| Chocó | -2.26 | -3.60 | -3.91 | -3.42 | -3.38 | -2.41 | -3.91 |
| Huila | -.243 | -.194 | -.125 | -.242 | .130 | .104 | -.346 |
| Guajira | .529 | .679 | .535 | -.285 | .356 | .485 | .536 |
| Magdalena | .250 | .207 | .175 | .253 | .482 | .223 | .0645 |
| Meta | .319 | -.0252 | .167 | -.165 | .581 | .181 | -.00095 |
| Nariño | -.698 | -.775 | -.887 | -.907 | -.619 | -.836 | -.930 |
| Norte de Santander | -.325 | -.236 | -.175 | -.282 | -.00934 | -.274 | -.424 |
| Quindío | -.214 | .156 | .210 | .179 | .252 | .194 | -.00825 |
| Risaralda | .157 | .149 | .352 | .248 | .255 | .477 | .0998 |
| Santander | -.307 | -.520 | -.500 | -.512 | -.340 | -.308 | -.694 |
| Sucre | .0515 | -.0372 | -.0132 | -.105 | .312 | .177 | -.0882 |
| Valle | .105 | .0649 | .179 | .112 | .195 | .293 | -.106 |
| Experience (Years) | .000521 (.06) | .00810 (.87) | -.00872 (.78) | .0145 (1.31) | .0153 (1.18) | .0303 (1.97) | .0241 (1.57) |
| Experience ² /100 | .0178 (1.05) | .000103 (.01) | .0138 (.82) | -.0184 (1.21) | -.0200 (1.25) | -.0307 (1.74) | -.0253 (1.65) |
| Years of Education | .102 (12.) | .110 (14.) | .104 (12.) | .107 (12.) | .104 (9.97) | .117 (9.13) | .103 (9.69) |
| Intercept | 5.95 | 5.96 | 6.22 | 5.90 | 5.74 | 5.34 | 5.69 |
| R ² | .222 | .302 | .330 | .272 | .300 | .235 | .307 |
| S.E.E. | .808 | .832 | .815 | .885 | .912 | .915 | .947 |
| Sample Size | 2865 | 3345 | 3064 | 3068 | 2295 | 1698 | 2517 |
| Joint F-test for Departamentos (degrees of freedom) | 28.19 (22,2840) | 52.55 (22,3320) | 59.59 (22,3039) | 44.19 (22,3043) | 38.17 (22,2270) | 19.69 (22,1673) | 43.85 (22,2492) |

* See note Table B-1

Note: Tolima is omitted department.

Estimated Urban Female Income Functions^{*}

| Variable | 20-24 | 25-29 | 30-34 | 35-39 | 40-44 | 45-49 | 50-65 |
|------------------------------|-----------------|------------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Bogota | .0922 | .179 | .190 | .302 | .187 | .341 | .374 |
| Atlantic Region | .0252 | .0364 | .192 | .106 | -.0344 | .236 | .183 |
| Central Region | .0474 | .0258 | .108 | .0952 | -.0357 | .140 | .113 |
| Pacific Region | -.0439 | .0465 | .243 | .0876 | .0922 | .136 | .203 |
| Experience (Years) | .0708 (2.06) | .116 (4.91) | .114 (2.93) | .104 (1.84) | .251 (2.69) | .189 (1.37) | .0224 (.23) |
| Experience ² /100 | -.298 (1.88) | -.347 (4.43) | -.257 (2.64) | -.239 (2.11) | -.328 (2.19) | -.318 (1.61) | -.0401 (.37) |
| Years of Education | .170 (7.98) | .191 (12.) | .187 (10.) | .154 (6.77) | .235 (8.17) | .158 (4.77) | .166 (9.06) |
| Intercept | 5.28 | 4.71 | 4.50 | 4.83 | 1.03 | 3.05 | 5.40 |
| R ² | .393 | .492 | .493 | .442 | .385 | .450 | .384 |
| S.E. E. | .672 | .650 | .696 | .774 | .764 | .852 | .921 |
| Sample Size | 639 | 1066 | 839 | 684 | 553 | 368 | 377 |
| Joint F-test for Regions | .84 (4,631) | 3.32 (4,1058) | 2.43 (4,831) | 3.64 (4,676) | 1.60 (4,545) | 1.62 (4,360) | 1.89 (4,369) |

^{*} See note Table B-1

Note: Eastern region is omitted category.

