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REPORT OF THE FEASIBILITY STUDY

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with the Assistance of
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CHAPTER I. INTRODUCTION

This is Part One of a report describing the results of a study to design the multivariate statistical analysis of survey data on child mortality in Latin America. The analysis is to be based on the data collected by the Pan American Health Organization for 13 project areas in Latin America. The purpose of such an analysis is to identify the determinants of infant and child mortality and to obtain measures of their net effects, in order to provide the groundwork for an examination of the effectiveness of alternative policies for combatting child mortality.

This report is part of the final product of Stage I of what has been viewed by AID as potentially a two stage project. The second stage would actually undertake the analyses planned in this first stage, which has been aimed at designing the statistical analysis and determining the ability of the data to support the analysis. A literature review and investigation of appropriate statistical techniques were specified as two major tasks under Stage I and the work completed on these tasks forms the bulk of the report.

The third major task, an edit of the data tape, proved impossible to complete because of the refusal of the Pan American Health Organization to release the tape. PAHO has, however, agreed to supply computations based on the tape for the study and Stage I has been extended to permit the workability of a cooperative arrangement between PAHO and NPA to be tested. Part Two of the Stage I report, due April 1, 1974, will describe additional work done during this experimental period and may be able to supply some initial regressions based on the data for one of the projects, San Juan, Argentina (see Chapter III). Upon final completion of Stage I, a decision will be made by AID about whether to continue with the analysis under Stage II.

The material contained in this report will serve as the foundation for the Stage II analysis and describes the approach that will be taken if that stage is approved. The next chapter is a review of the literature on infant and child mortality. The review has served to generate hypotheses and to suggest the variables and variable forms that should be tested. These hypotheses and variables are discussed, along with the supporting studies, and the problems and potential of applying them to the survey data are mentioned. An annotated bibliography of the references for this chapter is contained in the appendix at the end of the report.

Chapter III sets out the steps, to be carried out in cooperation with PAHO, for processing and analysing the data. This chapter reflects a considerable amount of work that has already been undertaken as part of the preliminary negotiations with PAHO about the work to be done. Five steps are described in detail: the selection of an initial project for analysis during the experimental period; the development of a tape with the needed variables; redefinition of the variables in the form needed for the regression analysis; weighting of the data; and the computation of the regressions and test statistics, including a discussion of the reasons for selecting the particular estimation techniques. During the experimental period we will try to complete as many of these steps as possible for the initial project. If it is successful, the same agenda will be used for the Stage II project analyses.

Finally, NPA was asked to consider whether the data could be used to study fertility decisions as well as infant and child mortality. Chapter IV briefly discusses this and several other questions that could be investigated with the data. In addition, one way of using the Stage II results from the study of infant mortality to examine the cost-effectiveness of different policies is suggested. None of these studies are currently planned as part of Stage II and they will not be included in the budget estimate.

The Data

This study is to be based on an investigation carried out by the Pan American Health Organization. Since the following chapters frequently refer to various aspects of this survey, a brief description of the survey will be provided at this point to help the reader.

The survey was carried out in 13 project areas in Central and South America and two project areas in North America during the years 1968-1972. The 13 Latin American projects were located in Argentina (2), Bolivia, Brazil (3), Chile, Colombia (3), El Salvador, Mexico, and Jamaica. In each area, a sample of infant and child deaths from death certificates (frequently all were taken), supplemented by a search for unreported deaths, was followed up and a lengthy questionnaire was completed for each case, using information from the family and from various medical sources. A total of 35,000 infant deaths in the 15 projects were investigated.

In addition, a sample of living children was selected by sampling households in the same project areas and completing a questionnaire for each child under 5 living in a sample household. Questionnaires similar to those for the child deaths were completed for more than 10,000 living children. No source of information other than the family was used to complete the questionnaires for the living children.

Much of the information about the child deaths has been transferred to tape and a full report on this part of the investigation has been published (Puffer and Serrano, Patterns of Mortality in Childhood, Pan American Health Organization, 1973). The information for the living children has only recently (October 1973) been transferred to tape and editing of the tape is being carried out as a report on this group is prepared.

CHAPTER II. DETERMINANTS OF INFANT AND CHILD MORTALITY: A REVIEW OF THE LITERATURE

(Full references for the works cited in this chapter are given in the annotated bibliography at the end of the report.)

Introduction

One reasonable way to organize a review of the variables that may affect infant mortality is to separate them into those that are expected to have their major influence during the prenatal period of the infant's life, and those that are expected to have their major influence in the postnatal period. For the purposes of statistical analysis, these groups of factors can be related to distinct dependent variables -- birth weight and mortality. These correspond to a view that the infant's life proceeds in a sequence in which prenatal factors, such as maternal nutrition and prenatal medical care, are hypothesized to affect birth weight, and birth weight can then be used as an independent variable in mortality equations to summarize the infant's prenatal history.

This is not to say that all variables can be neatly categorized as belonging only to the prenatal or postnatal course of the infant's life; some variables, especially the events surrounding birth, may belong to both. Nor is this division meant to imply that mortality is homogeneous. Clearly, we will expect that the coefficients of certain factors in an equation for perinatal mortality will differ from the coefficients of those same factors in an equation investigating deaths in the second year of life -- some factors may even be statistically insignificant in the one and significant in the other. The organization is based only on the notion that, in general, the types of variables to be considered and the ways in which they will affect different kinds of mortality are sufficiently similar to make it efficient to group them in this discussion.

The review will first describe the relationships that have been reported by investigators in this area between birth weight, or mortality, and other variables. On the basis of this material, the discussion will then outline the variables that should be tested, appropriate forms of the variables for testing and the expected signs of the relationships.

All of these hypotheses, but especially those about expected signs, should be viewed as tentative since none of the studies reviewed have been able to control for all the relevant variables that might affect the observed relationships. Some of the deficiencies of data and experimental design that weaken the conclusions of various of the studies cited will be mentioned in the discussion. In this context it should be noted that differences will be referred to as "significant" only when the strict statistical definition of the term applies with a level of confidence of 95 percent or greater. In other cases, the results are second-hand reports from the literature reviews of other authors and no judgements about the reliability of the original studies are possible.

The first section of this chapter will treat the factors associated with variations in birth weight. Section II will discuss determinants of infant and child mortality.

A. BIRTH WEIGHT

A growing volume of survey research supports the view that birth weight is an extremely important determinant of infant mortality (Kessner, *et. al.*, 1973; Puffer and Serrano, 1973). Further, it serves as a useful summary measure of the infant's prenatal history and his condition at birth. For both

these reasons, it deserves analysis in its own right, as well as respectful attention as an independent variable in the mortality regressions.

Since few studies have examined the factors associated with variations in birth weight directly, most of those cited in this section deal with infant mortality. They are included here because, where the factor is one that is likely to influence the course of pregnancy, birth weight may serve as the mechanism through which it subsequently affects the infant's chances of survival. The following variables, or groups of variables, will be discussed: maternal nutrition; reproductive history; complications of pregnancy, including aspects of maternal health other than nutrition; medical care before and at birth; maternal age; child parity and spacing; sex of the child; and altitude.

A.1. Maternal Nutrition

Pregnant women require more nutrients than non-pregnant women (Chopra, et. al., 1970; Goodhart, 1964; National Academy of Sciences, 1970), but there is considerable evidence that women in less developed countries do not get nutritionally adequate diets and, as a result, malnutrition during pregnancy is common. Berg (1973, p. 15) reports that between 29 and 63 percent of the pregnant women in Latin American countries suffer from anemia. Chopra and his collaborators summarize a number of findings presented at a World Health Organization conference that point to widespread malnutrition among expectant mothers in less developed countries. For example, women in these countries gain less during pregnancy than women in developed countries and such signs of malnutrition as facial lesions, thyroid enlargement, and goiter are common.

Anemia occurs twice as often in pregnant women as in non-pregnant women.

Evidence from many sources indicates that poorly nourished mothers are likely to give birth to low weight infants. In fact, Berg (1973, p. 9) believes that the link is so well established that low birth weight implies malnutrition in utero. Mata, et. al., (1972) cite studies by INCAP which conclude that maternal malnutrition during pregnancy is associated with low birth weight and that programs of food supplements for expectant mothers increase the birth weights of their infants. In a study of 146 underweight Jamaican mothers, Roopnarinesingh, et. al., (1971) found that their infants weighed significantly less at birth than those of a control group of 146 normal or overweight mothers. A Canadian group supplemented the diets of 1,544 pregnant women from the poorest classes and found that those who received the supplements longer had larger infants and fewer complications (Primrose and Higgins, 1971).

The National Academy of Sciences (1970) has reviewed a vast array of animal experiments and studies of human populations that show maternal diet has important effects on infant birth weight. A number of the studies summarized found strong positive associations between infant birth weight and both the mother's pre-pregnancy weight, which reflects her nutrition earlier in life, and her weight gain during pregnancy (see also Hillman and Hall, 1964; Mata, et. al., 1972). Further indirect evidence is provided by an autopsy study of over 1,000 perinatal infant deaths which found that the infants of poor families in New York City weighed less than infants born to more affluent families (Naeye, 1972).

In view of the emphasis in the literature on the importance of an adequate diet during pregnancy, the lack of any data on the nutrition of mothers included in the PAHO survey is particularly frustrating. The survey did not collect any information about either the mother's diet or about proxies suggested by the literature, such as height and weight. Other less suitable proxies can be used -- e.g., the type of neighborhood in which the family lives or the occupation of the father. But in addition to the fact that we will obviously have to be more tentative in drawing conclusions about the importance of maternal nutrition, the lack of a good direct measure will mean that the estimates of the coefficients of other variables which are correlated with maternal nutrition will be biased. In the birth weight equation this is particularly likely to be a problem for variables representing reproductive history, maternal age, parity, and spacing, all of which are frequently associated with poor maternal nutrition.

A.2. Complications of Pregnancy

Complications of pregnancy and delivery can reduce an infant's birth weight, prevent him from reaching full term, cause disease in the infant, or endanger his chances of survival in other ways. Many of the studies reviewed indicate that complications of pregnancy are related to maternal nutrition, although the nature of the relationship is often not well understood (National Academy of Sciences, 1970; Journal of Reproductive Medicine, 1971). Toxemia, for example, a rather vaguely defined metabolic disorder of pregnancy which is characterized by edema, hypertension, and albuminuria, is reportedly associated with overweight, but the accumulated evidence is contradictory -- for example, it also appears to be more common among underweight mothers (Hillman and Hall, 1964). Investigators in NIH's Collaborative Perinatal Research Project, a

longitudinal study of 60,000 U.S. births, now believe that the practice of strictly limiting weight gain during pregnancy does not reduce the incidence of toxemia, but does result in lower birth weight infants.

Findings presented at a World Health Organization conference (Chopra, et. al., 1970) indicate that poorly nourished mothers are more likely to develop pre-eclampsia (hypertension accompanied by proteinuria or edema) and eclampsia (convulsions following pre-eclampsia). As discussed in Section A.1, they are also more likely to have low weight babies and this appears to be associated with premature separation of the placenta. But Roopnarinesingh, et. al.,(1971) found that pre-eclampsia and hypertension (and fetal distress) were, if anything, less common in their sample of underweight Jamaican mothers than in the control group; premature labor was equally common in both groups. The underweight mothers did, however, have a much higher incidence of anemia and prolonged labor. No statistical tests were applied to these differences.

Intra-uterine infection during pregnancy is also suspected to be quite frequent in less developed countries. Mata, et. al., (1971) noted high levels of cord IgM and IgA (these are immunoglobulins -- apparently non-specific antibodies) in more than 40 percent of the 95 newborns they examined in a Guatemalan village during a two year period. They distinguish between the importance of an adequate diet and the importance of intra-uterine infection, although the extensive work on the synergism of nutrition and infection suggests that the two are closely related. In his study of U.S. perinatal deaths, Naeye (1972) found that a high proportion of the infants born to poor families had congenital pneumonia or chorioamnionitis, conditions related to maternal infection. Poor nutrition is also associated with congenital malformations (Hillman and Hall, 1964).

Unfortunately, the PAHO survey collected information on complications of pregnancy and maternal disease during pregnancy only for the child deaths; the questions were not included on the questionnaire for the sample of living children. Length of pregnancy was obtained for both groups and can serve as a measure of one sort of complication, but this variable must be used and interpreted with extra caution as the PAHO staff feels that the quality of the answers was quite poor for this item. Specific examination of other types of complications can only be made for the birth weights of infant deaths and this might make a useful addition to the analyses of the combined groups.

A.3. Medical Care

Medical care before and during birth is generally expected to reduce infant mortality, but it is not clear whether it can be expected to have any effect on birth weight. If it does, it seems likely that this would be due to improved nutrition recommended by the medical person, and the effect of medical care in preventing complications and premature delivery.

None of the studies we have reviewed have dealt directly with medical care and birth weight, but in a survey of 1,712 rural Chilean mothers, Plank and Milanesi (1973) found that the risk of postneonatal infant death was actually greater if the mother had prenatal care than if she had no care or care only at delivery. The authors used prenatal care as an index of the use of medical care generally, noting that they believed it had relatively little effect in itself on postneonatal deaths. The study did not report either the number of women who received prenatal care or any statistical tests of the difference.

It is also impossible to tell whether this finding might be due to a self-selection process whereby high risk mothers were more likely to seek out medical care because of recognized problems.

A.4. Reproductive History of the Mother

Women who have lost one infant are more likely to lose subsequent children. Reviewing the studies of others, Morris and Heady (1955) found that stillbirths and infant deaths were serially correlated in the experience of individual women. It is not clear whether this effect is independent of other conditions, such as maternal nutrition, but Hillman and Hall (1964) report that women with poor reproductive histories have an "abnormal work response," which is apparently related to a tendency toward spontaneous abortion or premature delivery.

In the proposed study, the reproductive history of the mother, which is available, will probably reflect her nutritional state, which is not available, and can thus be expected to pick up part of the effect of maternal nutrition on the birth weight of the survey infant as well as any independent effects that the reproductive history may have.

A.5. Maternal Age

Older mothers are more likely to have various complications of pregnancy and delivery, and there is considerable evidence linking maternal age and infant mortality (see, for example, the literature review in Morris and Heady, 1955). There is some disagreement over whether the relationship between infant mortality and maternal age is monotonically rising or U-shaped. Tabular data for developed and less developed countries indicate that younger mothers as well as

older mothers face higher risks of losing an infant. And in a study of Jamaican women, Roopnarinesingh (1970) found that maternal and fetal complications were more frequent in 122 mothers under 16 years of age than in a control group of 22-year-olds. But in regression analysis of English data Feldstein (1966) found that, when socio-economic class is held constant, women less than 20 years of age face a lower risk of perinatal infant death than older women.

The source of the disagreement may lie in the failure of many studies to hold other variables constant. Or it may be due to the differences in the classes chosen for the maternal age groups. The National Academy of Sciences (1970) concludes from its survey of past studies that 17 is the true watershed; mothers 17 and over face risks similar to those 20 to 24 years of age, while younger mothers show a sharply higher infant mortality rate which increases for every year below 17.

None of the studies investigated whether maternal age is associated with low birth weight, but it is one possible mechanism through which the age/mortality relationship may arise. (Another, which has been noted in the literature, is that older mothers in less developed countries, breastfeed their infants for shorter periods of time.)

A.6. Parity and Spacing

Data for England and Wales show that higher parity (birth order) is associated with lower birth weight as well as with more frequent antepartum hemorrhage and Rh complications (Morris and Heady, 1955). Another study notes that primaparity (first birth) is associated with fetal malnutrition (Journal of Reproductive Medicine, 1971). Morris and Heady also report that both very close

and very distant spacing are associated with a higher rate of stillbirths and neonatal deaths, but did not investigate the possibility of a connection between spacing and birth weight.

