Interactions of Childhood Mortality and Fertility in W. Malaysia: 1947-1970

by

Peter S. Heller

CENTER FOR RESEARCH ON ECONOMIC DEVELOPMENT
The University of Michigan
Ann Arbor, Michigan 48108

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Peter S. Heller

Department of Economics
&
Center for Research on Economic Development
University of Michigan

ABSTRACT

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This paper outlines a model of fertility and infant and toddler mortality that incorporates the perspective that parents have a substantial influence on the probability of childhood survival. Fertility is argued to be one potential factor influencing the child mortality rate. The hypothesis is tested through an econometric analysis of demographic change in W. Malaysia between 1947 and 1970. The empirical analysis relies principally on aggregate data collected during the 1947, 1957 and 1970 W. Malaysian censuses. The results suggest that (1) there is support for the view that higher fertility leads to higher child mortality, particularly at the beginning of a demographic transition; (2) models of fertility that do not consider the endogeneity of the child mortality rate may be biased toward accepting the hypothesis that parents "replace" child deaths by additional births.

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Cet exposé donne les grandes lignes d'un modèle de fécondité et de mortalité du nourrisson et du jeune enfant qui comprend la perspective que les parents ont une influence assez importante sur la probabilité de survie infantile. La fécondité est prétendue être un facteur potentiel influençant le taux de mortalité infantile. L'hypothèse est vérifiée par une analyse économétrique des changements démographiques dans l'ouest de la Malaisie entre 1947 et 1970. L'analyse empirique se base principalement sur des données globales rassemblées pendant les recensements de 1947, 1957 et 1970 dans l'ouest de la Malaisie. Les résultats suggèrent que (1) il y a un support à l'opinion qu'une fécondité plus importante entraîne une mortalité infantile plus élevée, en particulier au début d'une transition démographique; (2) les modèles de fécondité qui ne considèrent pas l'endogénéité du taux de mortalité infantile peuvent être prédisposés à accepter l'hypothèse que les parents "remplacent" les décès d'enfants par des naissances supplémentaires.

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Peter S. Heller
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In recent years, our understanding of the fertility behavior of households in developing countries has been enriched by viewing it within the framework of a general model of household decision-making. Both the number and quality of children of a family are recognized to be subject to parental choice in a way analogous to the choice of commodities and leisure. Such models generally assume these decisions are made subject to some socio-economic constraints, one of which is that the likelihood of a child's survival is beyond the control of the family. This assumption runs counter to our understanding of the determinants of infant and toddler mortality and morbidity, which suggests that the family has considerable influence over the health and survival of its children. Decisions concerning fertility, child quality and the consumption of "family public goods" in effect also become decisions on the probablility of survival.

This paper will outline a model of fertility and infant and toddler mortality that embodies this broader view. It provides a preliminary empirical test of its validity through an econometric analysis of demographic change in West Malaysia between 1947 and 1970. Section I briefly summarizes recent perspectives on the fertility and child quality decision, shows how our view of child mortality might be incorporated, and develops the specification of an econometric model.

The empirical work relies principally on aggregate data collected during the 1947, 1957 and 1970 W. Malaysian censuses, and which are described in Section II. Section III discusses the econometric procedure followed in estimating the model.

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In presenting the results in Section IV, we focus on three empirical issues. First, our model argues that the probability of child survival is endogenous to the family decision process. What factors explain differences in the level of child mortality within the Malaysian context? Is there support for our hypothesis that higher levels of fertility may be in part responsible for higher rates of infant and toddler mortality? Second, previous econometric models of fertility have generally concluded that the level of fertility is positively influenced by an exogenously specified probability of child mortality. Are these results robust to the assumption that the child mortality rate is endogenous to the model? Third, between 1947 and 1970, Malaysia has undergone what some might call a "demographic transition."[1] Age specific fertility rates and the crude birth rate rose slightly between 1947 and 1957 and then dropped sharply by 1970 (Table 1). The infant and toddler mortality rates have fallen since 1947. Does the strength of the hypothesized impace of fertility on child mortality, and vice versa, lessen as one moves to a lower fertility and child mortality rate environment? Section IV evaluates the econometric results and their implications are briefly examined in the concluding Section V.

Table 1

Fertility and Childhood Mortality Rates: W. Malaysia, 1947-1970

	1947	1957	1970
Fertility Rate, 15 to 19	126	136	57
Fertility Rate, 20 to 24	317	329	232
Fertility Rate, 25 to 29	278	346	236
Fertility Rate, 30 to 34	211	272	220
Fertility Rate, 35 to 39	144	165	133
Fertility Rate, 40 to 44	61	74	56
Crude Birth Rate	43	48	30
Infant Mortality Rate	90	71	39
Toddler Mortality Rate	Not Available	26	3

[1] Teitelbaum (1975), Oechsli and Kirk (1975)

I

A common perspective of recent models of fertility is that parents choose the number, n, of children they will have and the level of quality, q, to which they will be raised. These choices are made according to the same rationality and subject to the same constraints as their decisions concerning work, leisure, savings and consumption. A recent model by Willis illustrates this.[1] Parents are assumed to maximize their lifetime utility U:

$$U = u(n, q, s), \tag{1}$$

where s constitutes other sources of satisfaction to the parents, derived from the consumption of goods and leisure. It is assumed that parents choose an equal level of child quality, q, for each child born.

Through a household production function, homogenous of degree one, average child quality is produced by the input of parental time per child, t_c/n, and resources per child, x_c/n (in the form of food, clothing, education, and medical care):

$$q = q(t_c/n, x_c/n; \alpha, K), \tag{2}$$

where q_1, $q_2 > 0$, K is an index of parental knowledge and child-rearing efficiency and α is the probability of child survival. Parents are assumed to have control over the number of children born, although in a less developed country (LDC) context, this is likely to be a strong assumption. When considered, the rate of child mortality is usually introduced through the exogenous parameter α, which influences the perceived marginal cost and marginal return of additional children.[2] Finally, the level of s is produced as a function of parental consumption, x_s, and leisure, t_s, viz.,

$$s = s(x_s, t_x). \tag{3}$$

Lifetime allocation decisions are made by maximizing (1) subject to constraints on the amount of time available to the parents to allocate as

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[1]This model is developed by Willis (1973) from the original, less general model by Becker (1960). We have simplified some of Willis' assumptions.

[2]Schultz (1973).

between work and leisure, the level of family-owned property and human capital endowments and the level of market wages for both spouses:

$$p_s x_s + p_c x_c = wL + A_o \qquad (4)$$

$$T = L = t_c + t_s, \qquad (5)$$

where A_o are family assets at the beginning of the planning period, L is the collective market time input of the family, and p_s and p_c are the prices respectively, of x_s and x_c. By solving such a model, one may derive demand equations for the number and quality of children (n and q) and the level of parental satisfaction, s, which are functions of a measure of the family's full wealth, I, the shadow price of children, π_c, and of s, π_s (where c = nq).[1]

In the context of recent models on the demand for health, such a model is incomplete.[2] Grossman has suggested the need for an additional term in the utility function, ϕH, to represent the flow of healthy days produced by the stock of health capital H of the parents. Changes in H are partly a function of age but also of inputs of medical services and other goods and services (food, shelter, etc.) consumed by the parent. Yet if one accepts the concept that parental H is endogenous to the family decision process, it is difficult to justify the assumption that the probability of child survival is exogenous. Analogously, the Grossman and Willis works must be extended to reflect the parentally derived demand by parents for the health status of their dependent children.[3]

Specifically, the quality and quantity of parentally provided inputs to children will significantly affect their morbidity experience and likelihood of survival. This is particularly true from birth through the first three or four years of life. This encompasses the nutrient intake of the pregnant mother, the duration of nursing, the character of the weaning process, the degree of exposure to environmental risks, the use of preventive and curative health services and the quality and quantity of nutritional intake after weaning. These decisions may influence a child's birthweight, its likelihood of

[1]This is elaborated fully in Willis (1973).

[2]Grossman (1972).

[3]A start toward such a model has been made by Nerlove (1974), and Welch (1975).

malnourishment, the likelihood of exposure and susceptibility to illness, and the ability of the child to survive.[1]

The health status of any child may also be influenced by parental decisions concerning desired family size. The larger the family size, the smaller the family resources available to any one child in the short run. Particularly in a poor, agricultural society, there may be pressures to devote resources to the working members of the family, and the competition for residual resources is heightened in a high fertility environment. Families desirous of high fertility are also more likely to have mothers at the two extremes of the child-bearing years and shorter spacing between births. The latter two factors may adversely influence the mother's health and possibly the child's birthweight as well.[2] It may lead to earlier weaning of the previous child, with adverse accelerated exposure to the risks of inadequate and contaminated alternative food sources. Young mothers and high parity, older mothers are more likely to have low birthweight children (the former due to greater likelihood of prematurity) and such mothers are more commonly found in high fertility households.[3] The child's human capital endowment at birth, often proxied by its birthweight, will influence its capacity to resist and survive early infections and disease agents.