B-4

Estimated Rural Female Income Functions*

| Variable | 20-24 | 25-29 | 30-34 | 35-39 | 40-44 | 45-49 | 50-65 |
|------------------------------|----------------|------------------|-----------------|-----------------|----------------|-----------------|-----------------|
| Atlantic Region | .0759 | .507 | .173 | -.248 | .128 | .762 | .205 |
| Central Region | -.0850 | .543 | .242 | .355 | .587 | .460 | .527 |
| Pacific Region | -1.25 | -1.55 | -1.84 | -1.04 | -.583 | -.898 | -1.25 |
| Experience (Years) | -.229 (.90) | .137 (.67) | .488 (1.00) | -.487 (.77) | .238 (.25) | 2.34 (2.40) | .326 (.75) |
| Experience ² /100 | 1.71 (1.70) | -.674 (1.10) | -1.01 (.94) | .840 (.73) | -.210 (.14) | -2.89 (2.28) | -.315 (.70) |
| Years of Education | .408 (3.60) | .189 (2.04) | .391 (3.22) | .180 (1.47) | .520 (3.67) | .707 (4.40) | .353 (5.18) |
| Intercept | 4.28 | 4.55 | -1.00 | 12.08 | -1.65 | -42.89 | -3.51 |
| R ² | .568 | .607 | .551 | .334 | .402 | .478 | .343 |
| S.E. E. | 1.28 | 1.27 | 1.51 | 1.62 | 1.61 | 1.44 | 1.54 |
| Sample Size | 79 | 107 | 92 | 111 | 93 | 71 | 115 |
| Joint F-test for Region | 5.78 (3,72) | 15.76 (3,100) | 12.13 (3,85) | 4.49 (3,104) | 5.36 (3,86) | 5.07 (3,64) | 8.94 (3,108) |

*See note Table B-1

Note: Eastern region is omitted category.

Regressions of the Child Death Ratio on Years of Schooling

Completed by Parents, by Region and Mother's Age*

| Region and Age of Mother | Intercept | Age of Mother | Years of Schooling | | R ² (Significance Level) |
|-----------------------------|------------------|------------------|--------------------|-------------------|---|
| | | | Father | Mother | |
| <u>Urban:</u> | | | | | |
| 20-24 | .0780 (2.28) | .0000 (.02) | -.00161 (2.85) | -.00560 (6.09) | .0212 (.0000) |
| 25-29 | -.0236 (.77) | .00391 (3.45) | -.00155 (2.89) | -.00492 (7.37) | .0271 (.0000) |
| 30-34 | .00565 (.15) | .00291 (2.48) | -.00391 (6.72) | -.00395 (5.40) | .0388 (.0000) |
| 35-39 | .00806 (.18) | .00280 (2.27) | -.00495 (8.15) | -.00421 (5.58) | .0482 (.0000) |
| 40-44 | -.0882 (1.32) | .00522 (3.27) | -.00429 (5.21) | -.00500 (4.93) | .0347 (.0000) |
| 45-49 | .114 (1.21) | .00078 (.39) | -.00586 (5.83) | -.00460 (3.74) | .0405 (.0000) |
| 50-65 | -.0193 (.48) | .00385 (5.37) | -.00608 (5.49) | -.00693 (5.17) | .0517 (.0000) |
| <u>Rural:</u> | | | | | |
| 20-24 | .115 (2.13) | -.00031 (.11) | -.00502 (2.73) | -.00724 (3.69) | .0129 (.0000) |
| 25-29 | .0480 (.88) | .00265 (1.31) | -.00456 (2.56) | -.00663 (4.07) | .0132 (.0000) |
| 30-34 | .116 (1.85) | .00087 (.44) | -.00498 (2.88) | -.00923 (5.25) | .0180 (.0000) |
| 35-39 | -.0268 (.35) | .0466 (2.24) | -.00749 (4.23) | -.00243 (1.36) | .0140 (.0000) |
| 40-44 | .182 (1.78) | .0001 (.04) | -.00749 (3.39) | -.00594 (3.00) | .0103 (.0000) |
| 45-49 | -.0786 (.55) | .00571 (1.84) | -.00639 (2.23) | -.00594 (2.14) | .0103 (.0002) |
| 50-65 | .145 (2.87) | .00110 (1.21) | -.00523 (2.12) | -.00250 (.96) | .0038 (.0131) |

* Dependent variable is the ratio of children born now dead to the number of children ever born to mothers. Absolute value of t ratios reported below regression coefficients in parentheses.