In the present study both parity and spacing can be examined, but it should be remembered that both may act as proxies for maternal malnutrition. For example, Chopra, et. al., observed that protein-calorie malnutrition is more common in families with closely spaced pregnancies.

A.7. Sex of Child

Infant mortality among males exceeds that among females in both developed and less developed countries, although the male disadvantage is less in the lower socio-economic classes and in "medically underdeveloped" countries (Abramowicz and Barnett, 1970). The fact that the sex differential is greater during the neonatal period (based on data for the 20 largest U.S. states, Hammoud, 1965) suggests that the differential may be partly due to basic biological and prenatal influences and may show up as a birth weight differential.

A.8. Altitude

Babies born at high altitudes tend to be low weight. In a book on the subject, McClung (1969) concludes that this tendency cannot be attributed to malnutrition or premature delivery, but is instead the result of oxygen deficiency. The fact that the placentas tend to be the same in weight and larger in area than those of mothers in low-altitude areas provides supporting evidence. The Bolivia project included in the PAHO survey is located at a high altitude and, in regressions using data from more than one project, a "project dummy" can be expected to reflect, in part, the effect of high altitude on birth weight. Clearly, this hypothesis can only be tested if several projects are combined for analysis.

B. INFANT AND CHILD MORTALITY

This section discusses a number of factors that have been linked with infant and child mortality. Some of these are expected to have a direct relationship with mortality while others appear to serve as proxies for variables that were not, or could not be, measured directly in past studies. The PAHO survey attempted to get information about many of these previously unmeasured variables and, for both statistical and conceptual reasons, the analysis should focus as much as possible on those factors that have the potential for causing mortality directly and omit those, used as proxies in past studies, that have their effects indirectly through other variables.

The variables will be grouped for discussion under the following headings: birth weight and complications of pregnancy; medical care; nutrition of the child; the feedback from infectious diseases; environmental conditions; the quality of care given the child in the home; the sex of the child; and parity and spacing.

B.1. Birth Weight and Complications of Pregnancy

Low birth weight infants have a poorer chance of survival than infants of normal weight. In their sample of 323 liveborn Guatemalan babies, Mata, et. al., (1972) found that those with low birth weights were more likely to die from infectious diseases. This result is attributed to the same mechanism that applies to older children -- poor nutrition reduces the child's resistance to infectious diseases -- and low birth weight, as noted in the discussion of the last section, is often the result of inadequate prenatal nutrition.

In a medical discussion of nutrition in pregnancy Hillman and Hall (1964) report, without elaborating on the statement, that "babies with birth weights

one to two pounds above average (postmature) fared as poorly as infants of the same degree of underweight at birth " (p.1107), and note that the high weights typical of infants born to diabetic mothers may be due to thiamin deficiency. Data presented by Erhardt, et. al., (1970) for 7,308 infant deaths in New York City also show higher mortality rates for infants weighing considerably more than average at birth, as well as for those below average.

Clearly, the important hypothesis to be tested is that low birth weight, which is by far the most common condition in Latin America, is associated with a higher risk of death, other things constant. But it should also be kept in mind, especially when birth weight is entered in the regressions as a continuous variable, that the relationship may flatten out for weights above average, or even have an inverted U shape.

As indicated in Section A, many complications of pregnancy appear to be related to poor nutrition before or during pregnancy and it is possible that these complications are related primarily to the infant's birth weight or that they reflect, rather than add to, the poor start prenatal malnutrition gives him. But it is also possible that such complications have an independent effect on the infant's chance of survival, at least during his first few months. Erhardt, et. al., (1970) show that mortality rates are higher for premature infants in New York even when birth weights are held constant. Again, as noted in Section A, the only variable representing complications that is available for both the living children and the child deaths in the PAHO sample is length of pregnancy. The direct effects of specific syndromes, such as toxemia, on infant mortality can not be examined.

B.2. Medical Care

The evidence about the effect of medical care is conflicting, but the best studies available suggest that it has a small or even negligible effect on infant mortality. Hammoud (1965) obtained significant positive correlations between infant mortality and medical and other health workers per 100,000 population for 20 U.S. states. But aside from the infirmities of simple correlations -- that other factors which may be more important are undoubtedly correlated with medical resources, etc. -- the data do not measure the medical care actually received by infants and their mothers.

On the basis of the Chilean experience, Monckeberg (1970) suggests that medical care has very little effect. He reports that the Chilean National Health Service has placed particular emphasis on maternal and child health with the result that the number of children receiving medical care has increased "noticeably". According to Monckeberg, 80 percent of all infants receive care. In spite of the increase in medical care provided, infant mortality has not declined "significantly". Aside from the fact that Monckeberg does not provide the data necessary to show the reader what is meant by "noticeably" and "significantly", he is unable to hold constant other factors which changed during the period. For example, Berg (1973) notes that, in the early 1950's, 95 percent of Chilean mothers breast fed their children for more than one year; by 1969 only 20 percent nursed them for even 2 months.

Plank and Milanesi's (1973) finding, based on their survey of women in rural Chile, was discussed in Section A. Without correcting for other factors, they found that the postneonatal death rate among infants whose mothers received prenatal care was higher than the rate for infants whose mothers received no care, or care only at delivery.

In a carefully designed study of three Guatemalan villages, Scrimshaw (1970) observed that there was a "modest" decrease in preschool deaths, relative to a control village, in a village which was provided with a medical clinic, a vaccination program, a safe water supply, sanitary privies for each house, and the services of a sanitarian. No other changes were introduced. The modest reduction in pre-school deaths was the only result; sickness did not decrease and the physical development of the children did not improve relative to those in the control village. The study villages had small preschool populations, about 200 each, and there is no indication whether the decline in deaths was statistically significant. It is also not possible to tell, of course, whether the decline was actually attributable to medical care, traditionally defined, or to the changes in water supply and sewage disposal.

Finally, in his regression analysis of aggregate cross-section data for Costa Rica and Mexico, Sloan (1971) found that proxies for medical care were not significantly related to infant mortality. While the analysis suffered from a number of defects because of the aggregate nature of the data and the imperfections of the measures used for the variables, it agrees with the other available evidence in suggesting that medical care has little or no effect on infant and child mortality.

Obviously, none of these studies constitutes strong evidence about the effect of medical care. If the PAHO survey was actually able to get fairly complete and reliable information on the dimensions of medical care it attempted to measure, the data should provide a good test of this factor. Questions were asked about the numbers of hospital days and physician visits for the child

during the last year of life or, for living children, the year preceding the interview, and about the types of vaccinations given the child. With respect to this last, the detailed information is likely to be incomplete and it may only be possible to specify that the child had some sort of vaccination.

B.3. Nutrition of the Child

A great deal has been written about the nutrition of the child and the effects of nutrition on child mortality, morbidity, and development. The subject can be divided into two general categories; breastfeeding, which is important for infants and has special implications for maternal diet and behavior; and other foods.

B.3.a. Breast Feeding

Breast feeding has been associated with lower infant mortality for a long time. A study of English experience in the early 1900's found that the mortality of "hand-fed" infants was three times as high as that of breast fed infants (Aykroyd, 1971). On the basis of this kind of information, several European countries instituted programs offering meals or money to nursing mothers in order to encourage the practice (Berg, 1973, Chapter 7). More recent studies of developed countries indicate that bottle-fed infants suffer infections more frequently than breast-fed infants (Mata and Wyatt, August 1971).

Studies of the developing countries have also shown a correlation between breast feeding and infant health. Children who are being breast fed have a lower incidence of diarrhea, and incidence increases during and after weaning, a phenomenon which has given rise to the name "weanling diarrhea" (Mata and Wyatt, August 1971). Rulison observes that 70 percent of the deaths of children under four in rural India occur during the second year of life and attributes this to inadequate nutrition after weaning, complicated by weanling diarrhea. In their

Chilean survey, Plank and Milanesi (1973) found that death rates were higher for infants who were bottle fed, whether or not the bottle was supplemented by breast feeding, than for infants who were exclusively breast fed.

Three mechanisms have been suggested to explain the observed effect of breast feeding on infant mortality. The first is that breast milk is a nutritionally complete food for the very young infant (Holt and Syderman, 1964) and, when the mother's knowledge of proper nutrition is poor or inadequate, as it is in many developing countries, breast feeding may be the child's best guarantee of an adequate diet. Berg (1973) notes one practice, apparently common in Latin America, of bottle feeding infants a mixture of corn starch and water; since it looks like milk, mothers believe that it has the same nutritional properties and advertising encourages this belief. Second, breast milk contains agents, not available in other food sources, that increase the child's resistance to infection (Mata and Wyatt, August 1971). And third, bottle feeding (and other foods) require fairly complicated sterilization procedures, which may be insufficiently understood, or difficult to carry out under the conditions prevalent in developing countries, so that breast feeding may be the most sanitary feeding method available. In sum, breast feeding may improve the child's resistance to infection through improved nutrition and specific antibodies and it may reduce the child's exposure to infection through better sanitation.

Breast feeding is not, however, the only way to provide nutrition to an infant and, even more important, it does not provide adequate nutrition after the first few months (Holt and Syderman, 1964). In a summary of findings presented at a World Health Organization conference, Chopra, et. al., (1970)

reported that Latin American infants who were breast fed grew normally for the first few months, but their growth fell off in subsequent months (the falloff was greater among infants who were not breast fed). This suggests the importance of examining the effects of breast feeding in light of the child's age and the food supplementation being given (for example, Plank and Milanesi note that the mortality of bottle-fed children was lower if they also received other kinds of food). Berg's evidence also suggests the related problem that it is difficult to pinpoint the advantage of breast feeding over bottle feeding unless we know what is in the bottle. The PAHO survey requested admirably complete information on the child's nutrition and, if they were able to get the answers, the data will provide a good base for testing the importance of different aspects of nutrition.

The effect of the mother's nutrition on her ability to breast feed and on the nutritional quality of her milk is unclear. It is well known that nursing mothers need more nutrients to maintain their own health (Goodhart, 1964). Further, we can conclude from the widespread malnutrition during pregnancy that is observed in Latin America and from direct evidence on the point (Chopra, et. al., 1970) that nursing mothers in Latin America are likely to be undernourished.

Berg (1973) suggests that the major effects of malnutrition fall on the nursing mother herself, not the child. He reports that the quantity of breast milk is not reduced by malnutrition and that "generally, breast feeding is satisfactory for the infant even without extra food for the mother." This suggests that breast feeding will affect the health of subsequent infants adversely, because of its contribution to maternal malnutrition during pregnancy (repeated pregnancies followed by long periods of breast feeding give rise to what is

known as the "maternal depletion syndrome," Wray, 1971), but that it may contribute to the better health of an infant already born, in spite of the mother's inadequate diet.

But other sources suggest that maternal nutrition does have important effects on both the quantity and the composition of breast milk, although they do not make clear how serious the changes are or how great a degree of malnutrition is necessary to induce them. In a handbook on child nutrition, Jelliffe (1969) states that if the mother's diet is poor, the quantity of her breast milk may be reduced, especially during prolonged periods of lactation. He further reports that while maternal malnutrition has "relatively" little effect on the protein content of breast milk, it may cause the milk to be deficient in water soluble vitamins. In cases of severe malnutrition, the protein content as well as the quantity of milk are affected. In prolonged famine, lactation ceases entirely (Jelliffe and Jelliffe, 1971).

There is no way to tell whether any substantial number of the mothers included in the PAHO survey suffered from malnutrition sufficiently severe to affect the composition and quantity of their breast milk. But in our interpretation of the regression results we should keep in mind that the value of breast milk as an infant food is influenced by the mother's nutrition.

Finally, Pollitt (1973) brings up an interesting point related to breast feeding, namely, that whether the child is breast fed and for how long may depend, in part, on the child. He suggests that children who are born poorly nourished are likely to be lethargic about feeding and this may contribute to early weaning. This suggests that the length of the breast feeding period will be, in part, a function of low birth weight, parity, and spacing -- variables

that are likely to be correlated with poor initial nutritional status.

B.3.b. Other Foods

The discussion of nutrition is intertwined with the subject of infectious diseases in the literature. There is firm agreement that good nutrition is associated with lower mortality and morbidity and two reasons are advanced for this: poor nutrition reduces the child's resistance to infection; and infectious diseases can cause the child's nutritional status to deteriorate. The first of these two would seem to be the more likely as the primary causal link from nutrition to mortality. The second can perhaps be characterized as a feedback loop in the process.

Scrimshaw (1970) has reviewed the literature and reports evidence that improved nutrition may reduce the frequency and severity of infectious diseases and that poor nutrition is a major determinant of diarrheal disease. In their comparative study of three Guatemalan villages, he and his collaborators found that measles was much more frequently complicated by diarrhea in poorly nourished children than in better nourished ones; their measure of the child's nutritional status was his weight as a percentage of the weight normal for his age (Scrimshaw, et. al., 1966). And with respect to the effect of infection on nutrition, Scrimshaw, Taylor, and Gordon (1968) note that infections reduce food intake by dulling the appetite and that therapy often wrongly includes harmful changes in the diet; they observe that Vitamin A deficiency is particularly associated with increased vulnerability to infection.

In Scrimshaw's (1970) controlled study of the three Guatemalan villages, one of the experimental villages received a protein-rich vegetable supplement

(Incaparina) for all preschool children, pregnant women, and nursing mothers. No other change was introduced into the villagers' way of life. As noted in section A, programs of medical care and sanitation were established in the second village, and the third village served as a control group. Although participation in the program was irregular, the "feeding" village experienced significantly less preschool mortality and morbidity during the study period (1959-64) than the control village, and showed a slight but statistically significant improvement in growth and development.

In a somewhat more recent study covering the period 1962-67, investigators followed the experience of two experimental and two control villages on a sugar plantation in Northern Peru (Baertl, et. al., 1970). The two experimental villages were given food supplements of equal caloric value, although the supplement given one village had twice the protein content of that given the other. There were statistically significant declines in infant mortality, relative to the control villages, in both experimental villages.

Nutritional variables were one of only two factors -- the other was maternal education -- that were consistently significant in Sloan's (1971) regression analysis of data for Costa Rica and Mexico.

Thus all the evidence points to the importance of nutrition as a determinant of infant mortality although, as Scrimshaw suggests, the high rates that obtained even after the feeding program indicate that better nutrition alone is not sufficient. It is clear that the appropriate definition and testing of the nutrition variables are of major importance for the analyses proposed here.

B.4. The Child's History of Infectious Disease

Poor nutrition reduces the child's resistance to infection. At the same time infectious diseases can cause the child's nutritional status to deteriorate --

because of poor appetite, because of direct loss through vomiting and diarrhea, and because of harmful changes in diet that may result from the parents' misunderstanding of the child's needs during the illness. Scrimshaw (1970) observes that acute nutritional disease appears to be precipitated, in children already suffering from poor nutrition, by a bout with an infectious disease. In a study of the relationship between growth and infectious disease based on 95 live births in Guatemala, Mata, et. al., (February 1971) concluded that greater rates of viral infection were associated with growth retardation and that this effect was independent of the child's birth weight. They also noted that whooping cough, which is apparently characterized by a long period of low dietary intake, has a greater adverse effect on nutritional status than some of the other infectious diseases.

Such information suggests that the child's past history of illnesses may have an effect on his chances of survival, over and above the effects of his usual nutrition. (Or it may reflect the effects of diet changes that took place during the illnesses.) The PAHO survey attempted to collect data on the age at which the child contracted five major infectious diseases and thus may enable us to test for this "synergistic" effect.