This does not suggest the unimportance of environmental factors -- the incidence and strength of disease vectors -- on the probability of child survival, but there remains a substantial degree of parental control and influence.

In reformulating the model, it is the expected number of children that will survive, αn, that is relevant to parental decisions,

$$U = U(\alpha n, q, s). \quad (6)$$

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[1]These decisions are also influenced by the socio-economic environment in which the parents live, although even this is no longer exogenous where rural-urban migration is common.

[2]Puffer and Serrano (1975).

[3]The "weaning" and "resource competition" effects are most relevant for toddlers (aged 1-4) or infants during the last three to six months of the first year. The maternal age and parity effects are operable in some respects as early as the neonatal period. For evidence of the importance of these and other effects, see Wray (1972).

Secondly, the average quality of a child is determined by the available resources per living child, and thus for given levels of t_c, x_c, and n, q is inversely related to α:

$$q = \phi(t_c/\alpha n, x_c/\alpha n; K). \tag{7}$$

Thirdly, α is no longer assumed exogenous to the family:

$$\alpha = \Psi(q, n; W, E), \tag{8}$$

where E is an index of the exogenously determined risk of morbidity due to environmental factors and W is the child's birthweight.[1] The probability of child survival is determined by average child quality (where $\Psi_1 < 0$) and by the level of fertility within the household ($\Psi_2 < 0$).[2]

This would be the simplest form of model. A more complex and realistic approach would allow α $A(t_c/n, x_c/n, x_s, t_s, W, E)$ and would consider the composition of x_c and the role of joint production from parental consumption of x_s and t_s (housing, water supply, etc.)[3] The quality of nutritional intake appears as important as its qualtity in influencing whether the child is malnourished. Use of preventive health services may be crucial to ensure immunity from particular infectious diseases. The quality and quantity of nutritional intake to the mother during pregnancy, x_s, may substantially influence both her health status and the level of the child's birthweight. Also, W and E would be considered as endogenous; birthweight is likely to be influenced by the level of x_s and t_s to the pregnant mother, and E is influenced by the migration decision.

What is the effect of these added assumptions on the earlier model's implications for parental behavior? It should be emphasized that although our model argues that parents make daily choices and tradeoffs which implicitly affect the survival probability of their children, this is not inconsistent with their naive perception that α is exogenous to them. In this case, utility maximization by the parents would involve maximization of (6) subject only to

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[1]In a multiperiod framework, the specification of equation (7) would not be fully accurate. Costs are incurred prior to a child's death. Families with above (below) average mortality experience would thus have a greater (lower) level of resources per child. An exogenous increase in the probability of survival reduces the cost of surviving children and thus has both income and substitution effects on αn.

[2]A later parity child's human capital endowment W may, for physiological reasons, be inversely influenced by its parity level.

[3]There may be perverse income effects. Increases in x_c arising from increases in income may take the form of increased consumption of the normal good, bottled milk, and reduced consumption of the parentally perceived inferior good, breast-fed milk.

(7), (3), (4) and (5). The principal results developed by Willis and others concerning the characteristics of the demand for n and q would basically remain unchanged, except that αN would replace N in these models, with $\underline{\alpha}$ an exogenous parameter.[1] In a multi-period, sequential decision-making framework, this parental ignorance of the endogeneity of α could cause parents' actual childhood morbidity and mortality experience to differ from their initial expectations concerning the outcome of their family resource allocation decisions.[2] They would revise the level of q and n chosen, although the effect of a change in the perceived α on the level of n, c, and q are all uncertain [see Appendix]. An increase in the number of children, n, will lower the survival probability α indirectly through its effect on q, even if one ignored the direct parity effect of n on α as specified in (8).[3] This suggests that, _ceteris paribus_, parents opting for a higher n/q mix will experience greater likelihood of a lower actual α relative to their initially perceived α.

Alternatively, if one assumes parents recognize the ramification of trading-off resources between parents, fertily and child quality,[4] the model would include equation (8) as a constraint. Examination of the deman conditions indicates a significant difference in income and substitution effects, although the direction of the change become ambiguous [see Appendix].

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[1]In the Willis model, the income elasticity of c = nq, and n would be directly proportional to α, and the compensated substitution effects of c, q, n would be inversely related to α.

[2]See O'Hara (1975).

[3]From equations (7) and (8), if we assume that $dt_c=0$ and $dx_c=0$, then

$$\frac{d\alpha}{dn} = \frac{\Psi_2 n^2\alpha^2 - [\Psi_1\alpha(f_1 t_c + f_2 x_c)]}{n^2\alpha^2 + [\Psi_1 n(f_1 t_c + f_2 x_c)]} < 0.$$

[4]There are arguments in the literature that α is indeed perceived as endogenous by the parents, although parents may not put it in such stark terms. Sex preference may manifest itself in a biased allocation of resources among children. Primitive "taboos" may cause parents to ignore a child, partly as a social mechanism for dealing with families of excessive size (the "evil eye" in Columbia). Allocation of food resources to children of cultivator parents may be at the expense of adequate nutritional intake to the parents, with negative implications for productivity and family incomes.

Econometric Specification of the Model

Another important implication of our new assumptions is a change in the specification of the principal demand equations that flow from the earlier fertility model. In particular, the demand for fertility that emerges from maximization of (1) subject to (2) through (5) is a function of the price and wage parameters (p_c, p_s, w), the level of nonearned income (A_o), the quality of parental K and the exogenous parameter α capturing the perceived probability of child survival. By substituting equations (6) through (8) for (1) and (2), one can no longer assume that α is exogenous to the household. In the traditional fertility equation of Schultz and others, α must be considered as an included endogenous variable.[1] In addition, one can also specify a structural equation for α, which is a function of n and q, and other exogenous parameters. Thus, the level of fertility and child mortality are structurally interdependent.

In what follows, we shall describe the specification of our econometric model of fertility and child mortality in West Malaysia. Ideally, a test of the hypothesized endogeneity of α would be based on microeconomic data collected at the household level. One would want to explain whether a child's probability of survival is significantly lower in high fertility households and whether it is influenced by "child quality". Conversely, is fertility higher in households with greater expectation of child mortality? Unfortunately, we are limited in this study to data based on aggregative demographic and socioeconomic measures.[2] This places certain constraints on the specification of the model. Some of the variables suggested by the household model can only be imperfectly measured at an aggregative level. Aggregative measures often mask variations of a variable within the population and therefore cannot

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[1]Schultz (1973).

[2]The only such study on infant mortality that is available is by L. Russell (1974) based on a P.A.H.O. study of child deaths in Argentina. Unfortunately, it does not focus on the infant mortality-fertility interaction. Two recent micro-economic studies by the author, Heller (1976a, 1976b), examine the determinants of malnutrition and the demand for health services -- both of which are contributory factors to explaining the likelihood of child survival.

fully capture the endogeneity of an individual child's state of health to the choices of its particular family.[1] Finally, the specification of a model to explain patterns of aggregative demographic change will differ from that of a household model in order to account for the characteristics of group behavior over time.

The basic structure of our econometric model takes the general form:

$$D_i = D_i[(B_1, \ldots, B_k), C, E, K, t_c, Y] \qquad i = 1, 2 \qquad (9)$$

$$B_j = B_j[D_1, D_2, d, m, K, t_c, Y, V] \qquad j = 1, \ldots k \qquad (10)$$

where (1) D_1 and D_2 are the infant and toddler mortality rates, respectively;[2] (2) B_j is the fertility rate of the j^{th} age group; (3) K is the quality of the parental human capital brought to bear on the child rearing process, and thus on its efficiency; (4) t_c is the amount of parental time input to child rearing; (5) Y is a measure of the socioeconomic status of the group and thus its capacity to afford a better quality and greater quantity of X_c inputs; (6) E is the quality of the external environment in which the child or maternal population resides; (7) C is a measure of the availability of medical and preventive services; (8) d is a measure of the age structure of the population, which reflects differences across states or districts in the size of the reproductive age group; (9) m is a measure of the marital rate of females in different age groups of the population; and (10) V is a measure of the potential cost of children. The two sets of endogenous variables in the system are measures of the child mortality D_i and fertility experience B_j of the population.

In our estimation of the infant and toddler mortality rates, we use several alternative measures of fertility: (i) the crude birth rate $\bar{b}$, (ii) the age-specific fertility rate of women in the extremes of the child-bearing

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[1] In fact, one would want the average characteristics of households sampled by children, not by parents, and these will differ greatly.

[2] The infant mortality rate is defined as the number of infant deaths per year per 1,000 live births during the year. The toddler mortality rate is defined as the number of death to children, aged 1 to 4 per 1,000 children, during the year.

years, b_i, (for i = age 15-19 and 40-44) and (iii) the gross reproduction rate.[1]

The other variables in equation (9) reflect dimensions of the quality and quantity of resources brought to bear on the child-rearing process, the child's likely exposure to disease vectors and the quantum of disease-producing agents within its environment. Though one may attempt to isolate specific aspects, these factors are obviously highly correlated. Improvements in the socio-economic status of the family, Y, may be accompanied by a higher level, and possibly higher quality of nutritional intake to the child and fetus,[2] by less dense housing consitions, improved access to unpolluted water sources, less frequent exposure to diseases caused by inadequate human waste disposal, and by a greater capacity to afford preventive and curative medical care.

The quantity (t_c) and quality (K) of the parental time input provided to the child should have an influence on the child's quality and thus its chance of survival. More educated parents are more likely to provide the correct balance of nutrients, respond to medical and health needs more quickly and provide a hygienic food intake and living environment. Greater availability of public sector medical services in a community may imply a lower utilization cost, ceterus paribus, and may also signify a greater level of associated preventive health activities as well.

We have used the following variables to reflect the above factors: (1) indices of the availability and utilization of medical care (C) include the per capita availability of midwives, hospital beds, and main health centers, as well as the number of dispensary or hospital outpatient visits per capita; (2) as measures of environmental quality (E), we have used the urbanization rate, (the percentage of the population living in towns of more than

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[1] If our data had allowed, it would have been preferable to us an estimate of fertility among married women.

[2] The opposite is possible, e.g., the substitution of bottle-feeding for breast-feeding.

1,000), the percentage of living quarters with piped water inside the home, the percentage of living quarters reliant on bucket disposal of wastes, and the population density per living quarter; (3) the female literacy rate serves as a measure of the quality of parental input (K), and indirectly as a correlated proxy for Y; (4) the percentage of employed females engaged in agriculture or agricultural processing (primarily palm oil or rubber), the employment rate among females in the labor force, and the fraction of females in the 15 to 64 age group that are employed reflect the quantity of parental time input (t_c) and again, indirectly Y; (5) the number of vehicles or scooters per capita and the percentage of total employees in manufacturing may serve as indices of Y.

Although we have attempted to include variables which adequately proxy the variables conceptually relevant to our model, some are better proxies than others. For example, the female literacy rate variable hopefully captures differences in the average K level across districts, but it is certainly possible that it also captures other effects as well. This is merely to suggest the limits that exist on the interpretation of our results.

The specification of our fertility equation (10) is similar to that used in earlier studies by Schultz and others.[1] For an aggregative study, infant and toddler mortality rates are only indicators of the mortality experience on a community-wide basis, and would operate on an individual family only to the extent that these are perceived as directly relevant to them. It is unlikely that these rates capture any of the physiological relationships between mortality and fertility through the lactation effect. As well as the data allowed, we have also attempted to measure the differential impact of toddler and infant mortality experience on the fertility of women in different age groups.

To correct for differences in the demographic structure of the population, d and m, we have included as variables: (1) the percentage of the female population in the reproductive age group, 15-44, and (2) the percentage of women in different age groups that are married (in the age groups 15 to 19, 20 to 29, and 30 to 44). Presumably, if one racial group

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[1]For a fuller discussion of this literature see Schultz (1973), Nerlove and Schultz (1970), Ben Porath (1973), and Willis (1973).

experienced higher marriage rates in the early reproductive years, this will lead to a higher relative level of age specific fertility at that time. However, over the entire reproductive period, a later average age at marriage might cause a higher age-specific fertility rate in later age periods because the reproduction period is compressed to a shorter period. In addition, (3) the percentage of the Malay population that are Indonesian immigrants has been included to capture their known higher levels of fertility relative to Mainland Malays.

At an aggregate level, it is difficult to capture a meaningful measure of V, the cost of children. The percentage of children enrolled in school captures both positive and negative influences. While it implies monetary outlays for schooling and the partial unavailability for agricultural work, it also may relate to the returns from children. Similarly, the variables proxying t_c, the percentage of females engaged in agriculture or agricultural processing, may capture a partial measure of the cost of child care as well. In the fertility equations, male literacy rates were also used to measure Y.

II. Sources and Characteristics of the Data

The model is estimated on two separate data sets. The first (hereafter data set I) is a pooling of cross-sectional and time series observations for the periods 1947, 1957 and 1970, for each of the eleven Malaysian states and for each of the three principal racial groups (Malay, Chinese and Indian), thus yielding 99 observations. Malaysia is a multi-racial society, with approximately 51%, 36% and 11% of its 9.4 inhabitants in the three groups, respectively. These groups are dissimilar in demographic, cultural and socio-economic terms, thus allowing a wide range of demographic and mortality experience for the data over the period. The choice of time periods is dictated by the three post-war Population Censuses of West Malaysia. By going as far back as 1947, the data include much of the demographic change witnessed in West Malaysia.

The second set of data (data set II) is based on the 1970 Population Census of Malaysia.[1] This allows a more disaggregated cross-sectional breakdown of variables for each of West Malaysia's 70 districts as well as by each

[1] Much of this census is yet unpublished. The Department of Statistics of West Malaysia generously allowed us access to the preliminary summary results.

of the three racial groups. Its principal disadvantage is that the range of fertility and mortality experienced in 1970 is much narrower. The sources of data for both data sets are listed in the bibliography.

Several problems emerged in assembling this data. First, at the level of disaggregation suggested above, there will be obvious cases where the size of a racial group in a state or district is too small to use for the purposes of estimating a demographic measure such as the infant mortality rate. We exclude all observations where the number of births for a racial group in the district or state was less than five hundred. Second, some variables cannot be estimated on a race-specific basis, either for conceptual reasons or due to the absence of data. For those variables the statewide measure for each period is included. This may introduce bias in the coefficients where there exists a wide variance in the value of a variable across racial groups within a state.[1] Third, where a variable was not reported or collected on a comparable basis in the different censuses, further assumptions are required to render them comparable.[2]

Fourth, there are undoubted differences in the quality of the data. The 1970 Census is probably more accurate than the 1947 Census. A decline in the underreporting of both infant births and deaths has occurred over time, with likely <u>under</u>estimation of the birth rate and infant death rate in the 1947 period. Moreover, although we attempt to include birth and death data only when reported in terms of the place of residence, it is still likely that in some cases births or deaths are reported in the place of the vital event's occurrence. This would probably bias upward the birth and death rates in the urban areas containing the principal hospitals. The quantitative effect of this is unclear since it is also likely that there was low utilization of the major urban hospitals in some states by the residents of other states, par-

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[1]This primarily includes medical and environmental variables; specifically, hospital and dispensary outpatient visits per capita, midwives per capita, hospital beds per capita, main and subhealth centers per capita, scooters or vehicles per capita, the percentage of living quarters with piped water inside the house or reliant on bucket waste disposal and the population per living quarter.

[2]For example, in 1947 the female literacy rate was calculated only for the population aged 15 and over, whereas the literacy rate in 1957 and 1970 was estimated for the population aged 10 and over. We assumed that the ratios of the female literacy rate, by state and race, of those aged 10 and over to those aged 15 and over in 1947 equalled the known ratios for 1957.

ticularly in the mid-1940's. Finally some variables, particularly the age-specific fertility and gross reproduction rate variables are pieced together from several different sources.[1]

III. Econometric Issues

Several econometric issues arise in estimating this model. First, our model includes a simultaneous equation system and this suggests the need for a simultaneous equation estimation procedure to obtain consistent estimators for the model's structural coefficients. Since the equation system as specified is over-identified, two stage least squares (TSLS) were used in estimating each equation. The first stage estimations provided instruments for the two sets of endogenous variables in the system: the child mortality rates and the measures of fertility.

Second, our observations consist of "grouped" data on the individual variables. For example, the demographic rates represent an aggregation of the observations on the individuals within each group. Where there are large differences in the number of individuals within each group, the use of OLS estimators proves inefficient, yielding a downward bias to the _t_ ratios on the individual parameters.[2] This is a problem in both data sets, since the size of the population in a given racial group of a state may differ greatly from that of another racial group in another state. This is essentially a problem in heteroscedasticity. It may be corrected by transforming the variables in a particular equation by multiplying all variables for each observation by the square root of the size of the group associated with that observation.

Thus, in the equations explaining the crude birth rate, the population

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[1] For example, the age-specific fertility rates for 1970 are estimated from the Vital Statistics 1970 and the 1970 Population Census. For 1957, we use estimates provided by Saw Swee Hock (1967) of the GRR and age-specific fertility rates. For 1947, we rely on estimates from a study by T. Smith (1952), which provide estimates of age-specific fertility rates and of the GRR, but only for the Malay and Chinese population.

[2] Kmenta (1971), pp. 322-335.

group that is relevant is the total population during a given period.[1] For any observation, we can associate an index ijt where j is the racial group, i is the state or district, and t is the time period. If N_{ijt} equals the population of the ij^{th} group at time t, all variables in the crude birth rate equation (including the constant term) for observation kjt are multiplied by $\sqrt{N_{ijt}}$. Similarly, the relevant population group: (1) for the infant mortality rate equation is the set of live births to the ij^{th} group in the t^{th} year, (2) for the age-specific fertility rate equations is the total female population in the particular age group, (3) in the toddler mortality equations is the number of children in the one to four year age group. As above, all variables in a particular equation are multiplied by the square root of the size of the relevant population group for the ijt^{th} observation. The only exception relates to the infant mortality equation. Since the number of live births is endogenous to the model, the square root of the predicted number of births to the ijt^{th} group is used as our weighting factor. It should be noted that one effect of this common transformation of both dependent and independent variables is to slightly boost the level of the correlation coefficient for each equation, relative to the unweighted estimates.

IV. Econometric Results

A. Determinants of Infant, Toddler and Maternal Mortality

In Table 2, equations 1 to 3 illustrate the determinants of infant mortality between 1947 and 1970 (data set I), using three alternative measures of fertility. The first two, the crude birth rate (CBR) and the gross reproduction rate (GRR), provide measures of the aggregative fertility rate. The third, the age-specific fertility rates of women aged 15-19and 40-44, provides measures of the fertility of the two population groups for which high fertility may, on theoretical and physiological grounds, be associated with a high rate of infant mortality. Each fertility measure enters the equation

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[1] The crude birth rate is defined as the number of births in a year per 1000 midyear population.

Table 2

Econometric Estimates of Infant and Toddler Mortality Rate Determinants: Malaysia, 1947-1970 (state-data for three racial groups)

(t statistic in parentheses)

Indep. Variable \ Dep. Variable	Infant Mortality Rate			Toddler Mortality Rate[d/]		
Equation Number	1	2	3	4	5	6
Endogenous						
Pred. Crude Birth[a/]* Rate: 1947	.20					
	(6.30)					
Pred. Crude Birth[a/]* Rate: 1957	- .09			.71		
	(5.23)			(2.89)		
Pred. Crude Birth[a/] Rate: 1970	- .75			.42		
	(-2.31)			(1.40)		
Pred. Gross Reproduction[a/]* Rate: 1947		7.14				
		(4.69)				
Pred. Gross Reproduction[a/]* Rate: 1957		1.90			6.81	
		(4.69)			(4.10)	
Pred. Gross Reproduction[a/] Rate: 1970		-5.29			2.24	
		(-1.42)			(.84)	
Pred. Fertility Rate[a/] Females, Aged 15-19: 1947*			.22			
			(4.63)			
Pred. Fertility Rate[a/] Females, Aged 15-19: 1957*			.13			.05
			(3.95)			(2.11)
Pred. Fertility Rate[a/] Females, Aged 15-19: 1970			- .05			-.02
			(- .80)			(.30)
Pred. Fertility Rate[a/] Females, Aged 40-44: 1947*			.00			
			(.87)			
Pred. Fertility Rate[a/] Females, Aged 40-44: 1957*			- .09			.27
			(- .29)			(2.79)
Pred. Fertility Rate[a/] Females, Aged 40-44: 1970			- .07			.09
			(.57)			(1.08)
Exogenous						
Ratio of Children 5-9 to Children 0-4				-60.90	-74.70	-78.90
				(-2.98)	(-3.96)	(-4.17)
Outpatient Visits to Dispensaries Per Capita	-6.32	-2.83	-8.81	17.49	14.05	18.50
	(-.90)	(-.38)	(-1.26)	(3.08)	(3.06)	(3.43)
Outpatient Visits to Hospitals Per Capita	18.87	17.78	27.63	6.48	10.34	6.44
	(2.46)	(2.15)	(3.69)	(1.14)	(2.10)	(1.22)
Percent of Pop. in Urban Areas	-.04	-.03	-.01	-.20	-.26	-.26
	(-.37)	(.23)	(-.32)	(-2.04)	(-3.33)	(-2.69)
Percent of Literate[b/] Females: Chinese				.23	.39	1.01
				(.22)	(1.70)	(2.73)
Percent of Literate[b/] Females: Malay		-.67	-.51	-.20	-.18	-.19
		(-4.64)	(-2.94)	(-2.20)	(-2.60)	(-3.30)
Percent of Literate[b/] Females: Indian				.51	.52	-.38
				(2.18)	(2.42)	(-.23)
Percent of Literate Females: Total	-.53					
	(-3.68)					
Percent of Females in Agriculture		-26.10	-38.80	2.22		13.16
		(-1.78)	(-2.70)	(9.49)		(1.45)
Percent of Females in Agricultural Processing		-22.76	-46.60			
		(1.83)	(-3.8)			
Percent of Females in Agri. and Agri. Processing	-21.70					
	(-2.09)					
Midwives per Capita				-6075		
				(.96)		
Malay[c/]*	113.13	105.00	84.60	54.40	76.00	71.40
	(7.04)	(6.60)	(4.78)	(.92)	(1.24)	(3.58)
Indian[c/]*	116.61	97.50	77.13	5.50	15.50	19.10
	(6.90)	(6.58)	(3.86)	(-2.60)	(-3.03)	(.30)
Chinese[c/]	77.40	65.98	51.65	44.70	61.30	11.40
	(5.43)	(3.94)	(2.41)	(1.40)	(2.04)	(.36)
R^2	.96	.96	.96	.92	.91	.84
N	(96)	(96)	(96)	(63)	(63)	(63)

a/ These variables were estimated through the use of multiplicative dummy terms. For example, three variables were included in the specification for the variable "predicted crude birth rate": (1) var A = predicted crude birth rate; (2) var B = var A, for 1947 observations, 0 otherwise; (3) var C = Var A, for 1957 observations, 0 otherwise. The coefficient of the predicted crude birth rate variable in 1947 is $\beta_A + \beta_B$; for 1957 is $\beta_A + \beta_C$; for 1970 is β_A. In presenting the results we have already made the above additions for all multiplicative dummy expressions in order to facilitate the interpretation of the results. The "t" statistic displayed is that corresponding to β_A, β_B and β_C. For any given set of multiplicative dummies, the nonstarred term is equivalent to the variable A in the above example. Thus, to judge the significance of a starred coefficient value, one would have to examine its sum "t" statistic and that for the nonstarred variable as well.

b/ These variables are multiplicative dummy terms comparable to those described in footnote A, except that race instead of calendar year is the relevant classification. Var A corresponds to the Chinese term, var B to the Malay term and var C to the Indian term. The results are reported as in footnote a/.

c/ These variables are additive dummies, where the Chinese term corresponds to the constant, and the Malays and Indians were additive dummies. The results are reported as in footnote a/.

Table 3

Econometric Estimates of Infant and Toddler Mortality Rate Determinants: Malaysia, 1970 (district-wide data for 3 racial groups)

(t statistic in parentheses)

Dep. Variable / Indep. Var. — Eqn. Number	Infant Mortality 1	Infant Mortality 2	Toddler Mortality 3	Toddler Mortality 4
Endogenous				
Pred. Crude Birth	1.62		.18	
Rate: Chinese	(3.52)		(2.05)	
Pred. Crude Birth	1.44		.27	
Rate: Malay*[a]	(.40)		(1.25)	
Pred. Crude Birth	1.45		.21	
Rate: Indian*[a]	(-.24)		(.3)	
Pred. Age Specific				.06
Fertility Rate: Females,				(3.56)
aged 15-19: Total				
Pred. Age Specific				
Fertility Rate:[a] Females,		-.05		.06
aged 15-19: Chinese		(-.18)		
Pred. Age Specific				
Fertility Rate: Females,		.45		(3.56)
aged 15-19: Malay*[a]		(1.96)		
Pred. Age Specific		.14		
Fertility Rate: Females,		(.50)		
aged 15-19: Indian*[a]				
Pred. Age Specific		.49		
Fertility Rate:[a] Females,		(2.02)		
aged 40-44: Chinese				
Pred. Age Specific				
Fertility Rate: Females,		.01		
aged 40-44: Malay*[a]		(-1.54)		
Pred. Age Specific		.31		
Fertility Rate: Females,		(-.34)		
aged 40-44: Indian*[a]				
Pred. Age Specific				.04
Fertility Rate: Females,				(1.18)
aged 40-44: Total				
Exogenous				
Main & Sub-Health Centers	19.4	1.49	5.4	2.39
Per 10,000 Population	(2.53)	(.24)	(4.03)	(2.31)
Population Per Hospital	.4	-3.2	.64	-.01
Bed (in 1,000 of pop.)	(.15)	(-1.5)	(1.33)	(-.02)
Female Literacy Rate	-.36	-.22	-.03	-.02
	(-3.4)	(-1.64)	(-1.15)	(-.96)
Female Employment Rate	-70.9	-64.2	-10.1	-9.96
among Females in Labor Force	(-2.28)	(-1.92)	(-1.76)	(-1.71)
Percentage of Females (15-64)	14.5	4.51	.67	.39
Employed	(1.18)	(.33)	(3.08)	(1.70)
Percentage of Living	18.0	17.1	4.66	4.6
Quarters with Bucket Waste Disposal	(1.25)	(1.67)	(2.27)	(2.19)
Population Living	-3.9	1.27		
Density	(-1.75)	(.6)		
Percentage of Living			-6.7	-4.43
Quarters with Piped Water into Home			(-3.99)	(-2.94)
Scooters Per Capita			-53.1	-39.8
			(-2.7)	(-2.06)
Chinese	72.9	55.5	8.05	9.89
	(1.9)	(1.35)	(1.34)	(1.82)
Malay*	92.8	73.96	4.26	8.25
	(1.40)	(.89)	(-1.55)	(-1.77)
Indian*	89.0	73.92	6.32	7.61
	(.68)	(.55)	(-.47)	(-2.03)
R^2	.85	.86	.65	.65
(N)	(157)	(157)	(167)	(167)

[a] See Discussion in Footnotes a and b on Table 2

as an instrument derived in the first stage of the TSLS estimation process.

In general, the results suggest a positive impact of fertility on infant mortality, but only in the 1947 and 1957 periods. Using multiplicative dummy terms to test for differential fertility effects in the three time periods, the effect of fertility dampens over time. For example, the effect of the crude birth rate drops from .20 in 1947 to -.09 in 1957, to -.75 in 1970. The coefficient of the gross reproduction rate falls from 7.14 in 1947 to 1.90 in 1957 to -5.29 by 1970. The coefficient of the age-specific fertility rate for the 15 to 19 age group declines from .22 in 1947 to .13 in 1957 to -.05 by 1970. Only the age-specific fertility rate in the over-40 female age group does not have a statistically significant impact.

The change in the relationship would appear intuitively plausible, more so than that of the negative coefficients indicated for the 1970 period. The effect of a marginal fertility change when the fertility rate is already high may be to exacerbate the pressure on family resources and significantly influence the probability of childhood survival.[1] The effect of variations in fertility at a far lower level of fertility may place little strain either on family resources or on the health of the mother and infant.

The estimates based on the more disaggregated 1970 cross-sectional data (data set II) do not fully support the above hypothesis of structural change and suggests a continued positive impact of fertility on infant mortality. From Table 3 (equation 1), the coefficient of the crude birth rate is considerably higher than the estimate for 1970 in Table 2, 1.62, and that for the age-specific fertility of the 15 to 19 and 40 to 44 female age groups, equally so (.32 and .44, respectively).[2] Using race multiplicative dummies, there appears to be no difference in the CBR impact across races, suggesting the impact of overall fertility is fairly strong. On the other hand, there

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[1] One cannot conclusively draw this inference, since pressure on family resources is related to a stock variable - number of children ever born of families having another child. Our variables measure the fertility rate, or the flow of new births. If fertility has fallen rapidly, the latter may not be highly correlated with the former.

[2] These latter results are drawn from an estimation of the model without race-multiplicative dummy terms on the age-specific fertility rate variables.

are differences between the three races in the effects of age-specific fertility. The impact of high teenage fertility on mortality clearly affects only the Malays; that of late fertility, only the Chinese.[1] This may reflect that Malay women have a considerably higher fertility rate (74.7) than the Chinese (27.1), though not the Indians (77.4) in the 15 to 19 age group.[2] Early fertility is associated with a higher risk of infant mortality, due to a higher chance of premature, low birthweight infants. The Chinese have a higher fertility rate in the 40 to 44 age group (62.8, 57.7, 47.8 for the Chinese, Malays and Indians, respectively), perhaps reflecting their tendency toward late marriages, and this may similarly expose the infants of this group to greater physiological risk. Nevertheless, the differences between the Malays and Indians in the 15 to 19 age group, and the Malays and Chinese in the 40 to 44 age group are not extreme enough to fully explain the differential impact revealed in our results and other cultural factors associated with child rearing in high fertility situations may also be relevant.

The rate of toddler mortality is also influenced by high fertility. Lacking data for 1947, equations 4 to 6 in Table 2 encompass only 1957 to 1970. As above, the positive impact of fertility is strongest in the earlier period, regardless of whether the CBR, the GRR or age-specific fertility rates are used as the fertility measure. The argument for this interaction is perhaps stronger than for the infant mortality rate case, since it is the weaned child which is most dependent on the competition for family resources for nutritional intake. Breast-fed children are affected, but only indirectly until the child's need for additional food sources becomes relatively important. Comparable results in terms of the sign and magnitude of the fertility variables emerge from data set II (Table 3, equations 3 and 4). The 1970 coefficient for the CBR variable from dat set I is not sharply different from a coefficient of .18 in data set II (Table 2, equation 4 and Table 3, equation 3).

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[1]It is possible that there is sufficient collinearity between the teenage fertility rate and the total fertility rate that we may not have isolated the effect of teen fertility.

[2]This reflects the fact that almost 10% of the Malay women in this age group were married, compared to 2.8% and 7% of Chinese and Indian women, respectively.

What other factors prove important in determining the infant mortality rate? First, the results on the impact of medical care usage are weak, often contradictory and intuitive only in a perverse sense. For example, the results from data set I suggest that increased utilization of hospital outpatient facilities is associated with higher rates of infant and toddler mortality; and increased use of dispensary facilities also positively influences the latter. In data set II, the greater the population clientele of a main or subhealth center or per hospital bed, the lower the child mortality rate. Although it would not be surprising that medical care has little influence on the child mortality rate, it would be troubling if it actually contributed to it. One possible explanation is that facilities are located where the medical need for them is greatest, and patient's use is directly correlated with need. Alternatively, the results may simply reflect that the place of death may often substitute for the residence of the child in the death records, and this variable reflects the fact that desperately sick children are brought to the hospital and die there.

The female literacy rate, which may proxy both child care knowledge and income levels, has a consistently negative impact on infant mortality in both data sets, with a coefficient that is consistently in the range of -.22 (Table 3) to -.67 (Table 2) for the infant mortality rate equations. This suggests that the rise in the female literacy rate from 20% in 1947 to 50% by 1970 may have contributed to a 10 to 18 point fall in the infant mortality rate. The magnitude of its impact on toddler mortality is less clear. In data set I, the effect differs across racial groups. While the effect is consistently negative for Malays, it is actually positive for the Indian and Chinese populations, despite the fact that all three racial groups exhibited a comparable change in their female literacy rates.[1] In data set II, the effect on the toddler mortality rate is again negative but small and not significant in all equations.[2]

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[1]The literacy rates rose from 15.96%, 23.6% and 21.9% for the Malays, Chinese and Indians, respectively, in 1947, to rates of 51.2%, 47.7% and 51.8%, respectively, in 1970.

[2]The effect of adding race interaction terms with the literacy rate is to confirm the above results; whereas the Malay coefficient of -.07 if significant at a 15% level, the Indian and Chinese coefficients are not significantly different from zero.

The impact of environmental factors, such as the quality of water supply or of sewage treatment appears more significant for the toddler than infant mortality rate. For data set II, the variable measuring the percentage of living quarters using bucket disposal of sewage has a positive and significant effect. Similarly, higher percentages of households with piped water into the house are associated with lower toddler mortality rates. In data set I, our closest proxy for environmental conditions, the percentage of the population living in urban areas has a consistently negative and significant effect on the TMR. Yet for the IMR, these effects appear far less significant, whether it be urbanization or adequate sewage disposal or piped water supply. There is some effect; the sign of the bucket sewage variable is positive, that of urbanization negative, but these are not consistently significant. These results suggest that jeopardy to a child's health from an unsanitary environment principally occurs after the first year, probably at the time of weaning. However, this may mask a lagged effect, where exposure in the first year begins to weaken the child, but the probability of survival is lowered only later, in the toddler period.

The employment status of women is included within the model, though with the recognition that it embodies conflicting sets of forces with opposite effects, and with its definition possibly different across censuses. A higher percentage of employed females should imply a higher level of household income, but it may also be <u>necessitated</u> by low levels of income. It may draw the mother from the home but in many activities in rural and urban Malaysia, this separation may have only a minor impact on the level of attention given to children.

For our 1970 data set, we attempt to differentiate in some degree between the income effect of employment and the consequences in terms of reduced child care attention. Our variables include the employment rates among females in the labor force, and the fraction of women, aged 15 to 64, employed. While the former reflects the consequences of unemployment, given the decision to be in the labor force, the latter reflects the impact of a high degree of female employment in the community. The estimates on data set II suggest that female unemployment, among those desiring work, directly contributes to the rate of infant and toddler mortality; the coefficient on the employment rate is negative and significant in all cases. On the other hand, the degree of overall female employment involvement has little effect on the infant mortality rate, and becomes significant only as a positive influence on toddler mortality. In data set I, we cannot differentiate the above variables and thus use the percentages of females, aged 15 to 64, engaged in agriculture and in the processing of agricultural products, respectively.

These variables succumb to the ambiguities suggested above. One might expect the income effect to predominate to the extent that employment in agriculture or agricultural processings (rubber and palm oil estates) may involve less separation from the home. The results consistently suggest that employment in the agricultural sector may significantly lower the infant mortality rate, but as with our 1970 results, positively influence the toddler mortality rate. Inclusion of an alternative child care proxy, the ratio of chilfren aged 5 to 9, to the child population aged 0 to 4, does prove significantly negative, though it may be capturing other demographic effects.

B. Determinants of Fertility

Much of the focus in the literature is on the impact of childhood mortality on fertility. Much of the literature supports the proposition that high childhood mortality causes families to opt for a larger desired family size. Such an effect implies a "target family size" orientation, as families opt for more children desite the higher price of surviving children in a high mortality environment.[1] Higher fertility ensures "replacement" for probable child deaths, thus ensuring the realization of the desired family size. Assuming children are "normal" goods, this behavior runs counter to the income and substitution effects on the number of children that would be caused by the higher price of surviving children. Our estimations examine the impact of infant and toddler mortality rates on the crude birth rate and on age-specific fertility rates. Since our data do not permit measurement of the childhood mortality rate experienced by women of different age classes, we can only examine the impact of the overall infant (IMR) or toddler (TMR) mortality rate on age-specific fertility rates.

[1] See Schultz (1973) and O'Hara (1975) for a fuller discussion of this literature.

Table 4

Econometric Estimates of the Determinants of the Crude Birth Rate and Fertility: Malaysia, 1947-1976

Dep. Variable / Indep. Variable	Estimates Basid on State-wide Data: 1947-1970 for each of 3 races: Crude Birth Rate	Age-Specific Fertility Rate of Women in Age Group: 15-19	25-29	30-34	35-39	40-44	Estimates Based on District-wide Data 1970: for each of 3 races. Crude Birth Rate
Endogenous							
Pred. Infant Mortality Rate: 1947*[a]	.02 (2.36)	.67 (-.47)	-2.42 (2.4)	.35 (.23)	-2.25 (3.05)	-1.95 (4.8)	
Pred. Infant Mortality Rate: 1957*[a]	.14 (3.64)	1.48 (1.68)	-1.86 (4.70)	.59 (1.00)	-2.44 (2.95)	-2.05 (4.96)	
Pred. Infant Mortality Rate: 1970[a]	-.14 (-1.09)	.85 (1.32)	-3.18 (-4.60)	.26 (.30)	-3.29 (-4.56)	-2.8 (-7.49)	.24 (1.66)
Pred. Toddler Mortality Rate: 1947*[a]	.34 (-1.63)	-.32 (-.19)					
Pred. Toddler Mortality Rate: 1957*[a]	.18 (-2.13)	-2.0 (-1.59)					
Pred. Toddler Mortality Rate: 1970[a]	.70 (3.59)	-.10 (-.10)					
Pred. Toddler Mortality Rate			.79 (1.12)	-.73 (-.89)	1.14 (1.60)	1.03 (2.77)	-1.80 (-2.56)
Exogenous							
Female Literacy Rate	-.47 (-2.2)	-.38 (-.38)	-3.45 (2.2)	-2.11 (-1.16)	-2.15 (-1.37)	-.74 (-.90)	22.3 (1.63)
Male Literacy Rate	.40 (2.73)	-.48 (.64)	2.04 (1.81)	2.45 (1.89)	-.76 (-.67)	-.66 (-1.12)	2.25 (2.13)
Percentage of School Age Children Enrolled	4.61 (.74)	67.99 (1.91)	-26.6 (-.5)	-28.47 (-.51)	-54.1 (-1.10)	-41.9 (-1.66)	
Marriage Rate Females, ages 15-19	-12.83 (.99)	264.6 (4.00)					44.3 (1.73)
Marriage Rate Females, ages 20-29			126.5 (2.28)				
Marriage Rate Females, ages 30-44	14.17 (1.36)			100.9 (.44)	304.2 (1.53)	316.6 (3.07)	-30.9 (-.94)
Percentage of Females (15-64) Employed in Agriculture	-21.3 (-2.47)	2.4 (.07)	-147.6 (-3.25)	-104.4 (-1.7)	-100.8 (-1.89)	-79.9 (-2.89)	-5.61 (.94)
Percentage of Females (15-64) Employed in Agric. Processing	13.2 (2.28)	23.2 (.70)	135.0 (3.10)	116.0 (2.1)	119.5 (2.49)	4.9 (.19)	.71 (.14)
Percentage of Malay Pop. from Indonesia	.16 (2.15)						
Percentage of Females aged 15-44	-31.9 (-1.12)						
Percentage of Females aged 15-19							121.1 (1.92)
Percentage of Females aged 20-29							-18.0 (-.51)
Percentage of Females aged 30-44							-30.9 (-.94)
Percentage of Pop. with no schooling							16.26 (.81)
Vehicles Per Capita							-329.0 (-2.16)
Percentage of Females employed							1.02 (.08)
Malay Dummy	24.51 (1.89)	-52.50 (-1.75)	367.8 (.09)	65.2 (-.84)	103.5 (1.42)	26.9 (3.4)	25.94 (-2.75)
Indian Dummy	22.10 (.84)	-18.42 (.88)	319.0 (-2.06)	5.1 (-3.16)	29.3 (-2.14)	-38.28 (-2.68)	26.79 (2.61)
Chinese Dummy	19.57 (1.49)	-31.5 (-.74)	365.0 (5.85)	83.9 (.41)	75.9 (.42)	-8.06 (.09)	35.83 (1.11)
R^2	.97	.94		.92	.89	.89	.90
(N)	(99	(82		(82	(82	(82	(181

[a] See Footnotes [a] and [b] in Table 2

In Table 4, the estimates from data set I suggest that the "replacement" effect phenomenon is of questionable validity for some of the female age-groups, and to the extent that it has been valid, has become increasingly less relevant over time. In the equations for the estimation of the age-specific fertility rates, the coefficients of the infant mortality rate clearly fall between 1947, 1957 and 1970. Only for the 15 to 19 age group do we observe a positive and significant impact of a higher IMR rate on the level of fertility characteristic of a "replacement" hypothesis. For the 25 to 29, 35 to 39, and 40 to 44 age groups the relationship is significantly negative, though it is weaker in 1947 and 1957. The crude birth rate equation is consistent; the coefficient of the IMR rises between 1947 and 1957 from .02 to .14 but then falls to a negative, though hardly significant level of -.14 in 1970.

Whether it has become negative is rendered ambiguous by our estimates for data set II. Lacking age-specific birth data on a district-wide basis, we are forced to rely solely on an equation estimating the crude birth rate alone. In this equation, the IMR coefficient is positive, .24, and significant (t=1.66). Hence we cannot fully conclude that the positive association of infant mortality and fertility rate decline has disappeared, although the fertility rate equations support this hypothesis.

Theoretically, one might anticipate that the effect of changes in the toddler mortality rate should be comparable to that of the infant mortality rate, though possibly with stronger effect. A greater level of resources will be invested in a toddler than in an infant. For equal increases in the probability of an infant relative to a toddler death, the latter would raise the price of surviving children by a larger amount. Thus, one might expect the TMR to have a negative coefficient <u>larger</u> than that for the IMR rate. If it is simply a replacement effect that prevails, it is unclear whether the TMR coefficient should be quantitatively different than the IMR. In any event, one would anticipate that the impact of the toddler and infant mortality rate variables to be of similar sign.

Our results do not fully bear out these hypotheses. In data set I, the coefficient of the TMR variable on the crude birth rate is significantly positive for all three periods, is weakest in 1957 and <u>rises</u> by 1970. In other words, the replacement effect is strongest after a demographic transition has occurred. Yet for our 1970 data set, the toddler mortality rate clearly enters with a negative impact on the CBR. The age-specific fertility rate equations do not resolve this. No significant difference emerged in the coefficients of the three periods, except in the 15 to 19 female age cohort. For some age cohorts (females over 35) a positive relationship prevails, whereas the opposite holds for the youngest age group.

What is the effect of specifying the fertility equation as part of a simultaneous equations system? The principal consequence of taking account of the endogeneity of the infant mortality rate is to reduce the size of its coefficient in the fertility equations. Table 5 presents a comparison between the infant mortality rate coefficients derived from the two stage least squares estimation (Table 4) with the coefficients that result when the same equations are estimated using ordinary least squares (OLS). With the exception of the equations explaining the age-specific fertility rate of the 15 to 19 age group, there is a clear upward bias in the OLS estimated coefficients, i.e. a bias toward sustaining the hypothesis that the replacement effect of infant on fertility is dominant.

The econometric results also shed light on other determinants of fertility. Among demographic factors, age-specific marriage rates and the fraction of women in the reproductive age group are examined. The results support the argument that the greater the fraction of women married in an age cohort, the higher the age-specific fertility of that cohort. This is particularly the case for most of the age groups in data set I, with the strongest impact for the age-groups 15 to 19, 25 to 29 and 35 to 44. In data set II, marriage rates are not significant in explaining crude birth rate differences. The percentage of females in the 15 to 19 age group (relative to the population over age 10) is the only age group whose relative size positively influences the CBR. In data set I, such a variable proves insignificant. In general, none of the results strongly violate the hypothesized impact of demographic factors, and where significant, all prove of the correct sign.

The enrollment rate of children in primary and secondary schools is used in data set I to proxy the perceived cost of children to the parents, both in terms of cash outlays and foregone income. Although enrolled students

Table 5

Comparison of the Coefficients of the Infant Mortality Rate Variable on Alternative Measures of Fertility Using Two Stage Least Squares (TSLS) and Ordinary Least Squares (OLS) Estimation Procedures (t statistic in parenthesis)

	Crude Birth Rate		Age-Specific Fertility Rate Equations									
			15-19		25-29		30-34		35-39		40-44	
Estimation Procedure	TSLS	OLS	TSLS	OLS	TSLS	OLS	TSLS	OLS	TSLS	OLS	TSLS	OLS
Data Set I												
1947*	.02	.04	.67	-.25	-2.42	.32	.35	.35	-2.25	-.04	-1.95	.17
	(-1.09)	(2.63)	(-.47)	(-.98)	(2.40)	(-.74)	(.23)	(-2.12)	(3.05)	(1.09)	(4.80)	(1.51)
1957*	.14	.10	1.48	-.17	-1.86	.93	.59	.78	-2.44	-.18	-2.05	.07
	(2.36)	(4.66)	(1.68)	(-.71)	(4.70)	(.93)	(1.00)	(-1.44)	(2.95)	(1.00)	(4.96)	(1.47)
1970	-.14	-.11	.85	-.03	-3.18	.62	.26	1.28	-3.29	-.52	-2.80	-.23
	(3.64)	(-1.25)	(1.32)	(.08)	(-4.60)	(.99)	(.30)	(1.93)	(-4.56)	(-.76)	(-7.49)	(-.56)
Data Set II												
1970	.24	.26										
	(1.66)	(1.76)										

* See notes in footnote a/, Table 2.

may, at some later time, provide higher earning streams, one would expect this to be discounted heavily by the parents relative to these short-term costs. In the age-specific fertility equations, this cost is not significant for the youngest age group (15 to 19), but thereafter becomes relevant. The coefficient becomes negative and ultimately significant in the oldest age group. In the CBR equation, the coefficient is positive. In data set II, we lack district-specific enrollment statistics and thus use the percentage of the population with no schooling to capture the probability a family would not beat a high cost of schooling. It does not prove significant.

The male and female literacy rates are used to capture a composite of effects. Both are likely to be correlated with socioeconomic status, particularly that of males. A higher percentage of literate females in a community may imply greater knowledge concerning methods of birth planning, particularly in more recent periods. Several results emerge clearly. Higher male literacy rates positively affect the level of fertility. The coefficient on the CBR is .40 and 2.25 in data sets I and II, respectively. The coefficients on the age-specific fertility rates prove positive and significant only in the middle age groups. Over time, the rising female literacy rate (from 20% to 50%) has had a negative impact on the CBR and on the age-specific fertility rates as one might expect. However, in the low fertility environment of 1970, the reverse appears true, with higher fertility associated with higher literacy.

We discussed earlier some of the problems surrounding the use of female employment rate variables, specifically the possible ambiguity between income effects and the effects produced by a higher cost of child rearing. For our data set II, neither the fraction of females employed among the working age group nor the sectoral mix of the females employed (percentage in agriculture or agricultural processing) have an impact on the crude birth rate. In our data set I, the results appear stronger. The higher fraction of females employed in agricultural processing, the higher the CBR, whereas employment in agriculture lowers the CBR. We tested the consistency of these latter results with our 1970 data set by using the same two measures of employment participation and the results are affirmed for the agricultural processing sector (though the coefficient is not highly significant, with t = -1.01).

Conclusion

The principal implication of the econometric results is support for the hypothesis that the probability of childhood survival cannot be treated as an "exogenous" factor in the analysis of household demographic behavior in less developed countries. Infant and toddler mortality are in part consequences of several factors generally assumed to be subject to parental control, among which, in particular, fertility proves of considerable import. This last result is important because it implies that models of fertility which introduce the level of childhood mortality as exogenous may be subject to a signigicant simultaneous equations bias. Our results suggest that if this problem is ignored, there is a bias toward acceptance of the hypothesis that families respond to an increase in infant mortality with an increase in fertility.

The results also suggest that structural changes in the interaction of fertility and child mortality may be characteristic of a country undergoing a significant demographic transition. There is a clear pattern of dampening in these relationships as Malaysia moved to lower fertility levels. Although the results prove ambiguous on the sign of both sides of the relationship as one moves toward the completion of the transition, the existence of a nonlinearity in the relationship between fertility and mortality over the transition appears clear.

Finally, far more research is required on the character and determinants of parental decisions toward dependent children. Although the economic demography literature has delved extensively into the factors influencing the fertility decision, it has not focussed intensively on the determinants of child quality in the critical infant and toddler years, particularly in less developed countries. Such studies necessarily await the further development of microeconomic data bases. The extent of parental influence on the probability of child survival and child quality cannot be fully gleaned from the kind of aggregate data used in this analysis. It masks too many of the intra-familial allocational decisions as well as the interfamily differences in overall family input.

Appendix

The nonmyopic model of utility maximization may be expressed as a problem of maximizing utility,

$$U = U(\alpha n, q, s) \tag{1}$$

subject to the full wealth constraint of the form

$$\pi_c \alpha q n + \pi_s s = I, \tag{2}$$

where $c = \alpha n q$ is the expected level of child care services, π_c and π_s are the shadow prices of c and s, and I is a measure of full wealth. This model follows that of Willis (1973), where the principal change is to modify c to include the probability of survival, α, and where α is now itself endogenous. Following the model outlined in the text, α is a function of n and q,

$$\alpha = \psi(q,n) \tag{3}$$

where $\psi_1 > 0$ and $\psi_2 < 0$. Maximizing the LaGrangian equation,

$$L = U(\psi(q,n)n,q,s) + \lambda(\pi_c \psi(q,n)qn + \pi_s s - I),$$

the first order conditions are,

$$\frac{\alpha L}{\alpha n} = U_1(\alpha + n\,\psi_2) + \lambda\pi_c q(\alpha + \psi_2 n) = 0 \tag{4}$$

$$\frac{\alpha L}{\alpha q} = U_1\psi_1 n + U_2 + \lambda\pi_c n(\psi_1 q + \alpha) = 0 \tag{5}$$

$$\frac{\alpha L}{\alpha s} = U_3 + \lambda\pi_s \tag{6}$$

$$\frac{\alpha L}{\alpha \lambda} = \pi_c \alpha q n + \pi_s s - I = 0. \tag{7}$$

The effect of making α endogenous does not affect the first-order equilibrium conditions. Households will choose n, q and s such that

$$\frac{U_2}{U_1} = \frac{n\alpha}{q} \tag{8}$$

$$\frac{U_3}{U_1} = \frac{\pi_s}{\pi_c q}, \text{ and} \tag{9}$$

$$\frac{U_2}{U_3} = \frac{\pi_c}{\pi_s} n\alpha, \tag{10}$$

regardless of whether α is entered as an exogenous parameter or is endogenously determined by n or q. This insensitivity is not the case for expression of the demand functions for n, q and s. Totally differentiating the first-order conditions yields a set of simultanious linear differential equations written in matrix form.

$$\begin{matrix} {}_{11}(\alpha+n\psi_2)^2 + (2\psi_2+n\psi_{22})(U_1+\lambda\pi_c q) & (\alpha+n\psi_2)(U_{12}+U_{11}n\psi_1+\lambda\pi_c) + (\psi_1+n\psi_{21})(U_1+\lambda\pi_c q) & (\alpha+n\psi_2)U_{13} & (\alpha+n\psi_2)\pi_c q \\ U_{11}\psi_1 n+U_{21})(\alpha+n\psi_2) + {}_1(\psi_1+\eta\psi_2) + \lambda\pi_c(\psi_1 q+\alpha+n(q\psi_{12}+\psi_2)) & \psi_1\eta(U_{11}\psi_1 n+2U_{12})+U_1\psi_1 n + U_{22}+\lambda\pi_c\ (\psi_{11}q+2\psi_1) & U_{13}\psi_1\eta + U_{23} & \pi_c n(\psi_1 q+\alpha) \\ {}_{31}(\alpha+n\psi_2) & U_{31}\alpha_1 n + U_{32} & U_{33} & \pi_s \\ \pi_c(\alpha+\psi_2 n) & \pi_c\psi_1 q\eta+\pi_c\alpha n & \pi_s & 0 \end{matrix} \quad \begin{matrix} dn \\ dq \\ ds \\ d\eta \end{matrix}$$

$$= \begin{matrix} q(\alpha+n\psi_2)\lambda & 0 & 0 \\ \lambda n(\psi_1 q+\alpha) & 0 & 0 \\ 0 & \lambda & 0 \\ \alpha q n & S & -1 \end{matrix} \quad \begin{matrix} d\pi_c \\ d\pi_s \\ dI \end{matrix}$$

By holding 2 of the 3 parameters (π_c,π_s and I) constant, one may estimate demand functions for n,s or q using Cramer's rule. The effect of making α endogenous is to render the differential equation set substantially more complicated than in the Willis (1973) model, as the presence of first and second derivative expressions for the α function indicates. Without further information concerning the utility and survival functions, U and ψ (both in terms of the sign and magnitude of the first and second derivatives) one cannot say unambigously the impact of rendering α endogenous on the sign or magnitude of the demand function parameters.

References

BenPorath, Yoram. "Economic Analysis of Fertility in Israel," J. Polit. Economy, vol. 81, no. 2, pt. 2 (March/April 1973), pp. S202-233.

Becker, Gary. "An Economic Analysis of Fertility," Demographic and Economic Change in Developed Countries, Universities National Bureau Conference Series, no. 11, Princeton, New Jersey. Princeton University Press, 1960.

Caldwell, John. "Fertility Decline and Female Chances of Marriage in Malaya," Population Studies, vol. 17, (July 1963), pp. 20-32).

Chander, R. "Family Planning and Fertility Trends in W. Malaysia," in Report of the W. Malaysian Family Survey: 1966-1967, National Family Planning Board (Kuala Lumpur: 1968).

Cho, Lee-Jay, James A. Palmore, and Lyle Saunders. "Recent Fertility Trends in West Malaysia," Demography, pp. 732-744.

Dugdale, A.E. "The Weight of Malaysian Infants up to One Year," Medical Journal of Malaysia, vol. XXIII, no. 4 (June 1969), pp. 242, 243.

Grossman, Michael. The Demand for Health (New York: National Bureau of Economic Research, 1972).

Heller, P. and Drake, William, "Malnutrition, Morbidity and the Family Decision Process," CRED Discussion Paper No. 58 (University of Michigan, 1976).

Heller, P. and Meerman, J. "The Demand for Public and Private Health and Medical Services in W. Malaysia," Center for Research on Economic Development Discussion paper, (University of Michigan, 1976).

Hock, Saw Swee. "Fertility Differentials in Early Postwar Malaya," Demography, vol. 4, no. 2 pp. 641-656, (1967).

Hock, Saw Swee. "A note on the Fertility Levels in Malaya During 1947-1957," Malayan Economic Review, vol. 12 (April 1967), pp. 117-123.

Hock, Saw Swee. "Pattern of Fertility Decline in Malaya, 1956-1965," Kajian Ekonomi Malaysia, III, 1 (June, 1966).

Kemudahan-Kemudahan Perubatan and Kesihata di Keluakan Menurut Daerah Kesihatan and Mukim-Mukim, Ministry of Health.

Kmenta, J. Elements of Econometrics (New York: MacMillan Co., 1971).

Lourdenadin, S. "Hazards of Childbirth in West Malaysia," Medical Journal of Malaysia, vo. XXIII, no. 4 (June 1969), pp. 239-242.

Nerlove, M. and T. Paul Schultz. "Love and Life Between the Censuses: A Model of Family Decision Making in Puerto Rico, 1950-1960," Rand RM6322 AID (1970).

Nerlove, M. "Toward a New Theory of Population and Economic Growth," in T. W. Schultz, Economics of the Family (Chicago: University of Chicago Press, 1974), pp. 527-545.

O'Hara, J. Microeconomic Aspects of the Demographic Transition," J. Polit. Economy vol. 83, no. 6 (Dec. 1975), pp. 1203-1216.

Oechsli, Frank and Kirk, Dudley. "Modernization and the Demographic Transition in Latin America and the Caribbean," Economic Development and Cultural Change, vol. 23, no. 3 (April, 1975).

Palmore, James A. and Ariffin S. Marzuki. "Marriage Patterns and Cumulative Fertility in W. Malaysia 1966-1967," Demography, vol. 6., no. 4 (November 1969), pp. 383-401.

Puffer, Ruth and Carlos V. Seranno. Patterns of Mortality in Childhood, (Washington: Pan American Health Organization, 1975).

Russell, L. Determinants of Infant and Child Mortality, unpublished, National Planning Association, 1974.

Rutstein, Shea. "The Influence of Child Mortality on Fertility in Taiwan," Studies in Family Planning, vol. 5, no. 6 (June, 1974).

Schultz, T. Paul. "Explanation of Birth Rate Changes over Space and Time: A Study of Taiwan," JPE, vol. 81, no. 2 , pt. 2 (May/April 1973), pp. 238-278.

Sloan, Frank. "Survival of Progeny in Developing Countries: An Analysis of Evidence from Costa Rica, Mexico, East Pakistan and Puerto Rico," Rand Memo. R-773 AID (July, 1971).

Smith, T. Population Growth in Malaya: An Analysis of Recent Trends, (London: Royal Institute of International Affairs , 1952).

Teitelbaum, Michael S., "Relevance of Demographic Transition Theory for Developing Countries," Science, vol. 188 (May 2, 1975), pp. 420-425.

Welch, F. "Chance, Child Traits and Choice of Family Size," Rand Memorandum.

---------- "Sex of Children: Prior Uncertainty and Subsequent Fertility Behavior," Rand R1510RF (August 1974).

Willis, R. "Economic Theory of Fertility Behavior," J. Polit. Econ., vol. 81, no. 2, pt. 2 (March/April, 1973), pp.S238-278.

Wray, J., "Population Pressure on Families: Family Size and Child Spacing," Rapid Population Growth (Baltimore:Johns Hopkins University Press,1971(,pp.403-461.

Yusof, Zainal Asnam and Dr. Khainuddin Yusof. Some Socioeconomic and Medical Aspects of Malay Mortality in Urban and Rural Areas, (unpublished mimeo, Kuala Lumpar, 1972).

Governments Documents

Federated Malay States, Medical Department. Report of the Registrar General Births and Deaths, 1946, (Kuala Lumpur).

Malaya, Federation of, Report of the Medical Department, 1948, 1957 (Kuala Lumpur).

Federation of Malaya, Report of the Registrar General on Population, Births, Deaths, Marriages and Adoptions for the Year 1960 by Ibrahim bin Ali (1962).

Federation of Malaya, Report on the Registration of Births and Deaths, 1948, 1957 (Kuala Lumpur).

Malayan Union, Report of the Education Department

Malayan Union (Vital Statistics) Medical Department, Report on the Registration of Births and Deaths 1947 (Kuala Lumpur).

Federation of Malaya, Department of Statistics, 1957 Population Census.

Federation of Malaya, Department of Statistics, Vital Statistics 1964, 1970.

Federal Government of Malaysia, 1970 Population and Housing Census of Malaysia: Community Groups (1972).

Federal Government of Malaysia, 1970 Population and Housing Census of Malaysia: Age Distributions.

Population Census, 1947.

Federation of Malaya, Population Census, 1947.

Federal Government of Malaysia, Department of Statistics, A Bibliography of the Demography of Malaysia (September 1974).