Table C-2

Regressions of Child Death Ratio on Parent Imputed Monthly Incomes,
by Region and Mother's Age *

| Region and Age of Mother | Intercept | Age of Mother | Imputed Logarithm of Monthly Wage | | R ² (Significance Level) |
|-----------------------------|-----------------|------------------|--------------------------------------|------------------|---|
| | | | Father | Mother | |
| <u>Urban:</u> | | | | | |
| 20-24 | .351 (8.49) | .00141 (.97) | -.0136 (2.90) | -.0370 (7.04) | .0247 (.0000) |
| 25-29 | .224 (6.46) | .00400 (3.71) | -.00813 (2.52) | -.0337 (9.65) | .0306 (.0000) |
| 30-34 | .293 (7.29) | .00303 (2.76) | -.0231 (7.11) | -.0238 (6.14) | .0374 (.0000) |
| 35-39 | .369 (7.60) | .00246 (2.10) | -.0231 (7.02) | -.0330 (8.15) | .0492 (.0000) |
| 40-44 | .214 (3.24) | .00621 (4.17) | -.0243 (5.58) | -.0311 (6.20) | .0376 (.0000) |
| 45-49 | .479 (5.20) | .00107 (.58) | -.0306 (5.96) | -.0308 (5.36) | .0450 (.0000) |
| 50-65 | .265 (6.51) | .00474 (7.98) | -.0275 (4.29) | -.0300 (5.84) | .0421 (.0000) |
| <u>Rural:</u> | | | | | |
| 20-24 | .140 (2.13) | .00675 (2.77) | -.0105 (1.45) | -.0292 (5.98) | .0140 (.0000) |
| 25-29 | .213 (3.67) | .00047 (.25) | -.00562 (1.05) | .0184 (5.73) | .0123 (.0000) |
| 30-34 | .154 (2.41) | .00149 (.81) | .00281 (.54) | -.0193 (6.50) | .0114 (.0000) |
| 35-39 | .0335 (.44) | .00512 (2.70) | -.00536 (1.00) | -.0115 (2.57) | .0044 (.0003) |
| 40-44 | .159 (1.58) | .00194 (.84) | .00395 (.62) | -.0220 (5.52) | .0108 (.0000) |
| 45-49 | -.196 (1.41) | .00717 (2.50) | .0234 (2.69) | -.0213 (4.98) | .0107 (.0000) |
| 50-65 | .144 (2.39) | .00150 (1.75) | -.00258 (.49) | -.00360 (.51) | .0012 (.2598) |

* Dependent variable is the ratio of children born now dead to the number of children ever born to mothers. The imputed logarithmic income variable is calculated for each parent on the basis of their characteristics and the region/sex income equation reported in Tables B-1 through B-4. Absolute value of t ratio reported below regression coefficients in parentheses.

Table C-3

Regression of Child Death Ratio on Parent Imputed Monthly Income
and Years of Schooling, by Region and Mother's Age^{*}