B.5. Environmental Conditions

The term "environmental conditions" is used here as a shorthand phrase to describe such variables as public health programs, sanitation, and housing. These variables describe the conditions that allow infectious diseases to be transmitted to the child more or less readily and thus increase or decrease his exposure to them.

There is no question that public health programs can and have reduced the mortality from specific diseases such as typhoid fever and malaria, but the evidence on housing and sanitation, where such factors are measured by housing quality, persons per room, the availability of piped water and flush toilets, etc., is meager and contradictory. Sloan (1971) found no evidence, either in his own statistical analysis of Mexican and Costa Rican data, or in the studies he reviewed, that housing or sanitation has any effect on infant mortality. Monckeberg (1970) noted that the infant mortality rate is lower for those Latin American countries where higher percentages of the population are provided with sewage systems and public water supplies, but Plank and Milanesi reported that, in their Chilean survey, sanitary conditions were better in the homes where infant deaths occurred.

None of these studies constitutes persuasive evidence. Among the problems are the possibility that the measures used are poor proxies for the desired variables (e.g., is water piped outside rather than inside necessarily more contaminated?) and the failure of most studies to control for other variables.

Perhaps the best evidence available so far is provided by Scrimshaw's (1970) Guatemalan study in which the village receiving medical care and sanitation programs showed only a small reduction in deaths and no change in morbidity, relative to a control village. The study could not, of course, ascribe the results to a particular sanitary measure nor determine whether the medical care or the sanitation was perhaps the primary cause of the decline. The study gave added weight to the finding that the sanitation/medical care program was not very effective with tests showing that the incidence of intestinal protozoa and

bacterial infections, which could reflect sanitation, did not differ significantly between children with and without diarrhea; Scrimshaw hypothesized from this that the diarrhea was caused by agents that are present in most children but that are generally not pathogenic for a properly nourished child.

The moderate effect of sanitation and medical care in the experimental village indicates that neither is likely to be a major determinant of infant mortality, but that both should be tested in the analysis. The possibility of interaction effects should also be kept in mind. It is possible, for example, that sanitation measures have little effect for infants whose nutrition is poor, but that they may have very dramatic effects for infants receiving adequate nutrition.

B.6. Quality of Care Given the Child

Several studies have suggested that factors such as the mother's level of education and whether she works outside of the home will have an effect on the child's chances of survival. For example, Sloan's (1971) regression analysis of Mexican and Costa Rican infant mortality indicated that mortality was significantly lower where the average level of female education was higher (but Plank and Milanesi found, without controlling for other factors, that infant death rates in their Chilean survey rose with maternal education, before declining to a level for the best educated mothers just a little above the level for the least educated mothers).

The reasons put forth for expecting such a relationship have primarily to do with the mother's supposedly better knowledge of nutrition and sanitation and, if she does not work, greater free time to breast feed and to keep the child out of trouble. Thus maternal education appears to represent a number of variables for which data are less readily available.

For the most part it should be possible to represent these variables directly using the PAHO data. Information about breast feeding, post-weaning nutrition, sanitation, and whether some responsible person, either the mother or someone else, had primary responsibility for the child's care, are potentially available from the survey. With these variables included in the analysis, we would expect the mother's education to have little or no additional effect on the infant's chance of survival.

B.7. Sex of the Child

In general male infants face a greater risk of death than female infants (Abramowicz and Barnett, 1970; Hammoud, 1965; Morris and Heady, 1955), but the relationship is not completely consistent across countries and social classes. Hammoud reports that the differential is greater during the neonatal period, while Naeye found that it is actually reversed for U.S. stillbirths. Abramowicz and Barnett found that the male disadvantage is less in the lower socio-economic classes and in "medically underdeveloped" countries. In India and Pakistan, preschool mortality is higher for girls than for boys (Rulison, 1970).

These studies indicate that the male-female differential is a complex of biological and social factors. The Naeye findings suggest the hypothesis that girls are more likely to be born dead and thus that those born live are stronger, on average, than males born live. But shortly after birth social factors may take over. Given the strong parental preference for sons in many developing countries (see Berg 1973, for example), it seems likely that girl children may be more poorly fed or cared for in some cases. In the PAHO survey it may be possible to measure these socially influenced factors directly, so that the coefficient for sex should represent any biological advantage, net of birth weight, of one sex over the other.

B.8. Parity and Spacing

Both higher parity and shorter spacing between pregnancies are associated with higher infant mortality rates (for a literature review, see Wray, 1971). But the suspicion seems to be that these relationships are actually due to the association of parity and spacing with other, intervening, variables. Higher parity children are likely to be born to older mothers whose risk of complications is greater. Older mothers breast feed their children for shorter periods than younger mothers (Plank and Milanesi). Mothers with many children, particularly if they are closely spaced, are more likely to be suffering from malnutrition and thus give the next child a poor start in life. Large families are more often poor than small families so that the child is likely to be poorly fed and housed in unsanitary conditions. In India Gopalan (1972) reports that 61 percent of the cases of protein-calorie malnutrition are of birth order 4 or higher. Pollitt (1973) notes that malnutrition is associated with high parity and closely spaced pregnancies; he believes that malnourished infants are doubly vulnerable because they may be too lethargic to feed vigorously and thus may be weaned earlier than other children.

It thus appears likely that, once the child is born, parity and spacing do not exert an independent effect on the infant's chance of survival. Since most of the intervening variables should be available from the PAHO survey, these should be tested instead. Parity and spacing will be given second priority for testing in the infant mortality equations, particularly since the evidence suggests that they will contribute to serious multicollinearity.

CHAPTER III. THE STATISTICAL ANALYSIS

Introduction

This chapter describes the preparation of the data and the statistical analysis that will be undertaken. The basic output of the analysis will be a series of regressions for the two dependent variables discussed in the literature review -- birth weight and child mortality -- where either or both of these may be defined for sub-classes (e.g., mortality among infants aged 1 to 11 months). The regressions will relate each dependent variable to the types of independent variables discussed in the literature review. The regression output will provide estimates of the net effect of each factor on the dependent variable and will permit tests of the statistical significance of that net effect.

When this study was initiated both AID and NPA believed that we would be able to obtain a copy of the survey tapes from the Pan American Health Organization (PAHO), and we planned to carry out the statistical analysis using our own computer facilities. PAHO has, however, refused to provide the tapes. Instead they have offered to prepare any computations that may be needed for our study. The present extension of Stage I of the study through the end of March, 1974, was arranged to permit a test of the feasibility of a cooperative arrangement with PAHO. In the process, we hope to get some preliminary results for an initial survey project.

The following pages describe our proposed agenda for investigating the data from this initial project. If, by the end of March, it appears to be proceeding successfully, we would plan to follow a similar agenda for the subsequent survey projects. But, for a number of reasons, the steps outlined must be taken as tentative and no completion date can yet be specified for the analysis. The major reason is, of course, that the working partnership with PAHO is just getting started and we do not yet know what the limitations of that partnership

may be -- either in terms of the work that can be produced or the speed with which that work can be produced. It should be noted that we have been assured by PAHO that we will have their full cooperation and they have indicated that, should any of the computations be beyond the capabilities of their computer, they will make use of the established contracts for computer services that they have with outside organizations. It should also be noted that PAHO has not made any long term commitment to subsidize the computer work for this study.

One of the more customary difficulties is, of course, the fact that we may meet up with unforeseen problems due to deficiencies in the data. Further, there are tasks that must be undertaken to lay the groundwork for the project analyses and these will delay the completion of the first project analysis. A case in point is the work required to define summary measures of the nutrition variables, discussed in section C. Finally, the delays in Stage I caused by PAHO's refusal to release the tape mean that it will be completed at a time when the project staff will be unable to devote as much time as might be desirable, a short run problem which we have discussed with the AID staff. For all these reasons, we cannot say with certainty how far the analysis will have progressed by the next contract expiration date, April 1. We will proceed as far and as fast along the path outlined in the following pages as the partnership with PAHO and our low level of staffing during late February and March will permit.

With these caveats in mind, we can move on to the description of the proposed analysis. As part of the testing procedure, we will first analyze the data from one of the 13 Latin American projects in the survey. But more generally, developing the study project by project has a number of advantages. For one, the analysis of individual projects will allow us to become familiar with the attributes and data problems peculiar to each area. This will minimize

the chance that the results of the analysis will be misinterpreted. Also, by starting with those projects that have the best quality data we will be able to place more confidence in the results of initial exploratory work. We will thus be able to frame our hypotheses and interpret our results with greater confidence as we proceed to subsequent projects. If the results for the individual projects appear to warrant it, we can then look at a combination of projects, or even the full sample.

The data preparation and computations, to be done in conjunction with PAHO, will involve five steps. These are described in detail in the following sections, but in brief outline they include:

- The selection of a survey project for the analysis. This has already been done in consultation with the PAHO staff and the reasons for selecting San Juan, Argentina are discussed below.

- Creation of a tape, for San Juan, which combines the information for the living children and the child deaths, and the selection of those observations with sufficient information for the subsequent analysis. NPA has drawn up the specifications for such a tape (see the appendix to this chapter) and PAHO has agreed to develop the tape.

- Redefinition and recoding of the information to put it in the form needed for the regression analysis, based on tabulations showing the characteristics of the combined sample for each item of information.

- Weighting of the individual observations so that the sample observations reflect the population proportions of the living and dead children.

- The actual regression runs and statistical tests of the results. Alternative methods of estimation are discussed.

A. Reasons for Selecting the San Juan Project

Two criteria were used in the selection of the initial project for analysis. The first was that the project should be fairly large so that the sample would be large enough to support analysis of subsets of the children under 5 included in the survey. The second, and even more important, criterion was that the project should be one for which the data was complete and of high quality for as many of the surveyed children as possible. On the basis of these criteria, the PAHO staff recommended that the San Juan, Argentina, project would be the best to start with.

San Juan Province is located in central-western Argentina, close to the border between Argentina and Chile, and was one of the larger projects included in the investigation. It was also one of the few to include the surrounding rural area, in addition to the city of San Juan and its suburbs. The total population of the province was estimated at 384,020 as of 1 August 1969, of which 52,230 were estimated to be children under five years of age. Births per 1000 population averaged 30.4 for the two years of the project. Child death rates were among the highest found in the investigation. Deaths of children under one year of age, per 1000 live births, averaged 81.3 -- 50.7 in the city itself, 87.9 in the suburban departments, and 94.5 in the rural areas. Deaths of children one to four years of age averaged 3.0 per 1000 population. (See Puffer and Serrano, 1973, pp. 9-12, 35, and 61).

All the deaths of children under five occurring in San Juan between August 1968 and July 1970 -- a total of 2156 -- were included in the survey. In addition, one out of every 48.3348 households was selected for interview and these produced a sample of 891 living children under the age of five. Table III.1 shows the age distributions of the child deaths and the living children. Home interviews were, of course, completed for all of the living children and for over 90 percent of the child deaths ; the average for all projects was 81.7 percent .

TABLE III.1. San Juan, Argentina: Distribution, by Age, of the Child Deaths and Living Children included in the Investigation

Age	Number of Child Deaths	Number of Living Children
Under one year, total	1900	206
0-27 days	906	21
28 days - one month	163	23
two months	164	22
three months	164	16
four months	141	21
five months	103	17
six months	68	14
seven months	56	14
eight months	44	12
nine months	28	13
ten months	33	11
eleven months	30	22
One year	153	204
Two years	55	158
Three years	32	162
Four years	16	161
All ages, total	2,156	891

Source: Tabulations provided by the Pan American Health Organization.

B. Creation of the Tape

PAHO has arranged the material from the survey in two separate tape files one for the child deaths and one for the living children -- reflecting their interest in separate analysis of the two groups. The tape for the child deaths has been in existence for some time and was edited and corrected as the report based on it, Patterns of Mortality in Childhood (Puffer and Serrano, 1973), was written. The tape for the living children was created much more recently -- October 1973 -- and there has been little opportunity for editing. The PAHO staff feels that some editing of this tape should be done before the data are prepared for use in the present study.

For the purposes of this study, we need to merge the child deaths and the living sample for each project. Using the information about the tapes supplied to us by PAHO, we have drawn up a list of the variables that we would like to have recorded for each child in the merged San Juan sample; the variable list is included as the appendix to this chapter. We have met with the PAHO staff, discussed the proposed tape file with them, and they have agreed to begin creating it.

This tape will serve as the basic reference file for analysis of the San Juan project. The variable list has therefore been made quite inclusive in order to reduce the probability that we will later find that a needed variable has been omitted. With few exceptions, the codes used by PAHO will be retained for this step; the variables will not be redefined in the form needed for regressions until observations with insufficient information have been deleted and tabulations of each variable have been prepared for the remaining observations. (See section C.)

When the tape is ready, we will have it edited for observations with missing information. We have submitted a short memorandum to PAHO describing the items that should be printed out during the edit. For the most part, these consist of any item with a "not specified" code and the print-out will identify all of the troublesome items for each record. On the basis of the print-out, we will determine whether a given record is missing items of information that are crucial to the study. If so, the record will be discarded. If not, it will be retained and such items of information as are missing will be handled in the manner discussed in section C. All records without a home interview will automatically be discarded. The resulting tape will contain only those records with sufficient information for the analysis and will constitute the data base for the subsequent steps of the San Juan study.

C. Redefinition of the Variables for the Regression Analysis

Once the observations to be used in the sample have been selected, the information on the tape will be recoded in the form needed for the regression analysis. Information which is not naturally numerical will be represented by one or more binary variables. For example, if there are a sufficient number of observations for the TOILET codes 1, 2, 3, and 4 (see the appendix for code definitions), three binary variables will be defined for each record as follows:

X_1 = 1 if the code is 1, 0 otherwise

X_2 = 1 if the code is 2, 0 otherwise

X_3 = 1 if the code is 3, 0 otherwise

The fourth code, 4, is uniquely defined by entries of zero for each of the variables X_1, X_2, and X_3.

Variables that can sensibly be represented in either continuous numerical or binary form will generally be defined in several ways to permit experimentation with the alternative forms. For example, the mother's age at the birth of the child will probably be defined both as a continuous variable measured in completed years and by one or more sets of binary variables, one of which might be the following:

Y_1 = 1 if mother was 15-19, 0 otherwise

Y_2 = 1 if mother was 20-24, 0 otherwise

Y_3 = 1 if mother was 25-29, 0 otherwise

etc.

Again, the last age class would not have an explicit variable since it is uniquely represented by entries of zero for all variables representing the preceding age classes.

Because many of the variables will be defined in this binary form, we will need to have simple tabulations, for each item of information, of the distribution of the observations over the possible code values for that item. This will tell us whether, for example, there are enough multiple births in the selected sample to warrant defining a binary variable for this characteristic. More generally, the tabulations will give us the information we need to avoid accidentally defining a binary variable for a characteristic that, while conceptually distinct, does not appear in the selected sample, or a variable for a characteristic which applies to all the selected observations.

We have submitted a short memorandum to PAHO describing the tabulations which should be prepared when the tape is ready.

Two considerations prevent the creation of the variables from being a completely straightforward matter. First, for reasons of efficiency and economy in computation it is desirable to store a matrix of the dot products of all the variables (X'X) that might be wanted for a given set of regressions, including alternative forms of the same factors. But no computer can handle unlimited numbers of variables and the number of variables into which each factor will be divided (e.g., maternal age could be represented by a binary variable for every single year) will have to be chosen with an eye to the limitations of available regression packages.

The regression package presently available on the PAHO computer appears to be limited to a maximum of 40 variables when the computations are done in double precision arithmetic. This is probably well below the size that we will need for initial exploratory work and PAHO's computer director has indicated that it may be necessary to have some of the regression work done on the computers that are available to them through their service contracts.

Second, some of the information, for example the data on the child's nutrition or the mother's reproductive history, needs to be combined to increase its usefulness in the analysis. To pursue the example of the child's nutrition, the PAHO survey provides information about how many times per week the child ate each of nine different types of food and the age at which this food type was introduced into his diet. Aside from the fact that such extensive information might well exhaust the variable capacity of the regression programs by itself, it seems undesirable to enter it simply as a set of variables representing every detail recorded in the survey, since it is unlikely that the items act in an additive fashion. Instead several combinations of foods will constitute adequate diets while other combinations share a common deficiency(ies), e.g., protein.

PAHO has offered the services of their nutritionists to help us develop a scheme for summarizing the nutritional information. Dr. Carlos Serrano of PAHO has indicated that such a scheme is feasible and, after preliminary discussions with him, a member of the NPA staff has begun to collect the background information on dietary requirements and the composition of foods that he has indicated that he will need to create the summary classifications. In addition, Dr. Martin Forman of AID's Office of Nutrition has recommended a consultant in nutrition in case we should find that we need further assistance.

Missing values. It may well turn out that some of the observations in the full sample have fairly complete information, but are missing values for just a few variables. If this is the case, the observations will be retained for analysis and values will be created for the missing items, to avoid having to throw out the large amount of good information provided by the observations in question.

Because the analysis will make extensive use of binary variables there is one possibility which avoids the need to create values in certain situations. If an item of information is represented by one or more binary variables, and

if a large number of observations are missing the same item, then an additional binary variable can be introduced to represent the class "no information for thi item." This avoids making any assumptions about the missing information, while at the same time allowing the observations to be used.

If, however, only a few observations are missing an item, it is preferable to estimate a value for the missing item. A great many ways of estimating values for missing items have been suggested and are reviewed in the report of the econometric consultant to this project, but the properties of these methods are not well known. (V.K. Smith, 1973). In the absence of such information, the consultant suggests using the sample mean (i.e., the mean for those retained observations that have an entry for the variable in question) in place of the missing value; on intuitive grounds this appears likely to be the most robust method when the dependent variable is binary, as it will be in the infant mortality equations. Since the regression technique forces the estimated equation to pass through the point of means the created items carry no weight in the products and cross-products that determine the regression coefficients. Thus the coefficient of the variable in question is based only on the valid information about that variable while, at the same time, the other coefficients are based on a larger amount of information than if only the subset of complete observations had been used. It should be noted that this procedure implicitly assumes that there is nothing systematic about the missing items, an assumption which does not seem restrictive if values are estimated for only a few observations for any given variable.

Interaction variables. It sometimes happens that the relationship between a particular independent variable and the dependent variable is affected by the value assumed by another independent variable. For example, it might be true that sanitation is an important determinant of mortality for well-nourished

children, but that it has no effect on the mortality of poorly nourished children. This kind of relationship is known as an interaction effect and must be represented in the regression by an appropriate interaction variable (or variables) if the true state of affairs is to be revealed by the data. These interaction variables can be represented by binary variables, e.g., a variable that takes on the value one for children with good nutrition and good sanitation and zero for all other children, or by the product of a binary and a continuous variable.

In an area like infant mortality where little is known about the nature and form of the relationships between mortality and likely causal factors, a systematic method of searching for interaction effects could be a useful adjunct to the analysis. The Automatic Interaction Detection (AID) program was designed by the Institute for Social Research at the University of Michigan to search for interaction effects revealed by large sample surveys, and its most recent version, THAID, has been adapted especially for use with binary variables (see V.K. Smith, 1973; for a full description of the THAID program, see Morgan and Messenger, 1973). In brief, the older versions of the program proceed through a series of binary divisions, or splits, of the data, selecting in turn those divisions of the observations which reduce the total error sum of squares the most. The THAID program provides instead a choice of two new split criteria, one which focuses on the ability to predict individual observations accurately, while the other emphasizes the accurate prediction of group averages.

For a number of reasons we will probably not use the program for this study. For one, the program is not available at PAHO. Further, our exploratory discussions with people at other computer centers and with users of the program indicate that it is quite expensive to run and the results are not always useful to the researcher. We will continue to explore the possibilities. Meanwhile,

in lieu of such a formal search for interaction variables, ad hoc hypotheses about interaction will be formulated for testing on the basis of the literature review and the results of the exploratory regression runs.

D. Weighting the Sample Observations

The PAHO survey sampled different proportions of child deaths in different projects (in most projects all were taken), and the sample of living children was still another proportion of the related population. In order for the regression analysis to reflect accurately the probabilities of death associated with different characteristics, the sample numbers of living and dead children must be appropriately weighted.

The San Juan project will serve to illustrate the required procedure. In San Juan all child deaths for the two year period August 1968 - July 1970 were included in the survey. Thus the population of deaths is the same as the number surveyed -- 2156. PAHO has estimated that the population of living children under 5, defined for the same two year period, was 104,460 (Puffer and Serrano, 1973, p. 9), of which 891 were surveyed. The overall death rate for the survey period is thus 2156/104,460, or .02064. Now suppose that, of the 2156 child deaths, 1600 are retained for analysis and that 500 of the living children are retained. The information for these cases must be weighted by the same weights (call them w_D and w_L) that would be required to make the two samples yield a death rate of .02064. A number of sets of weights will fulfill this requirement, but it is convenient to select the set for which it is also true that:

$$1600w_D = 2156$$

and

$$500w_L = 104,460$$

To satisfy these illustrative equations, w_D must equal 1.3475 and w_L must equal 208.92.

The population data needed to calculate the weights for each project are published in Patterns of Mortality in Childhood, by age group so that the weighting can also be carried out specifically for each age group. Thus once the observations with sufficient information have been selected for a given project, the exact weights required can be calculated and incorporated into the analysis.

E. The Regressions

Two general sets of regressions will be estimated for the San Juan project and, if the analysis is successful, for the other projects in the survey during Stage II of this study. The first set will have birth weight as their dependent variable. The second more extensive set will have infant and child mortality as the dependent variable. The following specific dependent variables are likely to be represented in the final regressions:

- Birth weight
- Mortality among infants 1 to 11 months of age
- Mortality among one-year-olds
- Mortality among children between the ages of 2 and 5
- Mortality due to major infectious diseases

During this stage of the study we will work with PAHO to try to complete computations for at least some of the regressions for birth weight and mortality among infants 1 to 11 months of age in the San Juan project. The independent variables will be specified in accordance with the hypotheses developed from the literature review. In the next two sections, the reasons for selecting the ordinary least squares technique, and the statistical output for the regressions, are discussed in more detail.

E.1. Regressions on Birth Weight

The estimation of equations for birth weight is a straightforward matter. The dependent variable is continuous (in grams) and thus, *a priori* at least, has the properties necessary for ordinary least squares. Most or all of the independent variables will be binary and thus no specific functional form will be imposed on their relationships with the dependent variable. Estimates of the dependent

variable derived from the regressions will represent the mean, or expected, birth weight for children with the specified characteristics. Each coefficient will represent the increase or decrease in birth weight (in grams) associated with a value of one for that variable.

When a factor (e.g., sex) is represented by a single variable, the t-test is a reasonable test for the importance of the relationship between that factor and the dependent variable. But when several variables represent a single factor (e.g., maternal age might require five variables), the statistical significance of the factor should be tested by using an F-test for the entire group of variables and t-tests should be considered only if the F-ratio is significant (Melichar, 1965). T-tests of the differences between coefficients can then help to suggest whether the factor is perhaps divided into an unnecessarily large number of classes. The R^2 statistic can be interpreted in the usual way as showing the percentage of the total variation explained by the specified independent variables.

E.2. Regressions on Infant and Child Mortality

Infant mortality must be represented by a binary variable when the individual observations in the survey are used. Thus the dependent variable can take on either of two possible values, zero (if, say, the child is alive) and one (if the child died). The interpretation of ordinary least squares equations in this case is straightforward -- the estimate of the dependent variable obtained from an equation can be viewed as the probability of death for a child with the characteristics specified by the values of the independent variables, and the coefficient for a given variable shows the net contribution of that variable to the probability of death. But the binary nature of the dependent variable does create problems for the use of ordinary least squares (no such problems arise with binary independent variables).

The first problem is that the error terms of the equation are heteroscedastic; that is, they will vary systematically in size with the values of the independent variables. Now heteroscedasticity will cause estimates obtained by ordinary least squares to be inefficient, that is, the standard errors will be larger than if heteroscedasticity were not present, but the estimates will nevertheless be unbiased. Further, it appears likely that the inefficiency is only a serious problem for small samples. A Monte Carlo study which compared ordinary least squares (OLS) with a generalized least squares (GLS) method of correcting for heteroscedasticity found that the advantages of using GLS were not appreciable by the time the sample size reached 100. (V.K. Smith, 1973). For the present study, in which most projects will have several thousand observations, it appears that the efficiency gain of GLS would be negligible. In view of the greater expense of GLS estimation, OLS is to be preferred.

A second problem has to do with the interpretation of the OLS regression estimates as probabilities. Probabilities must, of course, fall in the interval zero to plus one. But there are no conditions on the OLS estimates that insure that this will be so. Unfortunately, while this is clearly a difficulty that can arise, there is no evidence about its empirical importance. It appears, from the discussion of one author (Cox, 1970), that this problem arises primarily in the context of extrapolation beyond the range of observed values. When a functional form is imposed on the variables, such extrapolation is possible; but it is not possible when binary variables (none of which are defined as open-ended intervals) are used. This suggests that the difficulty may not be important for this study and that OLS estimates will be satisfactory. We will, however, continue to look for information about the empirical importance of the problem and the following paragraphs discuss one method which has been developed as a solution to it.

Two methods of estimation, probit and logit, have been developed to deal with this second problem. Of the two the logit technique (for grouped observations) is more straightforward. Logit for grouped observations proceeds by partitioning the entire sample into cells on the basis of the independent variables specified for the regression (see Theil, 1971.) The probability of the dependent event, say infant mortality, is then calculated for each cell. The form of the dependent variable actually used for the regressions is the logarithm of the odds $\frac{p_i}{(1 - p_i)}$ of the event occurring, a number which can only take on values between zero and one.

The benefits of this theoretical improvement are not known, and at the same time, the method is more costly than OLS and has statistical problems of its own. For the pure logit form one statistical disadvantage is that the cells must be large enough to permit reliable estimates of the probabilities, so that the method partakes of the disadvantages of extensive cross-classification. A modified version of logit, described to us by Paul Schultz of the University of Minnesota, trades lower computing costs for yet another statistical problem. In this version the sample is partitioned on a set of independent variables as before but new variables are introduced, not by partitioning the sample again, but by using the averages of the new variable over the cells already defined. This approach introduces an unknown amount of information loss due to aggregation (Johnston, 1972). Sampling studies indicate that aggregate data show a poorer ability to discriminate between models and yield greater sampling variances than regressions based on OLS for the individual observations.

These deficiencies of OLS should be recognized but, as the preceding paragraphs have indicated, there are no alternative methods of estimation which are free of statistical problems. Thus, in view of the greater ease with which OLS estimates can be computed and interpreted, we will use the OLS technique for the infant mortality regressions.

Finally, the test statistics should be mentioned. The F and t-tests will be used as outlined in section E.1., and even for a binary dependent variable, the interpretation of these statistics in the conventional manner is justified for samples with more than 100 observations (V.K. Smith, 1973). The R^2, however, is apparently bounded from above by a value less than 1.0 when the dependent variable is binary. Thus, while it can be used in a relative sense to compare equations, it is a poor indicator of goodness of fit (V.K. Smith, 1973). Because of this it may be useful from time to time to calculate actual cell probabilities for the sample and correlate these with the average of the estimated probabilities for the same cells; the squared correlation coefficient may provide a useful alternative measure of explained variation.

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Morgan, J., and R. Messenger, THAID: A Sequential Analysis Program for the Analysis of Nominal Scale Dependent Variables, Ann Arbor: Institute for Social Research, University of Michigan, 1973.

Puffer, R., and C. Serrano, Patterns of Mortality in Childhood, Washington: Pan American Health Organization, 1973.

Smith, V.K., "The Analysis of Selected Problems with Survey Data," consultant's report, 1973.

Theil, H., Principles of Econometrics, New York: John Wiley and Sons, Inc., 1971.

**Indicates that coding or variable definition differs from that used by PAHO
? Indicates exact card and column number unknown
N.A. Not available

CHAPTER III. APPENDIX

SAN JUAN PROJECT: VARIABLES FOR COMBINED GROUP OF DEATHS AND LIVING CHILDREN

Card and Column Deaths	Sample	
?	?	RECORD (CHILD) IDENTIFICATION NUMBER **
I:2	I:2	DEATH OR SAMPLE 1 Death 0 Living Child
I:14	IV:12	AGE OF CHILD (at death or interview) Completed Years 0 Less than one year 1 1 year 2 2 years 3 3 years 4 4 years - Age not known (deaths only?)
I:15	IV:13	Completed Months 0 Less than one month 1 1 month 2 2 months . . - 10 months + 11 months blank no months indicated

Card and Column Deaths	Sample	
I:16	N.A.	Days, if under one month (deaths only)** 0 less than 1 day 1 less than 7 days 2 7-28 days 3 28-30 days - not specified blank child is living or was more than 1 month at age of death
I:13	?	SEX OF CHILD 1 male 2 female - not specified (deaths only?)
I:21	I:11	NEIGHBORHOOD 1 well-to-do 2 good 3 medium 4 poor 5 very poor 6 no neighborhood (isolated or rural) - not specified
I:22	I:12	TYPE OF HOUSING 1 independent, separate 2 rancho 3 apartment house 4 other
I:23	I:13	NUMBER OF ROOMS 1 one room 2 two rooms . . 9 nine or more - not specified
I:26-27	I:16-17	NUMBER OF PERSONS IN HOUSEHOLD 1 one person . . . 98 institution (deaths only?) 99 no home interview (eliminate the records of all cases without a home interview) NUMBER OF LIVING CHILDREN UNDER 5 IN THE FAMILY
I:24	?	WATER 1 piped water inside 2 piped water outside 3 other - not specified

Card and Column Deaths	Sample	
I:25	I:15	TOILET 1 flush 2 other 3 none - not specified 4 communal facility (if this code is presently used only for deaths, create 4 for each sample child for which water is coded 2 or 3 and toilet is currently coded 1.)
?	?	INFORMATION ON FATHER OF CHILD AGE OF FATHER AT INTERVIEW 01 1 year 02 2 years . . 85 85 years or more -- not specified 00 no information on father of child**
?	?	LEVEL OF EDUCATION REACHED BY FATHER 0 none 1 primary 2 secondary 3 technical 4 university 5 still in school 6 special school - not specified
?	?	OCCUPATION OF FATHER International Classification of Occupations, 1958
?	?	CURRENTLY EMPLOYED (FATHER) 0 no 1 yes 7 pensioned 8 occasionally - not specified or unknown
?	?	INFORMATION ON MOTHER OF CHILD AGE OF MOTHER AT INTERVIEW OR DEATH Completed Years 01 1 year 02 2 years . . . 85 85 years or more -- not specified or unknown

Card and Column Deaths	Sample	
?	?	AGE OF MOTHER AT BIRTH OF CHILD (code same as above)
		MARITAL STATUS OF MOTHER 1 single 2 married 3 common-law 4 divorced 5 separated 6 widowed 7 previously common-law, consort dead - not specified
?	?	LEVEL OF EDUCATION REACHED BY MOTHER 0 none 1 primary 2 secondary 3 technical 4 university 5 still in school 6 special school - not specified
?	?	YEARS COMPLETED AT HIGHEST LEVEL BY MOTHER 0 none 1 1 year . . . 8 8 or more - not specified
I:29	?	PERIOD OF RESIDENCE OF MOTHER IN THE COMMUNITY** 0 less than 5 years 1 5-9 years 2 10-14 years 3 15-19 years 4 20-24 years 5 25-29 years 6 30-34 years 7 35-39 years 8 40 or more years - not specified or unknown + Use this code if the mother is not a member of the household; do not code period of residence for anyone but the mother (this step will make the information for the deaths and the sample comparable)
?	?	LAST FIVE YEARS IN URBAN AREA (MOTHER)** 0 less than one year 1 1 year 2 2 years . . . 5 5 years 8 never - not specified + mother is not a member of the household (see previous item)

Card and Column Deaths	Sample	
?	?	OCCUPATION OF MOTHER
?	?	CURRENTLY EMPLOYED (MOTHER) 0 no 1 yes 7 pensioned 8 occasionally - not specified
III: 52-53	IV:39-40	PREGNANCY HISTORY OF MOTHER TOTAL NUMBER OF PRODUCTS 01 one 02 two . . . -- not specified
III:54-55	IV:41-42	TOTAL NUMBER OF PREGNANCIES 01 one 02 two . . . -- not specified
III:57	IV:43	CHARACTERISTICS OF HISTORY 1 sequence of pregnancies not established 2 definite remarks: data incomplete 3 definite remarks: deaths missing 4 apparently normal 5 data corrected from medical information (deaths only) 9 doubtful (sample only) - not specified
?	?	CONDITION AT BIRTH OF ALL PRODUCTS BORN PRIOR TO THE CHILD WHOSE RECORD THIS IS** Number of live born children (codes 1,2, and 5 for deaths; code 1 for sample) 00 none 01 one 02 two . . .

Card and Column Deaths	Sample	
?	?	Number of fetal deaths (codes 6,7,8,9, and + for deaths; codes 3,4,5 and 9 for sample) 00 none 01 one 02 two . . .
?	?	Number of products with condition unspecified (code "-") 00 none 01 one 02 two . . .
?	?	SURVIVAL AFTER LIVE BIRTH OF ALL PRODUCTS BORN PRIOR TO THE CHILD WHOSE RECORD THIS IS** Number still living (code o) 00 none 01 one 02 two . . . -- not specified
?	?	Number that died under 28 days of age (coded 6 and 7) 00 none 01 one 02 two . . . -- not specified
?	?	Number that died at 1 to 11 months (code 8) 00 none 01 one 02 two . . . -- not specified
?	?	All other deaths (codes 1,2,3,4,5, and 9) (Excludes fetal death and ectopic pregnancies) 00 none 01 one 02 two . . . -- not specified

Card and Column Deaths	Sample	
?	?	Number of live born children whose present condition is not known 00 none 01 one 02 two . . . -- not specified
?	?	NUMBER OF MONTHS BETWEEN LAST PRECEDING PRODUCT AND BIRTH OF CHILD WHOSE RECORD THIS IS** 01 one month 02 two months . . -- unknown
?	?	CONDITION OF LAST PRODUCT PRECEDING PRODUCT OF CHILD WHOSE RECORD THIS IS** 1 fetal death 2 born alive, still living 3 born alive, died at less than 28 days 4 born alive, died at more than 28 days - unknown
V:35 V:37	V:12 V:14	NUMBER OF PRENATAL VISITS** 0 none (only if no prenatal care indicated) 1 one . . 8 8 or more 9 Use this code if mother was seen by physician, or in hospital or clinic, during pregnancy but number of visits is not specified or is coded 0 - unknown
V:38	VI:15	LENGTH OF PREGNANCY 4 4 months . . 9 9 months 0 10 months - not specified DEATHS ONLY: LENGTH OF PREGNANCY FROM INTERVIEW (same code as previous item)** DEATHS ONLY: LENGTH OF PREGNANCY FROM MEDICAL SOURCES (Same code as previous item)**
V:39	N.A.	COMPLICATIONS OF PREGNANCY** 0 no 1 yes 9 unknown - not specified + all living children (no information)

Card and Column Deaths	Sample	
V:47	VI:16	PLACE OF BIRTH 1 home 2 hospital 3 other - not specified or not known
V:48	VI:17	WHO ATTENDED BIRTH? 0 no one 1 physician 2 midwife 3 other - not specified
VII:32	?	SINGLE OR MULTIPLE BIRTH** 0 single 1 multiple - not specified
V:55-56	VI:18-20	BIRTH WEIGHT (in hundreds of grams)** 001 one hundred grams 002 two hundred grams : : --- not specified DEATHS ONLY: BIRTH WEIGHT FROM INTERVIEW (same code as previous item)** DEATHS ONLY: BIRTH WEIGHT FROM MEDICAL SOURCES (same code as previous item)**
VII:35	VI:21	NUTRITIONAL STATUS <u>AT BIRTH</u> 0 normal 1 malnutrition, grade 1 2 malnutrition, grade II 3 malnutrition, grade III - no weight recorded or unspecified (does this code have the same definitions for the deaths and the sample?) 8 premature (deaths only; how would this be classified using codes 1,2, and 3?)
N.A.	VI:22-24	WEIGHT OF LIVING CHILDREN AT TIME OF INTERVIEW (in hundred of grams) e.g. 200 20,000 grams --- not specified

Card and Column Deaths	Sample	
V:57-58	VI:32-33	WAS CHILD BREASTFED?**
		8 (in first column) no
		- (in first column) unknown
		00 yes, weaning started less than 1 month
		01 yes, weaning started 1 month
		⋮
		23 yes, weaning started 23 months
		24 yes, weaning started 2 years
		36 yes, weaning started 3 years
		48 yes, weaning started 4 years
		50 yes, weaning started at unknown age
		60 yes, but not known whether weaned
		70 yes, never weaned
V:59	VI:34	REASON FOR WEANING
		0 milk scanty or insufficient
		1 sickness of child
		2 other reason relating to child
		3 sickness or death of mother
		4 mother works
		5 other reason relating to mother
		6 mother believed child should be weaned at that age (not for illness)
		7 physician indicated weaning due to age of child (not for illness)
		- not specified
		blank weaning not started
V:60-61	VI:35-36	BREASTFED, AGE WEANING FINISHED
		00 under 1 month
		01 1 month
		⋮
		23 23 months
		24 2 years
		36 3 years
		48 4 years
		50 weaning finished, but age not known
		55 weaning started, not known whether finished
		70 weaning started, not finished
		blank weaning not started
V:62	VI:37	REASON FOR NEVER BREASTFEEDING
		0 breastfed, does not apply
		1 mother did not have milk
		2 child died within 48 hours after birth
		3 child in hospital at time to begin breast-feeding
		4 child sick, not in hospital
		5 mother died
		6 mother sick
		7 mother works
		8 other reason
		- not specified

Card and Column Deaths	Sample	
V:63-64	VI:38-39	AGE IN MONTHS WHEN OTHER MILK GIVEN 00 less than 1 01 1 month : 23 23 months 24 2 years 36 3 years 48 4 years 50 age unknown 88 no other milk used -- not specified
V:65	VI:40	TIMES PER DAY MILK GIVEN 1 one 2 two : 7 7 or more 8 occasionally (this code available for living children only; enter 8 for dead child if milk given, but times per day not specified) - not specified
V:66	VI:41	WAS USE OF MILK CONTINUED? 0 no 1 yes - not specified
V:67	VI:42	OTHER WEANING FOOD USED? 0 none 1 Incaparina 2 Peruvita 3 Pochito 4 Fortifex 5 others 8 type unknown - not specified
V:68	VI:43	WEANING FOOD CONTINUED? 0 no or does not apply 1 yes - not specified
		OTHER FOODS
V:69-71	VI:44-46	JUICES
V:72-74	VI:47-49	CEREALS
V:75-77	VI:50-52	PULSES
V:78-80	VI:53-55	ROOTS, TUBERS
VI:9-11	VI:56-58	LEAFY VEGETABLES
VI:12-14	VI:59-61	EGGS
VI:15-17	VI:62-64	POULTRY
VI:18-20	VI:65-67	MEAT

Card and Column Deaths	Sample	
VI:21-23	VI:68-70	FISH For each category the first two columns will show age given, the third times per week: Age Given 00 less than 1 month 01 one month ⋮ 23 23 months 24 2 years 36 3 years 48 4 years 50 age unknown 88 never -- not known whether given, not specified Times per Week 0 none 1 one time ⋮ 7 7 times or more 8 occasionally or less than once per week - not specified
VI:38	VII:26	CARE OF CHILD 0 hospital 1 mother 2 grandmother 3 sibling over 15 years 4 sibling under 15 years 5 other relative 6 maid 7 day care 8 other - not specified
VI:39	VII:27	VACCINATIONS VACCINATED? 1 yes, type specified 2 yes, type not specified 8 no 7 all specific vaccination types are coded "-" - not specified
VI:40	VII:28	SMALLPOX
VI:41	VII:29	WHOOPING COUGH
VI:42	VII:30	DIPTHERIA
VI:43	VII:31	TETANUS
VI:44	VII:32	POLIOMYELITIS
VI:45	VII:33	MEASLES
		1 yes - no or not specified
VI:46	VII:34	OTHER VACCINATIONS 1 yes, type specified 2 yes, type not specified - no, or not specified

Card and Column Deaths	Sample	
		AGE IN MONTHS CHILD HAD THE FOLLOWING DISEASES
VI:47-48	VII:35-36	GERMAN MEASLES
VI:49-50	VII:37-38	MEASLES
VI:51-52	VII:39-40	CHICKEN POX
VI:53-54	VII:41-42	WHOOPING COUGH
VI:55-56	VII:43-44	MUMPS
		00 less than 1 month
		01 1 month
		02 2 months
		⋮
		23 23 months
		24 2 years
		36 3 years
		48 4 years
		50 age unknown
		88 never had
		-- not specified
		MEDICAL ATTENTION IN THE PAST YEAR
VI:57-58	VII:45-46	DAYS IN HOSPITAL
		00 less than one day
		01 1 day
		02 2 days
		⋮
		59 59 days
		61 1 month (sample only?=30 days?)
		62 2 months
		63 3 months
		⋮
		71 11 months (less than one year)
		81 1 year
		85 from birth (deaths only)
		88 never
		90 length of time unknown
		-- not specified
VI:59	VII:47	ALL CLINIC VISITS
VI:60	VII:48	CLINIC VISITS FOR WELL CHILD CARE OR VACCINATION ONLY
VI:61	VII:49	TOTAL VISITS TO PHYSICIAN
VI:62	VII:50	PHYSICIAN VISITS FOR WELL CHILD CARE OR VACCINATION ONLY
VI:63	VII:51	EMERGENCY VISITS
		0 no medical attention
		1 1 visit
		2 2 visits (a few? code for deaths)
		3 3 visits
		4 4 visits (several, various? code for deaths)
		5 five visits
		6 6 to 12 visits
		7 13 or more
		8 number unknown
		- not specified

Card and Column Deaths	Sample	
		CAUSES OF DEATH (FOR DEATH)
VIII:44-47	N.A.	UNDERLYING CAUSE OF DEATH ASSIGNED BY REFEREE
VIII:60-63	N.A.	CONSEQUENTIAL CAUSES: TERMINAL
VIII:65-68	N.A.	CONSEQUENTIAL CAUSES: FIRST INTERMEDIATE
VIII:70-73	N.A.	CONSEQUENTIAL CAUSES: SECOND INTERMEDIATE
VIII:75-78	N.A.	CONSEQUENTIAL CAUSES: THIRD INTERMEDIATE
IX:9-12	N.A.	CONTRIBUTORY CAUSE: FIRST
IX:14-17	N.A.	CONTRIBUTORY CAUSE: SECOND
IX:19-22	N.A.	CONTRIBUTORY CAUSE: THIRD
IX:24-27	N.A.	CONTRIBUTORY CAUSE: FOURTH
IX:29-32	N.A.	CONTRIBUTORY CAUSE: FIFTH
IX:34	N.A.	NUTRITIONAL STATUS
VI.74	VII:72-73	SOURCE OF INTERVIEW INFORMATION 1 father 2 mother 0 all other - not specified

CHAPTER IV. RELATED STUDIES

With a source of data potentially as rich as the PAHO survey, there are many possible areas for multivariate statistical analysis in addition to child mortality. This section will briefly mention several such areas. It should be noted, however, that the feasibility of the studies outlined in IV.A and IV.B is contingent upon the availability and quality of the data for the particular items and, even more important, PAHO's willingness to cooperate with additional studies.

The Stage II study of the determinants of infant mortality is intended to provide information to help in the comparison of different policies for influencing infant mortality. The last section of this chapter suggests how the regression estimates of Stage II might be incorporated in a linear programming framework that could examine the cost-effectiveness of different policies.

None of the studies outlined in this chapter are planned as part of Stage II and they will not be included in the budget estimate for that stage.

A. Determinants of Fertility

NPA was asked to consider, in particular, whether the survey data could support a study of the determinants of fertility. Many of the variables needed for such an analysis are available or could be generated from the survey data. For example, the pregnancy histories collected for each mother would permit the generation of year-by-year fertility histories, including information on child deaths, in the manner of Schultz and DaVanzo (1970). Similarly the number of children ever born could be derived for age-specific groups of women. Some of the suspected causal factors that have been examined in past studies (see Mason, et.al., 1971), but not all, are available. For example, information on family occupations, parental education, and child deaths is available, but information on religiosity and use of family planning services is not.

One problem which deserves careful consideration before any use is made of these data for fertility studies is the way in which the selection of the sample, which was, of course, designed to represent children, may have biased the representation of women of child-bearing age. Viewed as a sample of these women, the data will have the following characteristics:

- Women with a child that was born during the preceding 5-year period and that died during the two year sample period will be heavily over-represented.
- The sample will not include women who have never had any children.
- The sample will not include women who have not had any children in the last five years.

Thus it appears likely that the sample will be biased toward women who have experienced high and recent fertility and high infant mortality. This does not necessarily rule out an analysis of fertility, but it does mean that any such analysis should be undertaken cautiously and that the questions addressed should probably be carefully phrased with reference to the peculiar characteristics of the sample. For example, if the sample were appropriately weighted, it might be possible to examine the fertility patterns of women aged 20 to 28, on the assumption that virtually all married Latin American women have at least one child during that age period and thus that very few have been omitted.

B. Studies Related to Child Mortality

A number of interesting issues related to child mortality could be examined with the use of the survey data. For example, breast feeding is of great importance to the nutrition of young children in developing countries (Berg, 1973), and programs to encourage the practice would be one policy alternative. It might thus be useful to investigate the determinants of the decision to breast-feed and the length of breast feeding. The PAHO survey collected information on both of these variables as well as on a host of factors that might be causally related, such as the mother's reproductive history, her education, the child's parity, and the reasons for weaning or for never breast feeding.

As another example, the extensive information requested about the child's nutrition in addition to any breast feeding has already been noted. Questions were asked about the number of times each week the child received nine different types of food. Composite measures of the child's nutrition, such as those to be developed in Stage II (see Chapter III), could be related to such potential causal factors as income proxies (e.g., father's occupation), mother's education, parity, and sex of the child, and the type of person primarily responsible for the child's care. Such an analysis might be able to pinpoint the net effects of factors like the family's food distribution mores.

As a last example, the survey requested data on illnesses suffered by the child and medical attention received. These data were collected through the home interview questionnaire and the PAHO staff has doubts about their accuracy and completeness, but, in principle, they could permit an investigation of patterns of morbidity in infants and children, where the morbidity did not result in death.

C. The Cost-Effectiveness of Different Policies to Combat Infant Mortality

In the initial discussions between AID and NPA, it was stressed that the multivariate analysis of the PAHO data is a step toward determining the cost-effectiveness of different strategies for influencing infant mortality. If the analysis of Stage II identifies more than one or two variables that might be affected by policy choices, linear programming should be considered as a method for addressing the larger question of cost-effectiveness. The following paragraphs outline some thoughts on the subject.

As noted in Chapter III, a major part of the final stage II output will be regressions relating whether the child lived or died to a number of independent variables measuring living conditions, nutrition, medical care, etc. The estimates derived by inserting particular values of the independent variables will show the average probability of survival under the specified conditions.

Many of these independent variables, for example, nutrition or medical care, are related to programs that AID might wish to consider. Thus we can estimate the probability of survival associated with each program. We can also estimate the net addition to the probability of survival made by the program, relative to some specified base condition.

These net probabilities make good sense as weights for the objective function of a linear programming problem. The problem could be set up as one of maximizing the probability of survival of an infant population, subject to constraints on the number of medical personnel available, the amount of money, imports (if food needs to be imported, for example), and other factors reflecting local conditions relevant to the strategies being considered. The strategies, expressed in terms of their requirements for the various constrained resources, would be the "activities" of the linear programming problem.

Linear programming would offer, at least, the following advantages:

- It offers a way to compare and select among a large number of strategies simultaneously, according to the specified objective.
- If the problem includes more than one objective, additional objectives can be expressed as constraints on the solution set.
- It is easy to examine the effects of changing the constraints to reflect different local conditions or secondary objectives.
- The analytical method is well developed and powerful.
- The solutions produce "shadow prices" to show which of the constrained resources it would be most valuable to expand.
- The framework helps to suggest the additional data and areas of work that are needed. (Data on some of the strategies, such as maternal and child health programs, may be available from other parts of AID.)

References

Mason, K., A. David, E. Gerstel, Q. Lindsey, and M. Rulison, "Social and Economic Correlates of Family Fertility: A Survey of the Evidence," Research Triangle Institute, North Carolina, AID Contract NESA/460, 1971.

Schultz, T. and J. DaVanzo, "Analysis of Demographic Change in East Pakistan: A Study of Retrospective Survey Data," RAND, California, R-564-AID, 1970.

APPENDIX

ANNOTATED BIBLIOGRAPHY OF STUDIES IN THE AREA OF INFANT AND CHILD MORTALITY

Note. In addition to providing a brief description, this bibliography classifies each study according to a four part scheme in order to give the reader a more precise idea of the nature of the study. The four classifications are:

L - a review of the literature

G - a general discussion of the subject which may refer to other studies or statistical sources but does not make systematic use of them

O - a report based on an original study

S - a study which makes considerable use of tables, statistics, etc., from secondary sources such as original studies and censuses

Abramowicz, M., and H. Barnett
"Sex Ratio of Infant Mortality"
American Journal of Diseases of Children
Volume 119, April 1970

Data are presented for New York City, and for selected developed and underdeveloped countries, which indicate that the excess of males in infant death rates has declined; the relationship between the sex ratio of infant mortality and various factors are mentioned. (G,S)

Aykrod, W.
"Nutrition and Mortality in Infancy and Early Childhood: Past and Present Relationships"
American Journal of Clinical Nutrition
Volume 24, April 1971

Infant mortality in England in the early 1900's, as documented in Newman's Infant Mortality (1906), is compared to the present experiences of underdeveloped countries with respect to protein-calorie malnutrition; both similarities and differences in rates and causes of death are discussed. (G,S)

Baertl, J., E. Morales, G. Verastegui and G. Graham
"Diet Supplementation for Entire Communities. Growth and Mortality of Infants and Children"
American Journal of Clinical Nutrition
Volume 23, Number 6, June 1970

In northern Peru, 4 independent populations were observed from 1962-67 to measure the effects of food supplementation on people living in otherwise unfavorable environments. Two populations were given food supplements of equal caloric value, but one with almost twice the protein content of the other, and two populations were used as control groups. (One control group had a food supplementation program beginning in 1965 for 6-30 month old children.) All populations also received medical care. (O)

Berg, A. (portions with R. Muscat)
The Nutrition Factor: Its Role in National Development
Washington, D.C.: The Brookings Institution, 1973

This book documents the extent of the problem of malnutrition in less developed countries and discusses the effects of nutrition on mortality, family planning and the likely effects of economic growth on nutrition. It then reviews a number of possible mechanisms for solving the problem of malnutrition including the effects of new agricultural techniques, education, nutritional supplements, and public feeding programs. (G,S)

Berg, A. and R. Muscat
"Nutrition and Development: the View of the Planner"
American Journal of Clinical Nutrition
Volume 25, February 1972

The portion of this article relevant to the infant mortality study contains a brief literature review of infant and child malnutrition in developing countries and a discussion of the effects of malnutrition on intellectual development, physical size, and mortality; data are contained in an appendix regarding child mortality and malnutrition in selected countries. (L)

Chopra, J., R. Camacho, J. Kevany, and A. Thomson
"Maternal Nutrition and Family Planning"
American Journal of Clinical Nutrition
Volume 23, Number 8, August 1970

Findings presented at a WHO Expert Committee on Maternal Nutrition and Child Health correlating defective nutrition of pregnant and lactating women with their poor physique and health, and with high infant mortality rates and growth retardation are summarized in this report. (G)

David, A. (Editor)
"Infant and Child Mortality and Fertility Behavior Conference Report"
North Carolina: Research Triangle Institute (AID contract NESA/460), February 1971

The cost-effectiveness of allocating family planning resources to health and nutrition programs is discussed, with emphasis on the possible long term effects: a decline in fertility as better nutrition and general health result in lower infant and child mortality. (G)

Erhardt, C. and H. Abramson, J. Baxter and F. Nelson
"An Epidemiological Approach to Infant Mortality"
Archives of Environmental Health
Volume 20, June 1970

In this study of 7,308 infant deaths recorded among 299,316 live births in New York City during 1966 and 1967, the distributions of infant mortality rates by various socio-economic and pregnancy factors (e.g. length of gestation, parity) are examined. (O)

Feldstein, M.
"A Binary Variable Multiple Regression Method of Analysing Factors Affecting Perinatal Mortality and Other Outcomes of Pregnancy"
Journal of the Royal Statistical Society
Volume A 129, 1966

Based on data for 17,000 live births and 7000 perinatal and neonatal deaths in Britain, regression analysis is used to determine the relationships between perinatal mortality and three independent variables -- maternal age, birth order, and social class. (O)

Goodhart, R.
"Criteria of an Adequate Diet"
in Modern Nutrition in Health and Disease, Wohl and Goodhart (Editors)
Philadelphia: Lea and Febiger, 1964

In this general discussion of human dietary needs and the differences in dietary requirements as functions of various factors, vitamin, mineral, and protein requirements related to pregnancy, lactation and periods of rapid growth are mentioned. (G)

Gopalan, C. and A. Nadamuni Naidu
"Nutrition and Fertility"
The Lancet
November 18, 1972

With particular reference to India, the authors examine information linking the sex ratio of child deaths, the age of menarche, pregnancy wastage, and infant and maternal mortality to nutrition. (O,S)

Hammoud, E.
"Studies in Fetal and Infant Mortality: A Methodological Approach to the Definition of Perinatal Mortality"
American Journal of Public Health
Volume 55, July 1965

Child mortality rates at various ages from under one day to 11 months, and indicators of the level of living, for the 20 largest states, were derived from U.S. Census Data (1960) in order to determine if race, sex and level of living affected infant death rates. (O,S)

Heer, D. and Hsin-ying Wu
"The Separate Effects of Individual Child Loss and Community Mortality Level upon Subsequent Fertility in Taiwan"
Presented at the meetings of the International Union for the Scientific Study of Population, Leige, Belgium, 1973

Based on samples taken from two Taiwanese villages, one with high child mortality and the other with low child mortality, the authors present a multiple classification analysis showing that the high mortality village had more births, and that within the same village, parents who perceived a higher mortality had more births. (O)

Hillman, R. and J. Hall
"Nutrition in Pregnancy"
in Modern Nutrition in Health and Disease, Wohl and Goodhart (Editors)
Philadelphia: Lea and Febiger, 1964

The possible effects of maternal nutrition on infant birth weight, prematurity, toxemia, congenital malformations, and anemia are explored in this general discussion. (G)

Holt, L. and S. Snyderman
"Nutrition in Infancy and Adolescence"
in Modern Nutrition in Health and Disease, Wohl and Goodhart (Editors)
Philadelphia: Lea and Febiger, 1964

This study discusses nutrient requirements for maintenance of infants, in terms of body weight, metabolism and rate of growth. (G)

Jelliffe, D.
Child Nutrition in Developing Countries: A Handbook for Fieldworkers
Washington, D.C.: Agency for International Development, 1969

The relevant portion of this handbook for field workers is a discussion of tropical foods and their nutritional value. (G)

Jelliffe, D., and E. Jelliffe
"Symposium on the Uniqueness of Human Milk: An Overview"
American Journal of Clinical Nutrition
Volume 24, 1971

Findings about the comparative properties of human milk and cow's milk are reviewed, with particular reference to nutritional content and digestibility, the anti-infective properties of human milk, and the effects of breast-feeding on the mother. (G,L)

"Nutrition and Pregnancy: An Invitational Symposium"
Journal of Reproductive Medicine
Volume 7, Number 5, November 1971

This study offers a general discussion of pregnancy toxemias and concludes that their causes remain unclear, although it is known that they are more likely to occur in lower social groups and this seems to be related to maternal malnutrition. The article includes a brief discussion of the effects on the fetus of a restricted diet during pregnancy. (G)

Kessner, D., J. Singer, C. Kalk and E. Schlesinger
Infant Death: An Analysis by Maternal Risk and Health Care
Washington, D.C.: Institute of Medicine, National Academy of Sciences, 1973

Data for 142,017 live births in New York City were analysed to determine the relationships between risk of the mother, prenatal care received, and infant mortality. Mothers were classified into risk categories on the basis of an index based on a number of social, demographic, medical and obstetric characteristics. Within risk categories mothers who received better health care experienced lower infant mortality. Birth weight was found to be the single most important determinant of infant mortality. Other findings reported have to do with mortality rates by ethnic group and the effects of special maternity and infant care projects. (O)

Mason, K., A. David, E. Gerstel, Q. Lindsey and M. Rulison
"Social and Economic Correlates of Family Fertility: A Survey of the Evidence"
North Carolina: Research Triangle Institute (AID contract NESA/460), February 1971

The factors affecting family size decisions, such as social status, family division of labor, and religiosity, and their interrelationships are surveyed using the results from previous studies. The independent variables are reported by nature of relationship and strength of relationship. (L)

Mata, L., J. Urrutia, C. Albertazzi, O Pellecer and E. Arellano
"Influence of Recurrent Infections on Nutrition and Growth of Children in Guatamala"
American Journal of Clinical Nutrition
Volume 25, November 1972

To illustrate the influences of infection on nutritional status and growth retardation in children, this article presents observations regarding growth retardation at certain stages of development from a long-term field study (1964-1970) of a poor rural Guatemalan Highland village with minimum environmental intervention. (O)

Mata, L., J. Urrutia and A. Lechtig
"Infection and Nutrition of Children of a Low Socio-Economic Rural Community"
American Journal of Clinical Nutrition
Volume 24, February 1971.

In an examination of a cohort of 95 infants born during a two year period in a rural Indian community in the Guatemalan highlands, half were studied intensively for intestinal infections from birth to three years of age, in an attempt to discover whether prenatal and postnatal infections and infectious diseases contribute to the retarded growth of children who are receiving poor diets. (O)

Mata, L. and R. Wyatt
"Host Resistance to Infection"
American Journal of Clinical Nutrition
Volume 24, August 1971

Findings relevant to the mechanisms by which human milk induces host resistance to infection are reviewed in this article to determine whether human milk is better than cow's milk in protecting the newborn infant against infection. (L)

McClung, Jean
Effects of High Altitude on Human Birth
Harvard University Press, 1969

Births at the Cuzco Hospital at an altitude of 11,200 feet in Peru were compared to those at the Maternidad de Lima at an altitude of 665 feet in Peru during the summer of 1966 to determine whether low birth weight at a higher altitude results from shortened gestation period, fetal malnutrition, or a decrease in fetal growth rate, and whether the decrease in birth weight contributes to high neonatal mortality. (O)

Monckeberg, F.
"Factors Conditioning Malnutrition in Latin America, with Special Reference to Chile. Advices for a Volunteers Action."
Bibliotheca Nutritrio et Dieta
Number 14, 1970

Using data for the United States and selected Central and South American countries, this study examines the correlations between high infant mortality rates and poor socio-economic conditions. The effects of malnutrition on infant and preschool children mortality and morbidity are also discussed. (S)

Morris, J. and J. Heady
"Social and Biological Factors of Infant Mortality: I. Objects and Methods"
The Lancet
February 12, 1955

Based on data for England and Wales during the period 1949-51, this study reviews the relationships between infant mortality and such factors as social class, maternal age, and birth order. (O,S)

Naeye, R.
"The Epidemiology of Perinatal Mortality. The Power of the Autopsy"
Pediatric Clinics of North America
Volume 19, Number 2, May 1972

Autopsies of 361 stillbirths and 683 infants who died within 72 hours of birth were performed to examine the relationships between ethnic group, socio-economic class and measures of infant development such as birth weight and antenatal infection. (O)

National Academy of Sciences
"Maternal Nutrition and the Course of Pregnancy: Summary Report"
Committee on Maternal Nutrition, Food and Health Board, National Research Council
Washington D.C.: 1970

This report summarizes findings on nutrition and its relation to various aspects of pregnancy such as toxemia, fetal growth, and maternal anemia. (L)

Plank, S. and M. Milanesi
"Infant Feeding and Infant Mortality in Rural Chile"
Bulletin World Health Organization
Number 48, 1973

Information was gathered from 1712 women aged 15 to 44 years in 15 rural Chilean communities about their reproductive histories, infant feeding practices, housing, medical care and other factors. Data showing the relationships between these factors and postneonatal mortality are presented. (O)

Pollitt, E.
"Behavior of Infant in Causation of Nutritional Marasmus"
American Journal of Clinical Nutrition
Volume 26, March 1973

This article reviews studies on the occurrence of nutritional marasmus as influenced by infant behavior and concludes that sucking behavior, level of arousal, and interrelationship with mothers are commonly adversely affected in the nutritionally marasmic infant prior to the development of malnutrition because of factors such as parity, spacing and birth weight. (L)

Pollitt, E. and H. Ricciuti
"Biological and Social Correlates of Stature Among Children in Slums of Lima, Peru"
American Journal of Orthopsychiatry
Volume 39, Number 5, October 1969

Two groups of 48 children between 6 months and 4 years of age were selected, on the basis of height, from those attending a day care center in Peru. The

relationships between their heights and such factors as maternal height, number of previous pregnancies, birth weight, maternal education, and family income were examined. The study includes a literature review. (O,L)

Primrose, T. and A. Higgins
"A Study in Human Antepartum Nutrition"
The Journal of Reproductive Medicine
Number 6, December 1971

In Montreal, 1544 pregnant patients from the lowest socio-economic class were given diet supplements during pregnancy, with particular emphasis on protein. Mothers who were under treatment longer had higher birth weight infants and fewer complications of pregnancy. (O)

Puffer, R., and C. Serrano
Patterns of Mortality in Childhood
Washington, D.C.: Pan American Health Organization, 1973

This report presents data on child deaths from the 15 projects -- 13 in Central and South America -- that made up the Inter-American Investigation of Child Mortality carried out by the Pan American Health Organization (these data plus the data for the project samples of living children will form the base for the study proposed in this report). The projects are described and tabulations of such characteristics of the child deaths as birth weight, detailed causes of death, maternal reproductive history, length of breastfeeding, medical care, socioeconomic and environmental conditions are presented and discussed.

Roopnarinesingh, S.
"The Young Negro Primigravida in Jamaica"
Journal of Obstetrics and Gynaecology of the British Commonwealth
Volume 77, May 1970

The histories of pregnancy and labor of 122 Negro new mothers under 16 years of age were compared with those of 122 new mothers aged 22 in terms of maternal and fetal complications. A literature review is included. (O)

Roopnarinesingh, S., D. Morris, and E. Chang
"The Underweight Jamaican Parturient"
Journal of Obstetrics and Gynaecology of the British Commonwealth
Volume 78, April 1971

Birth weights and complications of pregnancy are compared for 146 Jamaican women weighing 100 pounds or less at the 14th week of gestation and an equal number of women weighing more than 100 pounds.

Rulison, M.
"Report on Topical Investigation and Analysis of Nutritional Supplements in Family Planning Programs in India and Pakistan"
North Carolina: Research Triangle Institute (AID contract NESA/460), 1970

This study reviews the literature to substantiate a series of hypotheses about relationships between nutritional supplements, child mortality, and fertility rates. Using these hypotheses and data on births and deaths in India, the results of simulating population growth based on three different assumptions about death rates and birth rates are presented and discussed. (O,S,L)

Schultz, T. and J. Da Vanzo
"Analysis of Demographic Change in East Pakistan: A Study of Retrospective Survey Data"
Santa Monica, California: Rand Corporation (AID/CSD-2151), 1970

The authors use regression analysis of survey data for a sample of 4,200 women in East Pakistan to test a number of hypotheses about the determinants of fertility, particularly present family size and child deaths. (O)

Scrimshaw, N.
"Synergism of Malnutrition and Infection. Evidence from Field Studies in Guatemala"
Journal of American Medical Association
Volume 212, June 8, 1970

To test the effects of nutrition as compared to medical care and sanitation on child morbidity, mortality, and growth and development, three Guatemalan villages with populations of about 1000 each were compared. One was provided with nutritional supplements, the second with medical care and sanitation programs, and the third served as a control. No statistics are provided in the article. (O)

Scrimshaw, N. and J. Salomon, H. Bruch and J. Gordon
"Studies of Diarrheal Disease in Central America, VIII: Measles, Diarrhea and Nutritional Deficiency in Rural Guatemala"
American Journal of Tropical Medicine and Hygiene
Volume 15, Number 4, 1966

Data from the study described in the previous reference are presented to show the interactions between nutritional status and measles. (O)

Scrimshaw, N., C. Tayler and J. Gordon
"Interactions of Nutrition and Infection"
World Health Organization Monograph Series No. 57
Geneva: 1968

This study discusses the effects of infection on nutritional status and the corresponding susceptibility to infection caused by nutritional deficiences. (G)

Sloan, F.
"Survival of Progeny in Developing Countries: An Analysis of Evidence from Costa Rica, Mexico, East Pakistan and Puerto Rico"
Santa Monica, California: Rand Corporation (AID/CSD-2533), 1971

Based on data for political subdivisions (e.g., provinces, counties) of Costa Rica, Mexico, East Pakistan, and Puerto Rico, regression analysis is used to test hypotheses about the relationships between infant (and child) mortality and such factors as maternal education, nutrition, sanitation, housing and medical care.

Wray, J.
"Population Pressure on Families: Family Size and Child Spacing"
Reports on Population/Family Planning
Number 9, August, 1971

Studies which relate to family size or birth intervals and their association with morbidity, mortality, physical growth, intelligence and maternal health are summarized in this article. (L)

Zucker, T. and L. Zucker
"Nutrition and Natural Resistance to Infection"
in Modern Nutrition in Health and Disease
Philadelphia: Lea and Febiger, 1964

This article discusses the relationship between microbial infectious states and nutrition, genetically determined physical mechanisms such as leukocytes, and environmental factors such as temperature. (G)

CHAPTER V. INTRODUCTION TO PART TWO

This is Part Two of the report on the feasibility study funded by AID under Contract AID/CM/otr-C-73-212, Work Order no. 1. The purpose of this study has been to design the multivariate statistical analysis to be used in an investigation of the determinants of child mortality in Latin America, and to assess the ability of survey data collected by the Pan American Health Organization (PAHO) to support such an analysis.

The first part of this report, submitted to AID in February, contained a review of the relevant literature, along with a discussion of the hypotheses generated by that literature, and a detailed description of the statistical techniques to be employed. This part of the report completes the feasibility stage with a description of the work that has been finished since the earlier report. The description has three parts:

(1) The last section of the introduction gives a progress report on the cooperative arrangement established with PAHO for the use of the survey data, and the work that has been completed under this arrangement;

(2) The infant's birth weight is an important item of information for the analysis, available only from the home interview for the living children. Information was available from two sources -- the interview and medical records -- for many of the infant deaths and Chapter VI presents correlations, provided by PAHO, which indicate the reliability of the interview information;

(3) Chapter VII describes a system, developed by NPA in cooperation with Dr. Carlos Serrano of PAHO, for summarizing the survey information available about each infant's diet in terms of important nutritional measures -- specifically calories, protein, vitamin C, iron and other vitamins and minerals. Separate rules have been developed for each of four infant age groups -- 0-3 months, 4-5 months, 6-8 months, and 9-11 months. If the system appears useful and reliable in the statistical analysis of infant deaths, it will be extended to include children 1 to 4 years of age.

<u>The Next Phase of the Study</u>. In the months following the submission of this report, NPA will undertake a complete analysis of the data for one of the survey areas, San Juan, Argentina. This pilot project will investigate the determinants

of infant and child mortality in San Juan, following the research design that has been set out in Parts I and II of this report. (The reasons for selecting San Juan, Argentina are described in Part I.) In addition to the intrinsic interest of the results for this project, the pilot will enable AID to decide whether analysis of additional survey projects appears useful.

The Cooperative Arrangement with PAHO: A Progress Report

During the early months of this feasibility study, PAHO refused to release the vey data tape to NPA. After negotiations involving all three of the organizations involved, PAHO agreed to begin doing the computational work required for the study, in return for the right to retain complete control over the data. The period of the feasibility study was extended to allow this cooperative relationship to be established and tested.

NPA then proceeded to specify an initial series of steps for the preparation of the data for analysis, to be completed by PAHO, in a memorandum of January 14, 1974. The steps included the creation of a tape combining the living children and the child deaths in the San Juan survey, an initial tape edit to guide NPA in selecting the observations to be retained for analysis, and tabulations to help in defining appropriate binary variables. Part I of the report, Chapter III and the Appendix to that chapter, provides a detailed specification of the tape requested, and a description of the other steps.

So far PAHO has been cooperative, but the process has been slow, at least partly because every step involves a meeting with the Director of PAHO's statistical department. The correlations shown in Chapter VI, which could be computed before the specified tape was created, were provided very quickly. The tape itself, although all essentials were agreed upon by January 18, was not completed until early March.

We are now in the process of reviewing, with PAHO, some initial edits of the tape. Items that are blank, unspecified, or coded with invalid codes have been

printed out, as we requested in our January 14 memo, and summary counts of the numbers of cases missing each item have been made. These initial edits indicate that the variables of interest to us are available for a very high proportion of the survey children. In future meetings with PAHO, we will discuss the interpretation of some items, and settle on the exact criteria for omitting observations from the final tape. The tabulations and numerical redefinition of the variables would then be the steps remaining before regression analysis could begin.

Finally, it should be emphasized that PAHO has not made any final decision about their part in this cooperative arrangement, so we cannot predict with confidence how long their cooperation will continue. At the moment, PAHO is taking the view that this is to be a joint NPA-PAHO project and their cooperation has extended beyond computational work, as noted before, to include the advice and time of Dr. Serrano, a nutritionist on their staff.

CHAPTER VI. BIRTH WEIGHT AND LENGTH OF PREGNANCY: THE RELIABILITY OF THE HOME INTERVIEW INFORMATION

The literature review has stressed the importance of an infant's weight at the time of birth. Not only is birth weight likely to be an important determinant of infant mortality, but it is worthy of analysis in its own right as a summary measure of the prenatal events that affect the infant. For these reasons the availability and reliability of a measure of birth weight is extremely important.

The infant's birth weight was requested both during the home interview and during the search of medical records for the infant deaths. Only the home interview was used to collect information for the living children and thus the interview provides the only estimate of birth weight for these children.

The reliability of the interview information for this variable is uncertain. The mother, or other person interviewed, may never have been told the birth weight, the interviewed person's memory may be faulty, especially if the birth took place some time ago, and so on. Similar questions arise about the reliability of a less crucial variable, length of pregnancy. The availability for the child deaths of birth weight and length of pregnancy information from two sources -- the home interview and medical records -- provides an obvious opportunity to check the reliability of the home interview information against a presumably much more reliable measure.

Simple correlations were computed to test the correspondence of the birth weights and lengths of pregnancy reported by the two sources. These correlations, presented for the San Juan project and for all projects combined in Table 1, show that the two birth weight measures are highly correlated. For

TABLE 1. Birth Weight and Length of Pregnancy: Correlations between item as reported on home interview and as reported by medical sources, for all projects and San Juan (Argentina), by age of child at death

Age of Child at Death	Correlation between item as reported on home interview and by medical sources[1]	
	Birth Weight	Length of Pregnancy
San Juan (Argentina)		
Under 1 month	.955	.834
1 - 11 months	.889	.551
1 - 4 years	.858	.555
All Projects		
Under 1 month	.953	.848
1 - 11 months	.907	.701
1 - 4 years	.858	.574

1. See Table 2 for number of observations used to compute correlations.

infants less than one month at death in San Juan, the correlation is .96. The San Juan correlations decline to .89 for infants 1 to 11 months at death and .86 for those 1 to 4 years. The correlations for all projects show a similar decline (these results are only suggestive since the analysis will proceed project by project, and the reliability of the birth weight information will be tested in this fashion for each project). This is what we might expect if the accuracy of recall declines with the length of time since the child's birth.

The correlations for length of pregnancy are much lower, generally between .50 and .60, except for the infants less than one month at death; these latter correlations are over .80. The results support the judgment of the PAHO staff that these data are relatively unreliable and should be used and interpreted with caution in subsequent analyses.

The simple correlation test provides strong support for the reliability of the birth weight information. This conclusion should, however, be tempered with two qualifications. The first is that information from both sources was not available for all the child deaths (Table 2 shows the number of child deaths with information from both sources). Aside from the resulting fact that the results do not apply to the whole sample, it seems likely that the omitted cases include some in which the interviewed person had no accurate information about the birth weight because the child had not been weighed. The test may thus exclude exactly those cases for which the interview information is least reliable.

Second, the PAHO staff has warned that the two estimates are not always independent. Where the information had not been supplied at the interview, but was available from medical sources, some enthusiastic interviewers used the medical information to complete the home interview form, without noting the source of the data. The questionnaires were typed before they were sent to PAHO's Washington headquarters and there is no way to

TABLE 2. Total Number of Deaths, Number with Home Interviews, and Number with Birth Weight or Length of Pregnancy Available from both Interview and Medical Sources, for all projects[1] and San Juan (Argentina), by age of child at death.

	Age of child at death		
	Under 1 month	1-11 months	1-4 years
San Juan (Argentina)			
• Total deaths	906	994	256
• Number with home interviews	809	940	247
• Number with birth weight from both sources	647	672	153
• as a percent of the total	71.4%	67.6%	59.8%
• Number with length of pregnancy from both sources	664	642	153
• as a percent of the total	73.3%	64.6%	59.8%
All Projects[1]			
• Total deaths	12,104	14,714	7,379
• Number with home interviews	9,502	12,409	6,025
• Number with birth weight from both sources	5,356	5,572	1,456
• as a percent of the total	44.3%	37.9%	19.7%
• Number with length of pregnancy from both sources	7,123	6,555	2,040
• as a percent of the total	58.9%	44.6%	27.7%

1. Excluding California. Home interviews were not completed for this project.

Source: Total deaths and number with home interviews from Puffer and Serrano, Patterns of Mortality in Childhood, Pan American Health Organization, 1973, p. 33 and p. 429.

tell, in retrospect, how often this was done. Viewed in this context the length of pregnancy correlations are encouraging since they suggest that, for many cases, the two items were independent.

CHAPTER V I. NUTRITIONAL CLASSIFICATION SYSTEM

This chapter describes a system, which was developed in consultation with Dr. Carlos Serrano of PAHO, for classifying the diets of children less than one year old as "probably adequate", "probably inadequate" or "grossly inadequate" in each of the major nutrients, i.e., proteins, calories (fats and carbohydrates), and vitamins and minerals. This system addresses survey data from the Latin American infant mortality tape on an infant's food intake. It identifies primary malnutrition or malnutrition due to inadequate food intake; it does not identify secondary malnutrition, common among severely ill children, which is due to rejection of food, poor digestion, malabsorption, inefficient utilization and excessive wastage. Specifically, it utilizes the survey data on whether or not the child was breast-fed, age weaning started, age weaning finished, age other milk was continued, other weaning food used, whether weaning was continued, other foods given, i.e., juices, cereals, pulses, roots and tubers, leafy vegetables, eggs, poultry, meat or fish, age when other food was introduced and times per week each other food was given. (See Part I of the Report, Appendix to Chapter III.)

This system is based on (1.) The National Academy of Sciences - National Research Council recommended daily dietary allowances, with the exception of iron where recommendations of the Protein Advisory Group of the U.N. System were used instead, (2.) the nutritional value of foods common to Latin America by major food type, (3.) the ages various foods should be introduced into an infant's diet and (4.) the quantities of food an infant is capable of consuming at each feeding.

There are many organizations which have established dietary standards for the maintenance of good nutrition for healthy people and all are different. One was chosen, the one recommended by the U.S. National Academy of Sciences (NAS)

and the U.S. National Research Council (NRC) as revised in 1968. Most standards are based on "reference people" with a given body size, who function at a given level of activity in a given climate and it is mainly assumptions about these characteristics which cause them to differ. The NAS-NRC uses as a "reference-child" one that is thriving and considered to be moderately active physically. He is presumed to live in an environment with an annual mean temperature of 20°C. His weight and height, which are considered "normal" for his age group, are as follows:

Age Group	Weight		Height	
	(kg)	(lbs)	(cm)	(in)
0-3 months	4	9	55	22
3-6 months	7	15	63	25
6-12 months	9	20	72	28
1-2 years	12	26	81	32
2-3 years	14	31	91	36
3-4 years	16	35	100	39

These weights and heights were used in all calculations, even though the averages for the Latin child tend to be smaller. This was done because a child, whether American or Latin, without acquired or congenital pathology, has the same growth potential irrespective of birth weight and height. In other words, the requirements for optimum growth are presented. Another reason why the NAS-NRC standards were chosen over those by the Institute for Nutrition in Central America and Panama, as well as others, is that they provide the finest age break for all categories of nutrients. Also, the annual mean temperature used as a basis for caloric requirements is similar to the annual mean temperature for most of Latin America.

The NAS-NRC recommended daily allowances for iron are replaced by those recommended by the Protein Advisory Group of the United Nations System. There is no agreement on the amount of iron necessary to maintain good nutrition, especially for infants, but it appears NAS-NRC standards are high. One reason

for this is that, in the United States, infant diets as well as adult are composed of large quantities of milk and milk is associated with less iron absorption.

The NAS-NRC recommended daily dietary allowances are contained in Appendix I. In addition, there is a discussion of whether or not human milk meets these requirements during the first 3 months.

The ages chosen for the introduction of various solid foods, which are reported in Appendix II, are those recommended by Dr. Serrano of PAHO. They agree both with those presented in The Heinz Handbook of Nutrition by Benjamin Burton (McGraw-Hill, 1959) and those in the Manual on Feeding Infants and Young Children by the Protein Advisory Group of the United Nations System (1971).

Averages of nutritional composition of foods common to Latin America, by food type, were calculated from data provided in Nutrition by Moises Behar and Susana Icaza (Mexico, 1972). Appendix III contains these averages.

The quantity of food an infant is capable of consuming at each feeding is restricted by the size of its stomach. The Protein Advisory Group of the United Nations Systems makes recommendations about how much food should be given infants, and how often, in order to provide sufficient nutrients given the limitation of stomach size. These recommendations are presented in Appendix IV.

It was necessary to make several assumptions in order to develop a nutritional classification system. First, adequate quantities of milk, either breast or bottle, are assumed to be available at each feeding, and if not, this is reflected in a reduction of the number of feedings. Also, breast milk and bottle milk (cow's milk) are assumed to be nutritionally equivalent. Second, the portion of food available at each serving is assumed to be "normal" for the age group or rather, it is restricted only by the size of the stomach. Third, the distribution of food within a week is even. For example, if an infant is fed 7 times per week, it is assumed to mean he is fed once a day.

The following discussion of the protein intake of a 7 month old infant is an example of how the rules for classifying infants' diets were developed.

> If you have an infant 7 months old, you know (1.) the NAS-NRC recommended daily allowance for protein is 16.2g., (2.) the infant should be eating all types of solid foods, (3.) the infant is capable of consuming 2 to 3 tablespoons of porridge 2 or 3 times per day in addition to milk.
>
> You then must assume (1.) the infant receives 550 ml. of milk, either breast or bottle, each day if he receives any milk (which is the normal amount of breast milk available at this stage of lactation) and (2.) the infant receives a normal portion each serving of any protein-containing foods he is given, which is approximately 1/2 egg, 2 teaspoons (30g.) of fish, meat or poultry, or 2 tablespoons (20g.) of pulses with 2 tablespoons of cereal. These portion sizes yield 5.4g. protein from the milk, 5.7g. of protein from the egg, 4.6 to 6.2g. of protein from the fish, meat or poultry, 4.4g. protein from the pulses, and 3.6g. protein from cereal each serving.
>
> Thus the rules for classifying this infant's protein intake are:
>
> 1. If he receives milk plus (egg, fish, meat, poultry or pulses) once a day, he receives 13.4g. to 15.2g. protein a day. If so, he is probably receiving adequate amounts of protein.
> 2. If he is receiving milk plus (egg, meat, poultry or pulses) 1 to 6 times per week, he receives 3.1g. to 12.0g. of protein per day. If so, he is probably receiving inadequate amounts of protein.
> 3. And if he does not receive milk plus (egg, meat, fish, poultry or pulses) or receives them occasionally, he receives grossly inadequate amounts of protein.

The procedure for developing the rules for classifying an infant's diet, which is used in the example, involves determining how often an infant must receive milk plus other foods rich in a specific nutrient in order to fall within a range around the NAS-NRC recommendations for that nutrient of approximately plus or minus 20%. If an infant receives enough milk plus other foods nutritious in a specific nutrient to fall within this range, he is classified as probably receiving adequate amounts of this nutrient. If an infant receives enough nutritious foods to fall within a range around about one-half of the optimum level recommended by the NAS-NRC for this nutrient, he is classified as probably receiving inadequate amounts of this nutrient. And, if an infant receives only enough nutritious food to fall within a range around about one-fourth of the optimum level recommended for this nutrient, he is classified as receiving grossly inadequate amounts of this nutrient.

The classification categories are not exhaustive. There are two obvious groups omitted - infants that receive no milk and infants that receive only milk. All cases that cannot be classified using the rules provided will be printed out and classified individually. This points out an important premise of the classification system. The nutritional requirements are presumed to be fulfilled by milk plus other foods after the first three months, with milk fulfilling proportionately less of the requirements as the age of the child increases.

The rules for classifying infant diets, by age group, are presented in the following sections.

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RULES FOR CLASSIFYING INFANT DIETS

Parentheses are used in the text of the rules in order to enclose groups of foods which serve as alternative sources for the nutrient under consideration.

RULES FOR CLASSIFYING DIETS OF INFANTS UP TO 3 MONTHS

Assumptions:

.Maternal prenatal diet is adequate in iron insuring the newborn has a 3 month store of iron.

.Infants are exposed daily to sunshine to insure endogenous vitamin D synthesis or, in the case of artificial feeding, formula is fortified with vitamin D.

.There is either a healthy well nourished mother with normal lactation or an adequate supply of cow's milk or other milk insuring adequate intake each time the infant is fed. If not, the number of feedings is decreased.

.The amount of milk a bottle-fed infant and a breast-fed infant receives at each feeding is the same.

.Infants receive about 850 ml. of milk each day, if fed milk 5 or more times per day, and proportionately less, if the number of feedings are fewer.

.Infants receive approximately 2 tablespoons of weaning food or 2 tablespoons of porridge made with cereal and possibly another food at each feeding, if any.

Classification Rules:

I. Calories (carbohydrates and fats)

1. If an infant receives milk 5 or more times per day, or if an infant receives milk 3 or 4 times per day plus (weaning food or cereals) at least 6 times per week, his caloric intake is "probably adequate."

2. If an infant receives only milk 3 or 4 times per day, or if an infant receives milk 3 or 4 times per day plus cereal less than 6 times per week, or if an infant receives milk 2 times per day plus (weaning food or cereal) at least 6 times per week, his caloric intake is "probably inadequate."

3. If an infant receives milk only 2 times per day or less, or if an infant receives milk 2 times per day plus cereal less than 6 times per week, his caloric intake is "grossly inadequate".

II. Proteins

1. If an infant receives milk 3 or more times per day with or without (weaning food or cereal), or if an infant receives milk twice a day plus (weaning food or cereal) at least 6 times per week, his diet is "probably adequate" in protein.

2. If an infant receives only milk twice a day, or if an infant receives milk twice a day plus cereal less than 6 times per week, or if an infant receives milk once a day plus (weaning food or cereal) at least 6 times per day, his diet is "probably inadequate" in protein.

3. If an infant receives only milk daily, or if an infant receives milk once a day plus cereal less than 6 times per week, his diet is "grossly inadequate" in protein.

III. Vitamins and Minerals (calcium, phosphorous, riboflavin, thiamine, vitamin A and vitamin C)

1. If an infant receives milk at least 4 times per day, his diet is "probably adequate" in all vitamins and minerals except for iron and vitamin D.

2. If an infant receives milk 2 or 3 times per day, his diet is "probably inadequate" in all vitamins and minerals except for iron and vitamin D.

3. If an infant receives milk once a day or less, his diet is "grossly inadequate" in all vitamins and minerals except iron and vitamin D.

RULES FOR CLASSIFYING DIETS OF INFANTS AGED 4-5 MONTHS

Assumptions:

.There is either a healthy, well nourished mother with normal lactation or an adequate supply of cow's milk or other milk ensuring adequate intake each time the infant is fed. If not, the number of feedings will decrease.

.The amount of milk a bottle-fed infant and breast-fed infant receive at each feeding are the same.

.Infant receives about 850 ml. of milk each day, if fed milk 4 or more times per day, and proportionately less, if the number of feedings are fewer.

.It is assumed that an infant receives a "normal" portion at each serving, which is approximately 2 tablespoons of weaning food or porridge made with cereal and another food, e.g., 1/2 egg, 2 teaspoons of fish, meat, poultry or pulses. or 60 grams of fruit juice or puree of fruit or 15 grams leafy vegetables.

Classification Rules:

I. Calories (carbohydrates and fats)

1. If an infant receives only milk 4 or more times per day, or if an infant receives milk 3 or more times per day plus (weaning food or cereal) at least 6 times per week, his caloric intake is "probably adequate".

2. If an infant receives milk 3 times per day plus cereal 1 to 5 times per week, or if an infant receives milk twice a day plus cereal at least 6 times per week, his caloric intake is "probably inadequate".

3. If an infant receives milk twice a day plus cereal less than 6 times per week, his caloric intake is "grossly inadequate".

II. Protein

1. If an infant receives milk 4 or more times per day plus (eggs, meat, fish, poultry or pulses) at least 6 times per week, his diet is "probably adequate" in protein.

2. If an infant receives milk 3 times per day plus (eggs, meat, fish, poultry or pulses) at least 6 times per week, or if an infant receives milk 4 times per day plus (eggs, meat, fish, poultry or pulses) 1 to 5 times per week or if an infant receives only milk 4 or more times per day, his diet is "probably inadequate" in protein.

3. If an infant receives only milk 3 times per day or less, or if an infant receives milk 3 times per day or less with or without other foods, his diet is "grossly inadequate" in protein.

III. Vitamins and Minerals

A. Calcium, phosphorous, niacin, riboflavin, thiamine and vitamin A.

1. If an infant receives milk at least 4 times per day, his diet is "probably adequate" in calcium, phosphorous, niacin, riboflavin, thiamine and vitamin A.

2. If an infant receives milk 2 or 3 times per day, his diet is "probably inadequate" in calcium, phosphorous, niacin, riboflavin, thiamine and vitamin A.

3. If an infant receives milk once a day or less, his diet is "grossly inadequate" in calcium, phosphorous, niacin, riboflavin, thiamine and vitamin A.

B. Vitamin C.

1. If an infant receives juices or leafy vegetables 7 or more times per week, his diet is "probably adequate" in vitamin C.

2. If an infant receives juices or leafy vegetables 2 to 6 times per week, his diet is "probably inadequate" in vitamin C.

3. If an infant receives juices or leafy vegetables once a week or less, his diet is "grossly inadequate" in vitamin C.

C. Iron

1. If an infant receives milk daily plus (meat or pulses) 7 or more times per week, his diet is "probably adequate" in iron.

2. If an infant receives milk daily plus (meat or pulses) 2 to 6 times per week, his diet is "probably inadequate" in iron.

3. If an infant receives milk daily plus (meat or pulses) once a week or less, his diet is "grossly inadequate" in iron.

RULES FOR CLASSIFYING DIETS OF INFANTS AGED 6-8 MONTHS

I. Calories (carbohydrates and fats)

Assumptions:

.Infant receives 550 ml. milk each day, if any. This is the amount received by both bottle-fed and breast-fed infants.

.It is assumed that an infant receives "normal" portions each serving which is approximately 1/2 egg, 2 teaspoons of fish, meat or poultry or 1 tablespoons of pulses with 2 tablespoons of cereals, or 2 to 3 tablespoons of cereal possibly with either leafy vegetables or roots and tubers.

Classification Rules:

1. If an infant receives milk plus (egg, fish, meat, poultry or pulses) and cereals 14 or more times per week, or if an infant receives milk plus cereal 14 or more times per week, his caloric intake is "probably adequate".

2. If an infant receives milk plus (egg, fish, meat, poultry or pulses) and cereal 7 to 13 times per week, or if an infant receives milk plus cereal 7 to 13 times per week, his caloric intake is "probably inadequate."

3. If an infant receives only milk, or if an infant receives milk plus (egg, meat, fish, poultry or pulses) and cereal less than 7 times per week, or if an infant receives milk plus cereal less than 7 times per week, his caloric intake is "grossly inadequate."

II. Protein

Assumptions:

.Infant receives 550 ml. of milk each day, if any. This is the amount received by both bottle-fed and breast-fed infants.

.It is assumed that an infant receives a "normal" portion each serving which is approximately 1/2 egg, 2 teaspoons of fish, meat, or poultry, or 1 tablespoons of pulses with 2 tablespoons of cereal.

Classification Rules:

1. If an infant receives milk plus (egg, fish, meat, poultry or pulses) once a day, his diet is "probably adequate" in protein.

2. If an infant receives milk plus (egg, fish, meat, poultry or pulses) 1 to 6 times per week, his diet is "probably inadequate" in protein.

3. If an infant does not receive milk plus (egg, fish, meat, poultry or pulses) or if an infant receives milk plus (egg, fish, meat, poultry or pulses) only occasionally, his diet is "grossly inadequate" in protein.

III. Vitamins and Minerals

Assumption:

It is assumed that an infant receives a "normal" portion each serving which is either the 60 grams of juices from one whole fruit or 1/2 egg, 2 teaspoons of pulses, 2 tablespoons of cereals or a few (15g.) leafy vegetables per serving.

Classification Rules:

A. Iron

1. If an infant receives milk plus cereal and (meat or pulses) 21 or more times per week, his diet is "probably adequate" in iron.

2. If an infant receives milk plus cereal and (meat or pulses) 7 to 20 times per week, his diet is "probably inadequate" in iron.

3. If an infant does not receive, or receives milk plus cereal and (meat or pulses) less than 7 times per week, his diet is "grossly inadequate" in iron.

B. Vitamin C.

1. If an infant receives juices and leafy vegetables 7 or more times per week or if an infant receives juices 11 or more times per week, his diet is "probably adequate" in vitamin C.

2. If an infant receives juices and leafy vegetables 1 to 7 times per week or if an infant receives juices 1 to 11 times per week, his diet is "probably inadequate" in vitamin C.

3. If an infant does not receive or receives only occasionally juices and/or leafy vegetables, his diet is "grossly inadequate" in vitamin C.

C. Other Vitamins and Minerals (phosphorous, calcium, vitamin A, riboflavin and niacin) One serving of a food that fulfills more than one of the food group conditions (the groups in parens) in the rules below is sufficient to fulfill each of those conditions and additional servings are not necessary.

1. If an infant receives (milk, eggs, meat, fish, poultry, pulses or cereal) and (milk, leafy vegetables or pulses) and (eggs or leafy vegetables) and (milk, eggs, meat, pulses or leafy vegetables) and (poultry, fish, meat or pulses) once a day in the case of milk and once a week or more in the case of other foods, his diet is "probably adequate" in other vitamins and minerals.

2. If an infant receives (milk, eggs, meat, fish, poultry, pulses or cereal) and (milk, leafy vegetables or pulses) and (eggs or leafy vegetables) and (milk, eggs, meat, pulses or leafy vegetables) and (poultry, fish, meat or pulses) only occasionally, his diet is "probably inadequate" in other vitamins and minerals.

3. If an infant never receives (milk, eggs, meat, fish, poultry, pulses or cereal) and (milk, leafy vegetables or pulses) and (eggs or leafy vegetables) and (milk, eggs, meat, pulses or leafy vegetables) and (poultry, fish, meat or pulses) his diet is "grossly inadequate" in other vitamins and minerals.

RULES FOR CLASSIFYING DIETS OF INFANTS AGED 9-11 MONTHS

I. Calories (carbohydrates and fats)

Assumptions:

.Infants receive 200 ml. of milk each day, if any. This is the amount received by both bottle-fed and breast-fed infants.

.It is assumed that an infant receives a "normal" portion each serving which is either approximately 1/2 egg, 2 teaspoons of fish, meat or poultry or 2 tablespoons of pulses with 2 tablespoons of cereal, or 2 to 3 tablespoons of cereal, possibly with either leafy vegetables or roots or tubers.

Classification Rules:

1. If an infant receives milk plus (egg, meat, fish, poultry or pulses) and cereal 21 or more times per week or if an infant receives milk plus cereal 21 or more times per week, his caloric intake is "probably adequate."

2. If an infant receives milk plus (egg, fish, meat, poultry or pulses) and cereal 14 to 20 times per week, or if an infant receives milk plus cereal 14 to 20 times per week, his caloric intake is "probably inadequate."

3. If an infant receives milk plus (egg, fish, meat, poultry or pulses) and cereal less than 14 times per week or if an infant receives milk plus cereal less than 14 times per week, his caloric intake is "grossly inadequate."

II. