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CHILD SURVIVAL

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DEMOGRAPHIC, SOCIOECONOMIC AND HEALTH-RELATED EFFECTS ON COMPONENTS OF PHILIPPINE CHILD MORTALITY

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Introduction

Several issues have drawn attention to a more comprehensive analysis of covariates of Philippine child mortality. The first is the call of planners for more substantive and scientific studies to supplement operational researches in providing insights for the determination of the best mix of strategies for preventing child deaths within the constraint of available health resources and manpower. A response of the Philippine government to the global promotion of primary health care and child survival led by international agencies like the World Health Organization (WHO) and the United Nations International Children's Emergency Fund (UNICEF) necessitates identification of the underlying causes of child mortality.

The second issue is the consistent indication that the long-term trend in Philippine child mortality decline has plateaued since 1960 (Cabigon 1990; Conccepcion and Smith 1977; Madigan 1977; Reyes 1981; United Nations 1982; Zablan 1978, 1983). The emergence of more detailed and relevant Philippine data and of sophisticated procedures for dealing with qualitative data in the analysis of determinants of child mortality provides a basis for in-depth analysis yielding some insights into such a trend.

The third issue deals with the part played by demographic or health-risk factors: maternal age (age of mother at childbirth), parity (birth order), pace of childbearing when they are systematically studied with other variables. Literature has been consistent in demonstrating the powerful effects of maternal age and birth order on infant and child mortality, but the effects of child-spacing have been the subject of further investigation due to the methodological difficulties and unclear types of mechanisms that operate (Ballweg and Pagtolun-an 1988; Boulier and Paqueo 1988; Casterline, Cooksey and Ismail 1989; Cleland and Sathar 1984; Cramer 1987; DaVanzo, Butz and Habicht 1983; De Sweemer 1984; Edouard 1981; Frenzen and Hogan 1982; Hobcraft, McDonald and Rutstein 1983; Hull and Gubhaju 1986; Kiely, Paneth and Susser 1986; Knodel and Hermalin 1984; Martin, Trussell, Salvail and Shah 1983; Palloni 1989; Palloni and Tienda 1986; Rutstein 1983; Trussell and Hammerslough 1983; Yudkin and Baras 1983). With the current Philippine national population program emphasizing the health benefits of family planning, the role of the health risk factors on child mortality needs to be further studied. What will happen with the role of birth order and maternal age at childbirth when other demographic, socioeconomic and health-related variables are taken into account? Is there a difference in the patterns of their net effects on various ages of child mortality?

The fourth issue pertains to the effects of education and household income on child mortality. While parental education (mother, father or both) strongly influences child mortality in the Philippines and in other countries (Boulier and Paqueo 1988; Cabigon 1982; Caldwell 1979; Caldwell and McDonald 1981; Concepcion 1982; Concepcion and Cabigon, 1982; Cramer 1987; Haines and Avery 1982; Hobcraft *et al.* 1984; Hull and Gubhaju 1986; Madigan n.d.; Martin *et al.* 1983; Trussell and Hammerslough 1983; Victora, Smith and Vaughan 1986), explanations of this relationship appear to be complicated. While there are reasons for arguing that the higher the educational attainment of parents, the lower the infant and child mortality, there is some uncertainty whether the measured effects are attributable to schooling in itself or to other characteristics such as economic status or various social roles adopted by people with different levels of education (Hull and Gubhaju 1986, pp. 116-117).

In addition, Hobcraft *et al.* (1984, pp. 219-220) noted the difficulty of interpreting socioeconomic differences in infant and child mortality, as the five socioeconomic factors they considered - mother's education, mother's work status, husband's occupation, husband's education and mother's place of residence at survey date - are all more or less remote in the causal chain leading to prevented deaths in early life. They contended that there are mechanisms other than formal schooling, which were not included in their model and may have been operating, such as income, mother's work habits, supply of medical and health care, and public health provisions, such as water supply, sewerage and refuse disposal. They also argued that education may succeed in ending traditional and unhealthy practices, although this may not require formal schooling.

Drawing on household production theory, Schultz (1980) also hypothesized that better educated women earn more in the labour market and marry better educated men; consequently they have higher family incomes enabling them to purchase goods and services that improve child health. Education may also increase the effectiveness of women's non-market child-care activities although as Schultz cautioned, the fact that paid work requires women to be absent from the home can have an offsetting negative effect on the quality of child care.

Furthermore, in rural northern Thailand, Frenzen and Hogan (1982) found no support for Caldwell's (1979) findings that maternal education and parental beliefs about wealth transfers are crucial factors affecting infant mortality declines in developing societies. These two variables become insignificant after adjusting for health information, social class, district development level and whether births are wanted.

One analytical strategy to shed some light on these uncertainties is to examine interaction or the extent to which the effect of education on child mortality varies according to various categories of other important variables. Studies found household income or its proxy, poverty, to be strongly associated with infant or child mortality (Casterline *et al.* 1989; Gortmaker 1979; Madigan n.d.; Victora *et al.* 1986). It is then worthwhile examining whether household income plays an important role in Philippine child mortality. If so, does the relationship between maternal education and child mortality then differ by income levels? Conversely, is the relationship between income and child mortality different for the low and highly educated groups? Moreover, because of the unavailability of reliable data on income in the Philippines, education has been taken as a proxy of socioeconomic status. If income is more important than education as a determinant of child mortality, then education is not an adequate measure of socioeconomic status in the Philippines.

The fifth issue relates to the impact of environmental factors on child mortality. Access to piped water plays an important role in early childhood in Brazil (Merrick 1985; Victora *et al.* 1986) and on infant mortality in Egypt (Casterline *et al.* 1989). Toilet facility is associated with lower child mortality in Sri Lanka[1] (Trussell and Hammerslough 1983), and with post-neonatal mortality in Malaysia (DaVanzo *et al.* 1983), but has no influence on infant and child mortality in Egypt (Casterline *et al.* 1989). Housing quality affects child mortality in Costa Rica (Haines and Avery 1982) and in a rural Philippine province (Johnson and Nelson 1984). Public sanitation and provision of safe drinking water are health programs of the Philippines. Assessing their roles in influencing child mortality is useful in health planning.

The last issue pertains to methodological problems. Long (1987, pp. 3-7) drew attention to common mistakes in quantitative social research resulting mainly from the rapid growth in the variety and complexity of methods available. These errors are both failure to apply appropriate techniques and inappropriate application of statistical methods. He stated that despite the frequent occurrence of these errors which often have solutions in the statistical literature, there are few articles or books that provide clear, practical, and accurate discussions of the issues.

On the use of weights in analysing survey data, Lee, Forthofer and Lorimor (1986) highlighted the problems and strategies for analysing survey data from complex sample designs. They presented three examples which indicate that sample weights are important in estimation, and standard errors, calculated by assuming simple random sampling (even with use of weights), do not always agree with those obtained by more appropriate methods that take the sample designs into account. Moreover, statistical packages do not always handle weighted data adequately.

In the statistical literature, there are arguments for and against the use of sampling weights. For instance, Clogg and Eliason (1987, pp. 21-27) and T. W. Pullum (personal communication, May 1, 1989) stated that in data sets weighted on a case-by-case basis, it is incorrect strategy to analyse the unweighted data by simply ignoring the weighting feature altogether, or analyse weighted data as if they were obtained from a data set without any weighting features. Unweighted estimated parameters are clearly biased and their corresponding standard errors are incorrect. Use of weights, which has been the common approach[2], will yield unbiased parameter estimates, but estimates of the standard errors and all other statistical tests will be biased. Lee *et al.* (1986) and Clogg and Eliason (1987) illustrated these biases clearly and suggested some solutions.

This paper presents insights into the above issues, through an exhaustive exploratory analysis and simultaneous examination of several demographic, socioeconomic and health-related variables to identify those which have a net influence on neonatal, post-neonatal, infant and child mortality and test for significant interactions between or among the emerging important variables. It uses appropriate methodological tools and strategies for analysing survey data. In the Philippine studies reviewed above, there has been no systematic study of the extent to which the effects of important variables may have been greater or less for various subgroups of the population in question. Interaction between or among the variables so far found to influence Philippine child mortality may be important; therefore it needs to be assessed both for policy significance and theoretical interest. The next section further elaborates these points.

Methods

Data

The analysis was based on the 1983 National Demographic Survey (NDS), conducted by a consortium of research centres composed of the University of the Philippines Population Institute (UPPI), University of San Carlos Office of Population Studies (USC-OPS), and Xavier University Mindanao Centre for Population Studies (XU-MCPS). The purpose of the survey was to gather information on fertility, mortality, migration, nuptiality, labour force participation and family planning.

The 1983 NDS collected information from a nationally representative sample of 13,000 households. To allow for regional-level analysis in line with the regional thrust of the government, a sample of 1,000 households per region was obtained.

The sampling design featured a two-stage sampling scheme where the primary sampling unit, *barangay*[3] was drawn with replacement and with probability proportional to the number of households per *barangay*, in each region. The ultimate sampling unit was the household and was drawn systematically with a random start.

Relevant child mortality data used in this article originated from the pregnancy history.[4] Background variables, such as socioeconomic, health-related and other demographic characteristics were drawn from the household and ever-married women files.

Births to ever-married women were units of observation, totalling 42,471, reconstructed from the pregnancy history record. The following were the factors examined for each birth.

Demographic factors: (a) birth order (first, second and third, and fourth and higher); (b) maternal age at birth of child (in years: less than 20, 20-34, and 35 and over); and (c) length of preceding birth interval (in months: less than 18, 18-30, and 31 and over). The present study focused on the estimation of the the effects of the first two factors. The most recent work of Palloni (1989) uncovered the persistent generalized and strong effects of the preceding and the following interval even when controlling for contextual variables such as mortality levels, breastfeeding patterns and contraceptive prevalence and for individual variables, such as mother's education and access to information. Palloni also found little support for the hypothesis that early cessation of breastfeeding is the main mechanism through which the negative effects of birth interval operate. Hence, it was important to allow for the role of the preceding birth interval in the present analysis. Nevertheless, because of the methodological problems and complicated mechanism through which it operates in the causal chain leading to deaths in childhood, preceding birth interval was treated as a control.[5]

Socioeconomic factors: (a) current residence (rural and urban); (b) presence of electricity in the household (with and without); (c) average household monthly income (less than P1000 and P1000 and over); (d) education of mother (primary and below, elementary, high school, and college and over). A three-level categorization of education is commonly adopted in the international literature: achieving literacy, completing elementary education and completing secondary education and proceeding to higher education. However, given the high level of literacy in the Philippines (above 80 per cent), a considerable proportion (about 50 per cent) with elementary education, a sizable proportion proceeding to high school and no further, and a quite small proportion continuing to higher education, a four-level categorization might provide clearer child mortality differentials by education in the Philippines. The primary and below category corresponds very well to illiteracy and bare literacy. Because a large proportion of those who succeeded in attaining high school education could not proceed to college, perhaps because of financial problems, it would be worthwhile to discover how high school education compares with elementary education in explaining child mortality.

Health-related factors: (a) source of drinking water supply (*unsafe*:lake or river, stream, spring, rainwater, open well, pump shallow well; and *safe*: artesian deep well, pipe water); (b) presence of toilet (none, outside the house, inside the house); (c) housing quality (*inadequate*: walls made of scrap materials, *nipa*, other thatch, *sawali*, bamboo, rough-hewn timber and/or poorly-fitted planks and floors being earth or constructed of bamboo, cement, and wood; and *adequate*: walls made of painted and /or well-fitted wood or hollow blocks, cement or other expensive materials and floors of wood, linoleum or tiles); and (d) household composition (extended and nuclear).

The socioeconomic and health related-environmental variables were characteristics at the time of the survey. They might or might not refer to the characteristics while the child was exposed to the risk of death. This problem might be more severe for the health related-environmental variables. For example, the source of drinking water supply, housing quality and toilet facility might have been recently upgraded such that some of the children classified as having better facilities might have been exposed to poorer facilities, thus resulting in a bias towards mortality risk higher than was the case. These limitations must be kept in mind when considering the results. Since they were the only available variables to consider, it was assumed, as what other studies have been forced to do (e.g. Trussell and Hammerslough, 1983; Casterline *et al.*, 1989), that these covariates did not vary with time. In fact, there has been no remarkable and persistent rapid economic change in the Philippines over time (Hill, 1986, 1988; Herrin, 1988); hence, it may be safe to assume that most of these variables might have been stable over time for most of the population in question.

Cabigon (1990) showed that infant and child mortality rates per 1000 births have levelled off since 1960. To allow for the higher rates before 1960 in these indicators and to include all births in the analysis, a variable for time period of birth was created by dichotomizing the births by occurrence into those before 1960, and 1960 and later.

The outcome variables examined here were neonatal, post-neonatal, infant and child mortality. Several studies revealed that factors affecting neonatal and post-neonatal mortality vary greatly, the former being more often biological, medical, and congenital and the latter more often social and environmental (Antonovsky and Bernstein 1977; Cleland and Sathar 1984; Cramer 1987; Gortmaker 1979; Hobcraft *et al.* 1983, 1984; Palloni and Tienda 1986; Pharoah 1976; Pharoah and Morris 1979; Shapiro, Schlesinger and Nesbitt 1968; Trussell and Hammerslough 1983). So it is pertinent to look separately at the two components of infant mortality, neonatal and post-neonatal, in this study. However, there may be some factors which do not appear important in either the neonatal or post-neonatal disaggregations, because of the small number of cases, but may be influential when infant mortality as a whole is considered, because of a sufficient number of cases. Estimates of coefficients based on small number of deaths tend to be erratic, indicating the existence of random variations. Hence, overall infant mortality was also examined.

The model

The log-linear rate or hazard model fitted by using the program GLIM 3.77 (Payne, 1985) was the statistical tool used to fulfil the above objectives. Basically, with a log-linear rate model, the ratio or rate (r_{ij}) of the total number of deaths (D_{ij}) of children with a particular set of characteristics, or in the ith row and jth column of a contingency table to the total amount of exposure (N_{ij}) of children with those characteristics is considered (Hobcraft *et al.*, 1984:209-210; T. W. Pullum, personal communication, May 1, 1989). This model is based on the assumption that there is homogeneity among children with similar characteristics and that the number of deaths follows a Poisson distribution with expectation calculated as:

$$E(D_{ij})=r_{ij}N_{ij}. \qquad (1)$$

It was also assumed that the effects of the explanatory factors on the rate are multiplicative and that each rate is composed of a product of a constant term (c), a row term (a_i), and a column term (b_i). That is,

$$r_{ij}=ca_ib_j. \qquad (2)$$

One of the complexities of all log-linear models is over-parameterization or too many parameters to estimate. In an over-parameterized model, individual parameters cannot be estimated unless some constraints are added to the model. In GLIM, the constraint imposed is that all parameters, with one or more index equal to one, are set to zero. This restriction imposed in GLIM is termed a regression-like constraint by Long (1984) or a dummy coding effect by Alba (1987). These parameters set to zero refer to the omitted or reference categories. Equivalently, to obtain estimates of parameters and to define the parameters uniquely, the restriction imposed is to set:

$a_1=b_1=1$ so that $r_{11}=c$ and the model can be re-expressed as

$$r_{ij}=r_{11}a_ib_j. \qquad (3)$$

In words, the cell in the table, corresponding to the row and column parameters set equal to unity, is called the baseline or reference cell. The parameters a_i and b_j are interpreted by using the epidemiological concept of relative risk, i.e., a_i as the relative risk associated with an individual being in the ith row relative to an individual being in the first row or baseline category and b_j to be interpreted analogously.

Transforming the multiplicative rate model into a linear equation by taking natural logarithms of all the terms eases its estimation. The equation is linear in its logarithm, hence called log-linear. Thus,

$$logE(D_{ij})=logN_{ij}+M+A_i+B_j \quad (4)$$

where $logN_{ij}$=offset (a quantitative variate whose regression coefficient is known to be 1)

M=constant term called the overall mean

$A_i B_j$=row and column effects, respectively, due to the qualitative factors in question.

Exponentiating the log-linear parameters restores the multiplicative form of the rate model. Since the model is log-linear rate, the exponentiated parameter estimates are relative rates. Any value less or more than unity means, respectively, lower and higher relative risk of dying at the age interval in question of the group under consideration than that of the baseline group. The exponential of the constant or overall mean is the fitted rate for the reference group, which is the reference rate. Multiplying this rate by the relative rates of the considered categories yields probabilities of dying or fitted rates for such groups (Hobcraft *et al.*, 1984; T. W. Pullum, personal communication, July 28, 1989).

Testing and model selection

To deal with the numerous available variables listed earlier and their high interrelationships (e.g. current residence, presence of electricity, household income and education) required two analytical steps. First was to identify those that remained significant after controlling for a number of other variables. This step produces main effects models (models with the minimum number of predictors). Log-linear analysis emphasizes goodness-of-fit of a model and often, the main effects model is not the optimal or best fitting model that provides the best explanation of the observed relationships between the explanatory factors and child mortality. Hence, the second step was to test for interaction effects.

In essence, determining the *total* and *specific* effects of covariates requires a systematic examination of interactions. When an independent variable does not interact with other independent variables, the specific effect for that variable equals its total effect and the magnitude of the effect does not depend on the levels of the other variables. The exponentiated estimates or relative risks are then interpreted in a straightforward manner. When the variable in question interacts with other independent variables, the total and specific effects of that variable depend on the level of the variable or variables with which it interacts. If it interacts with just one independent variable, then its total effect depends on the level of that variable and its specific effect is the ratio of total effects for the given levels of that variable. If it interacts with two other independent variables, then its total effect depends on both the levels of these two variables and its specific effect is the ratio of total effects for both levels of these two variables; thus the interpretation becomes more complicated. The higher the order of interaction effects, the greater the complications in interpreting the results of the log-linear analysis.

There are two extreme approaches to derive main effects or optimal models. One is the forward approach which starts with the simplest model and builds up the model by adding variables or terms one at a time. At each stage, the variable or term that makes the greatest improvement, according to some criterion, is brought in to produce the next model. The process is then repeated. In this approach, in the early stages, the model being tried is incomplete: for example, important regressor variables will not yet have been included in the model. This is its major drawback, the possibility of not being able to examine fully the importance of all potential regressors and hence the likelihood of some variables, though important, not being included, especially when the starting point is an arbitrary choice among several radically different possibilities.

The other is the backward approach which starts with all variables and terms (saturated model) in the model and systematically eliminates variables or terms according to some criteria. Having to start with all potential regressor variables or terms, the backward approach is not faced with the difficulty associated with the arbitrary choice among interrelated possibilities because it starts with all possibilities and eliminates irrelevant variables or terms. In this manner, no potential regressor is likely to be missed, especially if the saturated model is correctly specified. However, the important problem of this approach is that with so many possibilities to start with, it tends to involve only automatic selection procedures and because of too many parameters to estimate, in the early stages big models may not be very well fitted, making it difficult to distinguish between important and less important variables or terms. Nonetheless, despite its major limitation, the backward approach , as Cox and Snell (1981, p. 22) wrote,

> is the safer one and should normally be used when it is not too ponderous and especially when there is a major interest in and uncertainty over the primary formulation of the problem. The forward approach is more appropriate for the secondary aspects of the problem, e. g. over the structure error.

A synthesis of these two approaches is the stepwise approach which seeks to fulfil both the elimination and addition of variables or terms according to some criteria. Nonetheless, in log-linear models, where there are too many parameters to estimate, with many explanatory variables to choose from and a very large number of observations, stepwise and backward model selections require enormous cost, time and computer workspace. Most existing software packages cannot handle the problem. For example, GLIM does not allow stepwise derivation of optimal models. With 42,471 births to deal with, a consideration of all these points led to the adoption of the forward selection in the derivation of the main effects models. I used both forward and shortcut backward[6] approaches to identify significant interaction terms to arrive at the optimal models.[7] I pegged up the choice of the optimal model to third-order interaction parameters to avoid very complicated interpretations of results. I based the search for the optimal models on condensed files created by the GLIMTAB.FOR FORTRAN program written by T. W. Pullum (personal communication, May 1, 1989), as the 42,471 births taken individually could not be handled. However, calculating the deviances and degrees of freedom of the more complex models and the optimal models based on the individual files is straightforward once the baseline or null model deviance is calculated from the individual files. The DEVBASE.FOR FORTRAN program of T. W. Pullum (personal communication, May 9, 1989) yields both this deviance and its corresponding degrees of freedom although the latter is simply the total number of cases minus one. The appendix contains a detailed treatment of these two programs and the procedure of calculating the deviances and degrees of freedom of the more complex and optimal models based on the individual files.

Use of weights

As stated earlier, stratified sampling was employed in the probability of selecting the sample with *barangay* and household as the primary and ultimate sampling units, respectively. Weights were then assigned to each record in the survey to reflect the sampling proportions. Issues on the use of weights in the analysis of survey data were also noted above. The suggested solutions by Lee *et al.* (1986) and Clogg and Eliason (1987) and the currently available software packages that address such issues require extremely complicated approaches. So I chose the conventional strategy and as a compromise, as proposed by T. W. Pullum (personal communication, May 1, 1989), I used the weights for estimating parameters but not for testing and selecting the main effects and optimal models.

There is no question that fit statistics based on unweighted data disregarding the sampling design are less biased relative to the weighted data (conventional approach). But the biases that are raised may not be serious in some cases. One important point is that such biases are dependent on the range of the weights used. If a considerable proportion is weighted by a value close to unity, the biases may not produce serious problems. In the 1983 NDS, the weights range from 0.1734 to 2.0731 with around 33 per cent of the cases weighted by values close to one. This may not produce serious biases. Hence, the adopted approach of using the unweighted data in the testing and model selection in this analysis, though biased, may still be robust.

Results

Univariate analysis

Demographic factors. Table 1 presents the demographic, socioeconomic, and health-related differences in neonatal, post-neonatal, infant, and child mortality. Both demographic variables showed some relationships with each of the dependent variables: neonatal, post-neonatal, infant and child mortality. Birth order and mortality at ages beyond the first month of life showed a consistently positive association. During the neonatal period, first births were more likely to die than higher order births.

Table 1 about here

Children born to mothers aged less than 20 years were more likely to die in their first five years of life than those born to older mothers. Those born to mothers at high-risk ages, 35 years and over, did not differ in mortality during the first month and second to fifth years of their lives from those born to mothers at the middle ages, where associated risks, such as congenital anomalies, deterioration of uterine efficiency and difficult and prolonged labour, are expected to be generally low. However, it is during the post-neonatal and overall infancy periods that those born to mothers at the oldest ages of maternal delivery were more likely to die than those born to mothers at the middle age group.

Socioeconomic factors. All the socioeconomic variables manifested a clear negative relationship with each of the child mortality indicators in question, with education of mother emerging as the most important, followed by income, then presence of electricity, and current residence the least important. The relative importance of mother's education has been consistently established in related studies of the Philippines as well as other developing countries. The value of the four-level categorization of education was seen with child mortality as the mortality indicator, where the child mortality rate associated with the high-school category was twice as low as that relating to the category of elementary education. The clear univariate mortality differential by income might indicate that a neglect of this variable in the causal chain leading to child survival might exaggerate the effect of other socioeconomic factors, especially maternal education, which has been identified as a major socioeconomic determinant. The magnitude of the child mortality differential by current residence and presence of electricity in the household, other proxies for the socioeconomic status of the household, was not as large as that indicated by education and income.

Health related-environmental factors. Only the presence or absence of a toilet and housing quality had a clear and consistent relationship with child mortality at any age. That is, those belonging to households with unsanitary conditions (no toilet and inadequate housing facilities) were more likely to experience child mortality at any age than those living in a sanitary environment. Source of drinking water was slightly associated with mortality between the first and fifth years of life. Household composition was not related with any of the dependent variables.

Multivariate analysis

The observed bivariate associations warranted further investigation because most of the variables were interrelated. The next task then was to consider which of these variables constituted the model that best explained the outcome variables in question. This led to the search of the optimal main effects and final optimal models that best described the relationships between these variables and neonatal, post-neonatal, infant and child mortality.

Table 2 summarizes the null, main effects and optimal models for each dependent variable and their corresponding deviances and degrees of freedom resulting from the modelling exercise. Because the *forward model selection* was adopted to arrive at the main effects models, the variables were arranged according to importance, with the first as the most important and the last, the least important, in each of the main effects models. Nevertheless, it is important to note that the order of importance becomes meaningless when some variables significantly interact with each other. It is only when there are no significant higher-order interactions that ranking the variables by importance holds true, as evident with post-neonatal mortality[8] Hence with post-neonatal mortality, the interpretation of the effects of each of the predictors was straightforward since the effects on the outcome of post-neonatal mortality were direct. This means the effects did not depend on the levels of the other variables. For the other outcome variables, the optimal model was the main interest, in which the effects of interacting variables differing for the various levels of the other variables they interacted with were interpreted accordingly. The interpretation also considers that an interaction mainly cancels out large main effects.

Table 2 about here

The order of interpreting the effects of a specific variable accorded with its order in the optimal model, when it did not interact significantly with another variable. Where there were interactions, the predictors with no significant interactions were interpreted first. The next were the two-way interaction terms and the last, the three-way interactions. The following is a discussion of each of the optimal models treated separately under each of the components of child mortality.

Neonatal mortality. From Table 2, out of the 11 variables tested, the forward model selection method identified the length of the preceding birth interval (P), education of mother (ED), birth order (BO) and maternal age at childbirth (M) as the best predictors of neonatal mortality. Significant higher-order interactions among P, ED and M emerged. Table 3 presents the parameter estimates and their exponentiated values, which were termed relative rates with the exponentiated value of the overall mean as the reference rate, of the main effects and optimal models. Since birth order did not interact with the other predictors in the optimal model, its specific effect was its total effect on neonatal mortality. Its effect (Part A) was then dealt with first before the interacting effects (Part B) of the other important variables. To simplify the analysis of the interaction effects, the derived log-linear coefficients were occasionally interpreted. If the coefficient is negative, then the group has lower mortality than the reference group.

Table 3 about here

Thus, according to the optimal model, the chance of dying during the first month of life for a second or higher order birth was about 33-36 per cent lower than that for first births. Clearly, first births were most likely to experience the highest neonatal mortality in net terms.

The effect of the other health-risk factor, maternal age at childbirth, on neonatal mortality varied according to the length of preceding birth interval and mother's education. For all interacting variables, the reference was arbitrarily those births belonging to the shortest preceding birth interval, youngest maternal age at childbirth and lowest education of mothers. These births are most likely to be exposed to the highest relative risk of neonatal mortality. The interaction among maternal age at childbirth, mother's education and preceding birth interval shed further light into the observed main effects of the first two variables of interest. Effects were notably and generally large, although most deviations are not statistically significantly different from zero, at higher levels of mother's education at the shortest preceding birth interval and at any given level of mother's education at preceding birth intervals of 18 months and over. Effects were notably small at levels below college education of mothers at the shortest preceding birth interval.

Nevertheless, the inverted-J-shaped pattern of effect of maternal age at childbirth observed in the main effects model was evident at most levels of preceding birth interval and mother's education with the gap between the less than 20 and 20-34 years of maternal age at childbirth, ranging from 25 to 77 per cent. For example taking those statistically significant values, for babies whose mothers had primary or no education and with 31 months or over of preceding birth interval, the expected neonatal mortality rate for those delivered at ages 20-34 years of their mothers was 36 per thousand (exp(-1.33)*0.137), which is 25 per cent lower than the corresponding rate of 48 per thousand (exp(-1.05)*0.137) for those delivered at very young maternal ages. Those deviating from this pattern fell under the college or over educated mothers-all levels of preceding birth interval, the lowest educated mothers-shortest preceding birth interval and elementary educated mothers-18-30 months preceding birth interval groups. The very large standard errors of most of these deviant estimates indicate their instability as they were based on very few cases; therefore patterns manifested were inconclusive.

Moreover, the non-monotonic decrease of neonatal mortality with mother's education observed in the main effects model became more interpretable with the optimal model. Those that departed most from the expected inverse relationship between neonatal mortality and mother's education related again to most of the college or over educated mothers group where cases were very few. Strikingly however, at any given level of preceding birth interval and maternal age at childbirth, except the shortest preceding birth interval-oldest maternal age at childbirth, those babies of elementary-educated mothers experienced neonatal mortality much lower than babies of mothers with no or primary education. In fact, for the extreme preceding birth interval-youngest maternal age at childbirth and 18-30 months preceding birth interval-20-34 years maternal age at childbirth categories, the higher the education of the mother up to high school, the lower the expected neonatal rate.

The predictive power of the optimal model for neonatal mortality was clearly illustrated by contrasting the predicted neonatal mortality rates of two extreme groups. For example, the predicted neonatal mortality rate for the baseline group, first births with less than 18 months of preceding birth interval, delivered at the youngest ages by the lowest educated mothers was 137 per thousand, which is 82 per cent higher than than the predicted rate of 24 per thousand (0.137*0.670*0.264) for second or third births with 31 months and over of preceding birth interval delivered at ages 20-34 years by the same lowest educated mothers.

Post-neonatal mortality. For the post-neonatal mortality, all the health-risk or demographic variables - preceding birth interval (P), birth order (BO) and age of mother at birth of the child (M) - were highly significant covariates, with P and BO ranking first and second (Table 2). Among the socioeconomic variables, average household monthly income (IN) was more important than mother's education in affecting post-neonatal mortality. The inclusion of household income and mother's education in the modelling process eliminated the importance of both current residence and presence of electricity in the household. Time period of birth (BI) was important in delineating the post-neonatal experience between infants born in the distant past and those born in the recent past, with the latter showing lower post-neonatal mortality. Among the health-related variables, only housing quality (H) and toilet facility (T) showed significance.

Turning now to the impact of the significant predictors of interest, with P and BI as controls (Table 4), all other things being equal, the second or third order births had a lower rate (about 25 per cent) of post-neonatal mortality than first births. Although the effect estimate for fourth or higher order births is not statistically significantly different from zero, it implied a higher relative risk for this group than first births. In effect, first births and fourth and higher order births were more likely to be of greater risk to post-neonatal mortality than second or third births after controlling for all the other variables.

Table 4 about here

The higher the average household monthly income, the lower the chance of dying between the first and twelfth months of life. The expected relative rate for the more economically advantaged group was about 19 per cent lower than for those in the less economically advantaged group.

The net effect of education indicated that those born to mothers with college or higher education would experience post-neonatal mortality about 47 per cent lower than those born to mothers with no or primary education. Elementary and high school education reduced the risk of post-neonatal deaths by a little above 30 per cent.

Those delivered when their mothers were in their twenties and early thirties were less likely to die (about 30 per cent lower) than those delivered by mothers at ages below 20 years. Although the estimated effect for the oldest age at childbirth group is not statistically significantly different from zero, it indicated that the relative risk was lower for this maternal age group than for the youngest age of delivery group.

Babies born to mothers with adequate housing facilities were less likely by 15 per cent to die during the post-neonatal period than those born to mothers with inadequate housing facilities. Presence of toilet, at least outside, reduced the risk of post-neonatal deaths by 21 per cent. Again, the parameter estimate referring to the category 'inside' is not significantly different from zero. However, the direction of its effect was consistent with expectations.

Contrasting the estimated relative risks of the most advantaged and disadvantaged groups illustrated the predictive power of the best-fitting model for post-neonatal mortality. That is, the expected post-neonatal mortality rate for the second or third child born to a mother aged 20-34 years in a household with an average monthly income of one thousand or more pesos, with college or higher education, with adequate housing quality and with at least a toilet facility is about 28 per thousand (0.188*0.748*0.698*0.811*0.527*0.852*0.787), which is a little more than six times lower than that of a child in the baseline group (188 per thousand), namely a first birth to a mother aged below 20 years in a household with an average monthly income of less than a thousand pesos, with no or primary education, with inadequate housing quality and with no toilet facility.

Infant mortality. With overall infant mortality (Table 2), all the significant predictors of post-neonatal mortality except housing quality (H) maintained their importance. Source of drinking water (W) replaced H and the optimal model involved second-order interactions between P and M; P and W and third-order interactions among ED, T and W.

Table 5 displays the effects of these significant predictors of infant mortality. The predictors that did not interact with other variables were birth order and household income (Part A). As observed with neonatal and post-neonatal mortality, the relative risk to infant mortality of second and third order was 33 per cent lower than that of first births. Fourth or higher order births had a slightly lower relative risk than first births. As in post-neonatal mortality, the relative rate of the higher income births was 19 per cent lower than that of lower income births.

Table 5 about here

Maternal age at childbirth interacted with length of preceding birth interval. The shortest and longest preceding birth interval groups showed the smallest and largest effects, respectively, a pattern similarly observed with neonatal mortality (Part B). At any given level of preceding birth interval, the effects of maternal age at childbirth followed the same inverted-J-shaped pattern clearly evident with post-neonatal mortality and less clearly with neonatal mortality.

Among the three interacting variables (Part C), the interpretation took education first. Interaction effects of mother's education with toilet facility and drinking water source cancelled out the observed large main effects of mother's education. Educational differentials were greater among babies having unsafe source of drinking water than among babies having safe source of drinking water at any given level of toilet facility. Taking for example the no toilet facility-unsafe drinking water supply group yielded a difference of 43 per cent in the fitted rates between births of the lowest educated mothers, 353 per thousand, and those of elementary-educated mothers, 200 per thousand =0.353*exp(-0.57). On the other hand, the difference in the expected relative rates of births in the no toilet facility-safe drinking water supply group between the same two lowest educational levels of mothers was negligible. Also, the gap in relative rates between those with no or primary-educated and high school educated mothers but having the same unsafe source of drinking water were 54 and 41 per cent, respectively, for outside and inside categories of toilet facility. In contrast, the corresponding differences in relative rates between the compared educational groups but having the same safe source of drinking water were 16 and 10 per cent, respectively, for outside and inside categories of toilet facility.

The net inverse relationship between mother's education and infant mortality observed in the main effects model was evident only at the outside toilet facility-unsafe water source and inside toilet facility-safe water source levels. The remaining levels showed less clear patterns, although the general patterns of lower relative risk of births of elementary-educated mothers compared to that of births of the lowest educated mothers and of the lowest relative risks of births of mothers with the highest educational attainment prevailed.

On the effects of toilet facility, the log-linear significant coefficients consistently increased from -0.57 to -1.17 among those with an unsafe source of water and whose mothers had elementary education. The same pattern, although not uniformly consistent, held true with the other levels of education and source of drinking water, suggesting that among the three interacting variables, toilet facility had the sharpest impact on infant mortality.

In the main effects model, the net effect of source of drinking water followed the unexpected direction of causation. This was mainly because of the larger effects observed in the cells referring to the category 'unsafe' compared to the cells referring to the category 'safe' at the levels of: (a) no toilet-elementary-college-educated; (b) outside and inside toilet-high school-educated; (c) inside toilet-elementary-educated; and (d) outside toilet-highest educated mothers. For these groups, the infants with a safe source of drinking water were likely to experience higher infant mortality than those with an unsafe source of drinking water. This is a puzzling finding. Nonetheless, the remaining levels manifested the expected direction of lower infant mortality, the safer the source of drinking water in net terms. For example, among those whose mothers had no or primary education, irrespective of type of toilet facility, or whose mothers had high school education with no toilets, those with safe source of drinking water had lower relative rates than those with unsafe source of drinking water.

The unexpected direction of causation between drinking water supply and infant mortality in some of the levels of toilet facility and mother's education could be due to the dichotomous categorization of water supply source. However, examining the infant mortality rate by education and source of drinking water, with its most detailed categorization, in Table 6, revealed that among the elementary educated mothers, the infant mortality rate of those obtaining their drinking water from pipes was higher than most, if not all, of the other categories in question in both urban and rural areas. Regardless of current residence, a pump-shallow-well water supply, which was expected to be more unsafe than artesian deep well or piped water, and rain water implied lower infant mortality than did the other sources of water. If misreporting of sources of drinking water was the major reason for the unexpected pattern, the reverse pattern would have been observed among the higher educated mothers. Nonetheless, the same lower infant mortality rate for such sources relative to the others was observed.

Again, comparing the fitted rate of 19 per thousand (0.353*0.670*0.811 *0.239*0.419) for second or third births belonging to household income of P1000 or more (monthly), delivered by high school educated mothers at ages 20-34 years, with preceding birth interval of 31 months and over, with toilet outside the house but with unsafe source of water, with the fitted rate of 307 per thousand (0.353*0.869) for fourth or higher order births of mothers with low income delivered by mothers of no or primary education at ages below 20 years, with preceding birth interval of less than 18 months, no toilet and unsafe source of drinking water yields a difference of 94 per cent. This demonstrates how powerful was the optimal model for infant mortality.

Table 6 about here

Child mortality. Child mortality (Table 2) had the same eight significant covariates as post-neonatal mortality. The only difference was the way the effects of some of these predictors operated. While the optimal model for post-neonatal mortality was the main effects model, that for child mortality included more second-order and third-order interactions.

Table 7 shows the resulting parameter estimates and relative rates for the main effects and optimal models for child mortality. Interpreting the effects of the predictors with no interactions (Part A) yielded a clear and consistent impact of maternal age at childbirth and housing quality on child mortality. The predicted child mortality rates for those born to mothers aged 20-34 and 35+ years were respectively 22 and 34 per cent lower than for those born to mothers below 20 years. The inverted-J-shaped pattern of relationship between neonatal, post-neonatal and infant mortality and maternal age was not evident with child mortality. The higher the maternal age, the lower the child mortality. Those living in adequate housing were 28 per cent less likely to die during their childhood years than those in inadequate housing.

Table 7 about here

Part B presents the interaction effects of birth order and household income. In the optimal model, birth order interacted both with preceding birth interval and household income. Given that preceding birth interval was treated as a mere control, the interactions between birth order and household income were more relevant. Thus, regardless of income level, the fourth order births experienced the highest relative risk of child mortality. However, among low income-births the effect of birth order followed a J-shaped pattern. The relative rate for low income fourth or higher order births was 112 per thousand (0.082*1.363) while that for low income second or third births was 58 per thousand (0.082*.705) and that for first births (reference group) was 82 per thousand. Interestingly, for the higher income group, the higher the birth order, the higher the relative risk of child mortality. The relative rate for first births was 49 per thousand, for second or third order births, 77 per thousand and for fourth or higher order births, 100 per thousand.

Part C shows the coefficients from the three-way interactions. As had been done with neonatal and overall infant mortality, the effects of these interacting variables were occasionally assessed using the log-linear coefficients.

The effects of income depended on both the level of birth order and the levels of education and toilet facility, so they were interpreted first on the level of birth order and then on both the levels of education and toilet facility. The ratios of relative rates between household income category <P1000 and category P1000+ were 1.68 and 1.12 for first and fourth or higher order births, respectively, indicating higher mortality for the poorer group. According to the three-way interaction terms in C, although some coefficients are not significantly different from zero, for any given level of education and toilet facility, the lower the risk of child deaths, the higher the average income of the household. This indicated a clear and consistent negative association between household income and child mortality, net of the confounding effects of all other important variables.

There was an inverse relationship, although not as clear and consistent as that observed with household income, between mother's education and child mortality. Among those with a toilet outside the house and a lower income level, the higher the educational attainment, up to high school, the lower the child mortality. In fact, if statistical significance is disregarded, for those with toilets inside the house, the higher the household income and education of the mother, the lower the risk of child mortality. For those with toilets outside the house, the same pattern existed for levels of education above primary. The only exception to this pattern occurred to births to college educated mothers with no toilet and low household income. The estimate, although not significantly different from zero, meant that those belonging to mothers with the highest educational attainment, below average income level and no toilet were likely to experience the highest mortality (log-linear coefficient=0.27). However, since there were only 98 births in question and the estimate is not statistically significant, the pattern observed should be treated with caution.

The effects of toilet facility were more or less in the expected direction, although less clearly than income. The general pattern observed was that having at least a toilet was associated with lower child mortality. For example, taking the significant estimates, among the births to high school educated mothers, the better the toilet facility the lower the child mortality as seen in the increasing log-linear coefficients from -0.58 to -2.19.

The estimated child mortality rate for second or third order births delivered by college educated mothers at ages 20-34 years with adequate housing quality and toilet outside but low income was 6 per thousand (0.082*0.779*0.719*0.705*0.186). This value is 88 per cent lower than the rate of 49 per thousand (0.82*0.657*1.363*0.664) for fourth or higher order births to mothers of no or primary education at ages 35 years or more with inadequate housing quality, toilet outside but low income. This again indicated how fit the optimal model was to the child mortality data.

Discussion

The present log-linear rate analysis of covariates of child mortality has identified demographic, socioeconomic and health-related factors affecting neonatal, post-neonatal, infant and child mortality in the Philippines using the 1983 NDS. The importance and patterns of effects of these variables on each of the components of child mortality varied to a certain extent. Hence, a discussion of the main findings and their corresponding implications under each component is helpful.

(1) The 'best' model that predicted neonatal mortality included all the demographic or health-risk factors____preceding birth interval, crudely measured, birth order and maternal age at childbirth____and mother's education. All other things being equal, the pattern of net effects of birth order and maternal age at childbirth was an inverted J-shape, with first births or any birth to mothers at their youngest ages of reproductivity experiencing the highest risk, followed by fourth or higher order births or any birth to mothers at their oldest ages of reproductivity. Differences by maternal age at childbirth were great with preceding birth intervals of less than 18 months, regardless of mother's education and with preceding birth intervals of less than 31 months and no or primary education of mothers. Also, educational differentials were marked at the youngest maternal ages at childbirth and shortest preceding birth interval. These patterns identify the groups most likely to experience higher than average neonatal mortality. They are first births and any birth at very young ages of mothers with no or primary education and with very short preceding birth intervals. They are targets requiring top priority in the implementation of health programs.

The prominence of all three health-risk factors____preceding birth interval, birth order and maternal age at childbirth____reinforces findings of several studies that biological or medical rather than environmental factors are associated with neonatal mortality. However, the emergence of education as an important variable in the 'best' model may imply that the dominance of the biological or medical factors in affecting neonatal mortality applies mainly to high-income countries. In low-income countries, like the Philippines, there tend to be socioeconomic differentials in neonatal mortality, as evidenced by the significant impact of education of the mother. Nevertheless,the interaction effects of mother's education with preceding birth interval and maternal age at childbirth indicates that formal schooling as such is not the key determinant of neonatal mortality. Although births to highly educated mothers tended to show the lowest risk of neonatal mortality, variations by mother's education at longer preceding birth intervals and older maternal ages at delivery were small and non-uniform. These patterns imply that mother's education may be significant in its own right, or may be a reflection of differentials owing to education in nutrition of the mother, care of the mother during pregnancy or in conditions of maternal delivery.

(2) The best-fitting model for post-neonatal mortality is consistent with the theory that socioeconomic and health related-environmental factors become more prominent after the first few months of life. Demographic or health-risk factors, length of preceding birth interval and birth order, remained the most important predictors; the socioeconomic factors, average household income and mother's education, ranked next; and health-related factors, housing quality and presence of toilet, came last. It may be argued that this order of importance of the predictors is biased through the forced assumption that the socioeconomic and health-related covariates did not vary with time. Nonetheless, confining the analysis to births occurring five years before the survey did not change the above ranking (Cabigon 1990).

That the direct effect of average household income was greater than that of mother's education implies that formal schooling, which has been shown in previous Philippine studies as the strongest socioeconomic determinant, may have reflected income characteristics and that maternal education may not be an adequate proxy of Philippine socioeconomic status. In addition, increasing the purchasing power of the populace may need attention equal to or even more than improving their educational levels.

The patterns of effects of these 'best' predictors of post-neonatal mortality show that post-neonatal mortality was high for babies: (a) in the first and fourth or higher order; (b) delivered at very young and old ages of their mothers; (c) belonging to low income households; (d) with low-educated mothers; (e) living in an inadequate housing environment; and (f) in households lacking toilet facilities. These are the critical groups to be given top priority in health planning and implementation if the goal is to reduce Philippine post-neonatal mortality.

(3) The most parsimonious model for infant mortality identified the same significant demographic and socioeconomic covariates as in the post-neonatal mortality model. However, while the net effects of these predictors on post-neonatal mortality were uniform across all subgroups of the population in question, they were not so with overall infant mortality. Only birth order and average household income maintained their direct effects on overall infant mortality. The rest showed varying effects on various levels of the other predictors they had interactions. Also, both models differed in the identification of important health-related predictors. Housing quality was important for post-neonatal mortality but not for the overall infant mortality. It was replaced by source of drinking water in the infant mortality model. It must be noted though that source of drinking water was only influential with overall infant mortality, a finding consistent when provinces were units of analysis (Cabigon 1990) and with the finding of Martin *et al.* (1983) of its insignificance on child mortality.

The observed dissimilar patterns of covariates of post-neonatal and overall infant mortality suggest the necessity of examining infant mortality, in both its disaggregated and overall forms. Analysing its components is important, as many factors are associated with different risks at different ages of the infant. Examining overall infant mortality may show some patterns obscured when its components are investigated, because of smaller sample size, which had been the case with the present data.

Turning to the patterns of effects of these predictors of infant mortality reveals the same patterns of effects of birth order on neonatal mortality and of household income on post-neonatal mortality. That is, first and fourth or higher order births and low-income births were likely to experience very high infant mortality. As with neonatal mortality, maternal age at childbirth interacted with preceding birth interval. For the shortest and longest preceding birth interval, those delivered at the youngest maternal age were most likely to have the highest risk, followed by those at the oldest maternal age at delivery. The reverse held true for births with 18-30 months preceding birth intervals.

The effects of education depended on the level of source of drinking water. Differences by mother's education were greater with unsafe than safe source of drinking water. Among those with unsafe sources of drinking water, the expected pattern held, although not very consistently: that is the higher the mother's education, the lower the infant mortality, at any given level of toilet facility. Among those with safe source of drinking water, the net inverse relationship was less clear although the general pattern was in the expected direction.

Net effects of toilet facility were, however, in the expected direction of negative association with infant mortality at any given level of education and source of drinking water. In fact, among the three interacting variables, mother's education, toilet facility and source of drinking water, toilet facility showed the sharpest association with infant mortality within the explanatory framework used.

It is the effect of source of drinking water that displayed expected and unexpected patterns at different levels of mother's education and toilet facility. The unexpected pattern persisted even with the most detailed categorization of source of drinking water.

Several explanations of the unexpected pattern are advanced. First is misreporting of the type of drinking water source. It may be possible that unsafe sources were reported as safe by some respondents in the survey. However, the detailed categorization of drinking water supply by infant mortality level did not show a systematic bias towards reporting sources of drinking water as safe even if they were not. Nonetheless, further investigation of this aspect is important before reaching definitive conclusions.

Second is the role played by behavioural practices enhanced by non-formal or formal education as clearly indicated by the marked educational differentials by unsafe source of drinking water. Perhaps, knowing their sources of drinking water are unsafe, most mothers with at least an elementary education may have been boiling the water before consuming it, so it may be the behavioural practices rather than the source of drinking water *per se* that were measured. This may be a more reasonable explanation than misreporting.

Third is the manner of transport from the source to the house and the means of storing the water. While piped water and artesian wells were reported as sources of drinking water, these sources are likely to be public sources for the majority of the population in question. Therefore, the container, the mode of transport from the public source to the house, and the way of storing the water are important factors to be considered for this segment of the population. In fact, the present study showed that as expected, the higher educated mothers, who were more likely to afford tap water inside their houses, experienced fewer infant deaths than those with other sources of drinking water, irrespective of current residence.

The last explanation is the possibility of contamination of water from rusting pipes or pipes contaminated by floods. This particularly may be more serious in areas frequently flooded, for example the Metro-Manila area.

While the behaviour of mothers or the suggested contaminating factors may have played major roles, as these are mere speculations, further research verification is needed. Moreover, the same points raised with post-neonatal mortality, regarding the observed net effects of demographic factors and income, apply with infant mortality. The persistent independent effect of income suggests that it is a significant determinant in its own right. The interaction of education with the health-related factors indicates that apart from formal schooling there are other attributes, like behavioural practices, which may be equally important determinants.

(4) The optimal model for child mortality had exactly the same covariates as that for post-neonatal mortality. However, as with infant mortality, the effects of most predictors varied by different levels of the other predictors with which they interacted. Maternal age at childbirth and housing quality did not interact with the other predictors in the model. The higher the maternal age at delivery and the better the quality of housing, the lower the child mortality. The underlying biological mechanism associated with maternal age during infancy is no longer a relevant issue at later childhood ages. Perhaps, after the first year of life, the mechanism associated with maternal age may be more a reflection of how the child is cared for. It is likely that older women are more experienced than younger women in caring for their children to prevent child mortality. The finding on the significant role of housing characteristics in affecting child mortality augments the few published works, as reviewed earlier. One possible explanation of the importance of housing quality is that the mortality risk of already poor children is exacerbated by the poor quality of their housing. Possibly, a poor child, living in inadequate housing conditions and sick with an infectious disease, such as pneumonia and influenza, is likely to have a higher risk of mortality than a child, sick with the same disease, but living in better housing.

On two interacting variables, birth order interacted with both preceding birth interval and household income. Regardless of income level, the fourth or higher order births manifested the highest risk; nevertheless, while among the low income group, first births ranked second, among the high income group, second or third order births ranked next.

With the three interacting variables, household income, mother's education and toilet facility, on child mortality, income effects were the sharpest, followed by the toilet facility effects and last, the education effects within the analytical framework used. The effects of income depended on the levels of birth order, maternal education and toilet facility. For the first and fourth and higher order births, the higher the child mortality, the lower the household income. The reverse held with second or third order births. For any given level of education and toilet facility, the general pattern persisted of lower child mortality risks with higher income. The effects of toilet facility more or less reflected the general pattern that having at least a toilet was associated with lower child mortality, regardless of income and education levels. Disregarding the only deviant cell based on very few cases, the effects of mother's education also followed an inverse pattern of association with child mortality. These illustrate the great role of household income, mother's education and health-related factors in the causal chain leading to child mortality. Having a college education may be not enough, unless the attained education is a means of generating income. The issue of producing college-educated mothers but not providing corresponding job opportunities arises. The impact of education, operating on the levels of toilet facility and household income and showing less clear associations than income, suggests the possibility of exaggeration in the measured effects of maternal education on child mortality in previous Philippine studies.

On the whole, this paper clearly identified the groups at higher risk of each of the components of child mortality. The outcome of targeting these groups in the implementation of health programs is undoubtedly a better survival of Filipino children. The paper demonstrated the varying patterns of effects of demographic factors (birth order and maternal age at childbirth), socioeconomic factors (household income and mother's education) and health-related factors (housing quality, toilet facility and source of drinking water) on neonatal, post-neonatal, overall infant and child mortality. However, there still remain several issues needing further inquiry such as those already raised in the discussion. One additional issue worth investigating is whether the inclusion of proximate variables in the analytical framework changes the patterns of effects of these emerging important but non-proximate variables.

Notes

[1] The authors cautioned that the toilet facility variable, being measured only at the time of the survey, may not be a good proxy for the type of sewage disposal present when the children were exposed to risk.

[2] Trussell and Hammerslough (1983, p.14) used sample weights assigned per case and treated the weighted sample as a simple random sample.

[3] The *barangay* is the smallest political unit in the Philippines.

[4] An evaluation of the 1983 NDS pregnancy history revealed that the problems common in many surveys - systematic event misplacement toward the survey, and omission of events, especially by earlier cohorts and in earlier periods - were not noticeable in most of the cohorts of women in the 1983 survey. As in previous surveys, the errors observed might not have caused serious distortions in the maternity history. Therefore, the 1983 NDS provided data suitable for assessing the size and relative influence of each of the demographic, socioeconomic and health related-environmental variables on neonatal, post-neonatal, infant, and child mortality (Cabigon, 1990).

[5] I recognize one main flaw of considering the preceding birth interval as a control. The preceding birth interval was loosely defined for it included first births. Theoretically, the effect of birth intervals should only be studied with birth orders two and above. It is only interbirth intervals that are relevant, where the three mechanisms - foetal growth, milk diminution and resource competition - operate. First births obviously cannot properly be assigned an interval since a previous birth. However, this study was not focused on sorting out the processes producing the effects of the preceding birth interval. The methodological problems inherent in the analysis of child-spacing effects on child mortality noted above, calls for a separate investigation and I am currently working on it under a Rockefeller Foundation postdoctoral fellowship. As around 80 per cent of the births analysed here belonged to birth orders two and over and as first births are subject to somewhat higher than average mortality risks, it was considered more illuminating to concentrate on measuring the influence of the other demographic, socioeconomic and health related- environmental variables on neonatal, post-neonatal, infant and child mortality, taking into account the length of the preceding birth interval. The strategy followed then was to assign the first births the longest category interval to ensure that they were not characterized by a short preceding interval (and the accompanying stresses).

[6] As suggested by T. W. Pullum (personal communication, June 16, 1989), the easiest, shortcut and backward elimination from a three-way interaction can be obtained by comparing the deviances of the three-way interaction model and its implied two-way interaction model. For example, given variables A, B and C, the two nested models to be compared to identify third order interaction of A, B and C are: A*B*C (which includes all the implied lower order effects or interactions) and A*B+A*C+B*C (the two-way interactions and all the implied main effects).

[7] The deviance is a measure of how closely the model fits the data and is distributed asymptotically as chi-square under the null hypothesis that the log-linear rate model and the underlying assumptions are correct. Testing the significance of specific variables or with the addition of further terms was based on the differences in deviances between the baseline model and a more complex model (nested models) compared with the tabulated chi-square, with degrees of freedom (df) equal to the difference between the df's of the nested models under comparison. The df indicates how much information is available for estimating the 'background noise' with the residual variance (Swan 1985, p.18).

[8] A three-way interaction among household income, mother's education and maternal age at childbirth is significant at 0.05 level but adding this interaction term to the main effects model did not improve the fit of the main effects model. The difference in deviance was 22.8 at 17 degrees of freedom, which is not statistically significant. Moreover, the estimated interaction effects were practically unimportant quantitatively for they slightly changed the main effects of each of the variables in question (results not shown).

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Appendix

Derivation of the deviance and its corresponding degrees of freedom of a given model

Given individual files that are too large because of many variables to consider, creation of a condensed file is necessary for GLIM to run successfully. T. W. Pullum's (personal communication, May 1, 1989) GLIMTAB.FOR FORTRAN program constructs a condensed file in which the number of cases is equal to the number of distinct combinations of the predictor variables. More simply, this program produces the accumulated number of cases and amount of exposure in each cell. The deviances (G^2_c) and their corresponding degrees of freedom (df_c) calculated from the condensed file served as basis for the search for the optimal models in the present study.

To derive the deviance of a given model (G^2_m) and its corresponding degrees of freedom (df_m) necessitates calculation of the baseline or null model deviance (G^2_0) from the individual file and its corresponding degrees of freedom (df_0) which is simply the total number of cases minus one. T. W. Pullum's (personal communication, May 9, 1989) DEVBASE.FOR FORTRAN program calculates G^2_0 and df_0 according to the formulas of McCullagh and Nelder (1983:25).

There is a simple relationship between a GLIM run on the individual file and a GLIM run on the condensed (c) or aggregated file. That is,

$$G^2_{c0} - G^2_{cm} = G^2_0 - G^2_m.$$

Therefore,

$$G^2_m = G^2_0 - (G^2_{c0} - G^2_{cm}), \text{ and}$$

$$df_m = df_0 - (df_{c0} - df_{cm})$$

where:

G^2_{c0} = deviance for the null model based on the condensed file

df_{c0} = df of G^2_{c0}

G^2_{cm} = deviance for the more complex model based on the condensed file

df_{cm} = df of G^2_{cm}.

Table 1: Demographic, socioeconomic and health related differentials in infant and child mortality, Philippines: all children, 1983 NDS

	Mortality rate per 1000 births			
Variables	Neonatal	Post-neonatal	Infant	Child
Demographic				
Birth order				
1	26(9504)	20(9242)	45(9504)	21(8702
2-3	21(15255)	24(14897)	45(15255)	28(13800)
4+	22(18220)	34(17769)	55(18220)	36(16103)
Maternal age at birth of child (years)				
<20	31(5269)	33(5099)	63(5269)	36(4766)
20-34	21(33116)	26(32326)	46(33116)	29(29821)
35+	22(4593)	32(4482)	53(4593)	27(3947)
Socioeconomic				
Residence				
Rural	24(28473)	28(27723)	51(28473)	33(25537)
Urban	20(14506)	27(14185)	46(14506)	23(13367)
Presence of electricity in the household				
Without	23(21963)	31(21405)	53(21963)	38(19599)
With	22(21016)	24(20503)	45(21016)	21(19005)
Average household monthly income				
<P1000	24(32350)	30(31493)	53(32350)	35(28868)
P1000+	18(10629)	19(10415)	37(10629)	14(9737)
Education				
<Elem.	31(11932)	40(11539)	70(11932)	48(10688)
Elem.	20(17531)	25(17150)	44(17531)	30(15889)
H Sch.	20(9152)	22(8939)	42(9152)	15(8160)
Coll.+	16(4363)	14(4279)	30(4363)	9(3867)

Table 1. Demographic, socioeconomic, and health related differentials in infant and child mortality, Philippines: all children, 1983 NDS (cont'n)

Variables	Mortality rate per 1000 births			
	Neonatal	Post-neonatal	Infant	Child
Health Related				
Source of drinking water				
Unsafe	23(23858)	27(23265)	49(23858)	32(21435)
Safe	22(19121)	27(18643)	49(19121)	26(17169)
Presence of toilet				
None	25(9227)	37(8971)	62(9227)	50(8052)
Outside	23(25296)	26(24639)	48(25296)	28(22825)
Inside	18(8456)	20(8297)	38(8456)	12(7727)
Housing quality				
Inadequate	23(27300)	31(26590)	53(27300)	37(24333)
Adequate	21(15679)	21(15317)	42(15679)	17(14272)
Household composition				
Extended	23(10621)	27(10348)	49(10621)	28(9411)
Nuclear	22(32358)	28(31560)	49(32358)	30(29192)

( ) N of births

Table 2: Models that describe the relationships between neonatal, post-neonatal, infant and child mortality and demographic, socioeconomic and health related-environmental factors: all children

Mortality indicator/ model type	Model	Deviance	df	Difference from the simpler model	
				Deviance	df
Neonatal					
Null	-	11668.10	42470	- *	-
Main effects	P+ED+BO+M	11464.50	42461	203.60	9
Optimal	Main effects + P.ED.M	11417.30	42433	* 47.20	28
Post-neonatal					
Null	-	11036.38	41408	-	-
Main effects	** P+BO+IN+ED+BI+M+H+T	10621.88	41394	* 414.50	14
Infant					
Null	-	21356.49	42470	- *	-
Main effects	P+BO+IN+ED+BI+M+T+W	20847.49	42456	509.00	14
Optimal	Main effects+P.M+ P.W+ED.T.W	20715.79	42433	* 131.70	23
Child					
Null	-	11320.76	38107	- *	-
Main effects	IN+T+ED+P+BO+BI+H+M	10789.46	38093	531.30	14
Optimal	Main effects+P.BO+P.ED+ IN.BO+IN.T.ED	10716.66	38066	* 72.80	27

Notes: Null=baseline grand mean model or a model with no covariates in which a single overall value of the rate is assumed to apply to entire population; optimal model=most adequate description of the relationships between the response variable and its covariates; main effects model=adequate description of the relationships between the response variable and its covariates excluding significant interaction terms between the covariates; P=length of preceding birth interval; BO= birth order; M=age of mother at birth of child; IN=average household monthly income; ED=mother's education; H=housing quality; T=toilet facility; W=source of drinking water; BI=Period of birth; A dot means interaction - two-way and three-way. The deviance measures how closely the model fits the data and it is distributed asymptotically as chi-square under the null hypothesis that the model used and the underlying assumptions are correct. The degrees of freedom (d.f.) indicate how much information is available for estimating the 'background noise' with the residual variance.

*
Statistically significant at 0.025 or lower level.

**
Three-way interaction, but not two-way, among IN, ED and M is statistically significant at 0.05 level; however the estimated interaction effects were small relative to the main effects. Hence on the basis of parsimony (a model with minimum number of parameters), the main effects model is the optimal model.

Table 3: Parameter estimates and relative rates from the main effects and optimal models for neonatal mortality

	Model/Parameter					
Variable	Main effects			Optimal		
	Estimate	Standard error	Relative rate	Estimate	Standard error	Relative rate
Constant or grand mean	-2.05	0.14	0.129	-1.99	0.28	0.137
A. No interactions						
Birth order						
1	0.00	-	1.000	0.00	-	1.000
2-3	-0.44*	0.12	0.644	-0.40*	0.14	0.670
4 and over	-0.46*	0.12	0.631	-0.45*	0.14	0.638
Maternal age at childbirth (in years)						
<20	0.00	-	1.000			
20-34	-0.45*	0.10	0.638			
35 & over	-0.15	0.15	0.861			
Mother's education						
Prim. & below	0.00	-	1.000			
Elementary	-0.41*	0.08	0.664			
High School	-0.23*	0.09	0.794			
College +	-0.36*	0.13	0.698			

Table 3: Parameter estimates from optimal model with significant interactions for neonatal mortality (continuation)

Preceding birth birth interval/ maternal age at childbirth	Education of Mother							
	Primary & below		Elementary		High School		College+	
	Estimate	S.E.	Estimate	S.E.	Estimate	S.E.	Estimate	S.E.
B. With interactions								
<18								
<20	0.00	-	-0.32	0.40	-0.61	0.56	-3.79	6.73
20-34	-0.37	0.27	-1.07	0.77	-0.90	1.03	-1.21	11.67
35 & over	-0.63	0.38	-0.31	0.94	-0.60	1.38	-4.16	14.14
18-30								
<20	-0.71	0.47	-2.11	1.24	-0.31	1.41	-0.62	11.73
20-34	-1.41	0.89	-1.75	2.08	-1.80	2.37	-1.59	19.16
35 & over	-1.03	1.06	-2.17	2.39	-1.08	2.90	0.07	21.59
31 & over								
<20	-1.05*	0.32	-1.09	0.82	-1.18	1.09	-0.27	11.69
20-34	-1.33*	0.64	-1.76	1.46	-1.30	1.88	-1.62	19.10
35 & over	-1.08	0.86	-1.23	1.79	-1.08	2.57	-1.69	22.94

Note: The relative rate of the constant is the reference rate.
Preceding birth interval is a significant control.

* Statistically significantly different from zero.

Table 4: Parameter estimates and relative rates from the main effects or optimal model for post-neonatal mortality

Variable	Parameter		
	Estimate	Standard error	Relative rate
Constant or grand mean	-1.67	0.16	0.188
Birth order			
1	0.00	-	1.000
2-3	-0.29*	0.12	0.748
4 and over	0.11	0.12	1.116
Household income			
<P1000	0.00	-	1.000
P1000+	-0.21*	0.08	0.811
Mother's education			
Prim. & below	0.00	-	1.000
Elementary	-0.37*	0.07	0.691
High School	-0.38*	0.09	0.684
College +	-0.64*	0.14	0.527
Maternal age at childbirth (in years)			
<20	0.00	-	1.000
20-34	-0.36*	0.10	0.698
35 & over	-0.24	0.13	0.786
Housing quality			
Inadequate	0.00	-	1.000
Adequate	-0.16*	0.07	0.852
Toilet facility			
None	0.00	-	1.000
Outside	-0.24*	0.07	0.787
Inside	-0.17	0.11	0.844

Note: The relative rate of the constant is the reference rate.
Significant controls are preceding birth interval and time period.

* Statistically significantly different from zero.

Table 5: Parameter estimates and relative rates from the main effects and optimal models for infant mortality

Variable	Model/Parameter					
	Main effects			Optimal		
	Estimate	Standard error	Relative rate	Estimate	Standard error	Relative rate
Constant or grand mean	-1.20	0.12	0.301	-1.04	0.18	0.353
A. No interactions						
Birth order						
1	0.00	-	1.000	0.00	-	1.000
	*			*		
2-3	-0.40	0.08	0.670	-0.40	0.10	0.670
4 and over	-0.13	0.09	0.878	-0.14	0.10	0.869
Maternal age at childbirth (in years)						
<20	0.00	-	1.000			
	*					
20-34	-0.27	0.07	0.763			
35 & over	-0.18	0.10	0.835			
Household income						
<P1000	0.00	-	1.000	0.00	-	1.000
	*			*		
P1000+	-0.20	0.06	0.819	-0.21	0.06	0.811
Mother's education						
Prim. & below	0.00	-	1.000			
	*					
Elementary	-0.41	0.05	0.664			
	*					
High School	-0.41	0.06	0.664			
	*					
College +	-0.62	0.10	0.538			
Drinking water source						
Unsafe	0.00	-	1.000			
	*					
Safe	0.12	0.04	1.127			
Toilet facility						
None	0.00	-	1.000			
	*					
Outside	-0.13	0.05	0.878			
	*					
Inside	-0.23	0.08	0.795			

Table 5: Parameter estimates from optimal model with significant interactions for infant mortality (continuation)

Interaction term/variable	Variable/parameter

B. Predictors with 2-way interactions

Maternal age at child-birth	Preceding birth interval (months)								
	<18			18-30			31 & over		
	Est.	S.E.	R.Rate	Est.	S.E.	R.Rate	Est.	S.E.	R.Rate
<20	0.00	-	1.000	-1.05*	0.19	0.350	-1.11*	0.17	0.330
20-34	-0.24	0.13	0.787	-1.19*	0.36	0.304	-1.43*	0.31	0.239
35+	-0.23	0.17	0.794	-1.14*	0.43	0.320	-1.20*	0.39	0.301

C. Predictors with significant 3-way interactions

Toilet facility/ water source	Education of mother							
	Primary & below		Elementary		High School		College+	
	Est.	S.E.	Est.	S.E.	Est.	S.E.	Est.	S.E.
None								
Unsafe	0.00	-	-0.57*	0.13	-0.20	0.19	-1.86*	0.93
Safe	-0.46*	0.15	-0.44	0.35	-0.55	0.45	-0.11	1.70
Outside								
Unsafe	-0.09	0.09	-0.60*	0.27	-0.87*	0.37	-1.19	1.64
Safe	-0.42	0.29	-0.71	0.64	-0.60	0.81	-0.63	2.83
Inside								
Unsafe	-0.34	0.27	-1.17**	0.60	-0.86	0.64	-0.93	1.71
Safe	-0.51	0.57	-0.62	1.14	-0.62	1.23	-1.06	2.95

Note: The relative rate of the constant is the reference rate. Significant controls are preceding birth interval and time period.

*

Statistically significantly different from zero.

**

Nearly statistically significantly different from zero.

Table 6: Infant mortality rate (per 1000 births) by education and water(most detailed categorization): all children

Residence/ water source	Education			
	Primary & below	Elementary	High School	College+
<u>All</u>				
Lake/river/stream	118(501)	51(354)	56(178)	59(51)
Spring	75(1842)	40(1483)	34(535)	49(123)
Rainwater	54(240)	31(323)	21(187)	36(139)
Open well	71(2449)	47(2953)	35(882)	19(155)
Pump, shallow well	69(2892)	35(5141)	34(2416)	18(986)
Artesian,deep well	71(2027)	44(3322)	53(1802)	40(866)
Pipe water	52(1974)	54(3951)	45(3140)	32(2042)
<u>Urban</u>				
Lake/river/stream	-	56(18)	29(35)	-
Spring	85(130)	30(135)	38(78)	118(17)
Rain water	39(51)	43(47)	37(27)	64(47)
Open well	53(207)	53(282)	34(118)	26(39)
Pump, shallow well	76(589)	32(1229)	42(914)	11(449)
Artesian,deep well	72(624	47(1025)	55(874)	31(422)
Pipe water	52(893)	57(2262)	47(2311)	30(1655)
<u>Rural</u>				
Lake/river/stream	122(485)	51(336)	63(142)	59(51)
Spring	75(1713)	40(1348)	33(457)	38(105)
Rainwater	58(189)	33(276)	19(160)	21(93)
Open well	73(2242)	46(2672)	37(764(	7(115)
Pump, shallow well	67(2303)	36(3911)	29(1503)	24(537)
Artesian well	71(1403)	43(2297)	51(928)	50(444)
Pipe water	52(1080)	50(1689)	37(829)	39(387)

( ) N of births

Table 7: Parameter estimates and relative rates from the main effects and optimal models for child mortality

Variable	Model/Parameter					
	Main effects			Optimal		
	Estimate	Standard error	Relative rate	Estimate	Standard error	Relative rate
Constant or grand mean	-2.73	0.15	0.065	-2.50	0.18	0.082
A. No interactions						
Birth order						
1	0.00	-	1.000			
2-3	-0.02	0.12	0.980			
4 and over	0.32*	0.12	1.377			
Maternal age at childbirth (in years)						
<20	0.00	-	1.000	0.00	-	1.000
20-34	-0.21*	0.10	0.811	-0.25*	0.10	0.779
35 & over	-0.40*	0.14	0.670	-0.42*	0.15	0.657
Household income						
<P1000	0.00	-	1.000			
P1000+	-0.40*	0.10	0.670			
Mother's education						
Prim. & below	0.00	-	1.000			
Elementary	-0.29*	0.06	0.748			
High School	-0.74*	0.11	0.477			
College +	-0.82*	0.19	0.440			
Housing quality						
Inadequate	0.00	-	1.000	0.00	-	1.000
Adequate	-0.34*	0.08	0.712	-0.33*	0.08	0.719
Toilet facility						
None	0.00	-	1.000			
Outside	-0.45*	0.06	0.638			
Inside	-0.81*	0.13	0.445			

Table 7: Parameter estimates from optimal model with significant interactions for child mortality (continuation)

Interaction term/ variable — Variable/parameter

B. Predictors with 2-way interactions

Birth order	Household income					
	<P1000			P1000 & over		
	Estimate	S.E.	R.Rate	Estimate	S.E.	R.Rate
1	0.00	-	1.000	-0.52	0.37	0.594
2-3	-0.35*	0.17	0.705	-0.06	0.58	0.942
4+	0.31*	0.14	1.363	0.20	0.57	1.221

C. Predictors with 3-way interactions

Toilet facility/ household income	Education of mother							
	Primary & below		Elementary		High School		College+	
	Estimate	S.E	Estimate	S.E	Estimate	S.E.	Estimate	S.E.
None								
<P1000	0.00	-	-0.47*	0.16	-0.58*	0.25	0.27	0.50
P1000+	-0.52	0.37	-1.31	0.78	-6.28	6.96	-2.45	1.67
Outside								
<P1000	-0.41*	0.10	-0.82*	0.29	-1.62*	0.42	-1.68*	0.87
P1000+	-1.61*	0.61	-1.20	1.34	-2.56	11.02	-2.90	2.91
Inside								
<P1000	-0.34	0.25	-0.93	0.55	-2.19*	0.71	-3.30*	1.30
P1000+	-1.78**	0.92	-2.21	1.82	-3.24	11.11	-3.49	3.34

Note: The relative rate of the constant is the reference rate.
Significant controls are preceding birth interval and time period.
*
Statistically significantly different from zero.
**
Nearly statistically significantly different from zero.