| Region and Age of Mother | Intercept | Age of Mother | Imputed Log Wage | | Years Schooling | | R ² (Significance Level) |
|-----------------------------|-----------------|------------------|------------------|------------------|-------------------|-------------------|---|
| | | | Father | Mother | Father | Mother | |
| <u>Urban:</u> | | | | | | | |
| 20-24 | .876 (4.77) | .00221 (1.48) | -.0110 (.84) | -.134 (4.23) | -.00058 (.30) | .0159 (3.10) | .0264 (.0000) |
| 25-29 | .628 (6.20) | .00483 (4.39) | -.00040 (.04) | -.116 (7.10) | -.00148 (.99) | .0149 (5.16) | .0337 (.0000) |
| 30-34 | .615 (5.23) | .00364 (3.26) | -.0363 (3.56) | -.0670 (3.86) | .00218 (1.27) | .00751 (2.49) | .0384 (.0000) |
| 35-39 | .756 (6.65) | .000718 (.59) | .00274 (.26) | -.116 (7.04) | -.00475 (2.62) | .0148 (5.22) | .0528 (.0000) |
| 40-44 | .415 (3.46) | .00826 (4.62) | -.0316 (2.52) | -.0718 (3.47) | .00123 (.56) | .00770 (2.01) | .0384 (.0000) |
| 45-49 | .921 (4.82) | -.00187 (.93) | -.00621 (.39) | -.112 (4.93) | -.00472 (1.68) | .0164 (3.71) | .0481 (.0000) |
| 50-65 | .0205 (.34) | .00377 (6.08) | .00565 (.43) | -.0111 (1.05) | -.00398 (1.83) | -.00747 (2.85) | .0480 (.0000) |
| <u>Rural:</u> | | | | | | | |
| 20-24 | .103 (1.54) | .00619 (2.41) | -.00227 (.29) | -.0277 (4.31) | -.00474 (2.60) | .000301 (.13) | .0163 (.0000) |
| 25-29 | .162 (2.74) | .00087 (.46) | .00021 (.04) | -.0145 (3.57) | -.00489 (3.05) | -.00265 (1.40) | .0172 (.0000) |
| 30-34 | .112 (1.75) | .00116 (.64) | .00776 (1.41) | -.0115 (3.02) | -.00508 (3.08) | -.00509 (2.47) | .0181 (.0000) |
| 35-39 | -.0445 (.58) | .00528 (2.79) | .00167 (.29) | -.00248 (.42) | -.00679 (3.98) | -.00325 (1.54) | .0111 (.0000) |
| 40-44 | .106 (1.05) | .00236 (1.01) | .0154 (2.19) | -.0272 (4.04) | -.0109 (5.03) | .00582 (1.68) | .0186 (.0000) |
| 45-49 | -.259 (1.81) | .00764 (2.56) | .0348 (3.56) | -.0251 (3.13) | -.00877 (3.30) | .00413 (.92) | .0152 (.0000) |
| 50-65 | .109 (1.79) | .00133 (1.55) | .00373 (.60) | .00048 (.06) | -.00575 (2.33) | -.00298 (.90) | .0044 (.0152) |

* Dependent variable is the ratio of children born now dead to the number of children ever born to mothers. The imputed logarithmic monthly wage variable is calculated for each parent on the basis of their characteristics and the region/sex income equation reported in Tables B-1 through B-4. Absolute value of t ratios reported below regression coefficients in parentheses.

Table D-1

Relative Size of Samples from Colombian 1973 Census Sample
for Different Groups Defined by Family and Fertility Status

| Region of Residence and Woman's Age | Number of Women Enu- merated in 4 Percent Sample | Percent of All Women in Category | | | | |
|--|--|---|-----------------------------------|---|---|--|
| | | Reporting Education and Marital Status | Reporting Fertility and (2) | Reporting Positive Fertility and (3) | Husband Present, Education Reported and (4) | Husband's Income Reported and (5) |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| <u>Urban:</u> | | | | | | |
| 20-24 | 27,117 | 97 | 78 | 42 | 21 | 19 |
| 25-29 | 19,960 | 97 | 87 | 67 | 40 | 37 |
| 30-34 | 15,418 | 97 | 91 | 79 | 50 | 46 |
| 35-39 | 14,460 | 97 | 92 | 83 | 51 | 47 |
| 40-44 | 11,812 | 96 | 91 | 83 | 49 | 45 |
| 45-49 | 9,822 | 97 | 92 | 82 | 44 | 38 |
| <u>Rural:</u> | | | | | | |
| 20-24 | 9,951 | 95 | 80 | 56 | 35 | 31 |
| 25-29 | 8,029 | 95 | 87 | 77 | 54 | 48 |
| 30-34 | 6,872 | 95 | 89 | 82 | 60 | 53 |
| 35-39 | 6,914 | 95 | 90 | 84 | 62 | 54 |
| 40-44 | 5,534 | 95 | 90 | 84 | 59 | 52 |
| 45-49 | 4,430 | 95 | 89 | 84 | 56 | 49 |

Source: Author's tabulations of Colombian 1973 four percent sample. Column (6) samples used in regressions reported in Table C-1 (and Table 1) and column (5) sample minus those with zero income are used for regressions reported in Tables C-2 and C-3 (Tables 2 and 3).

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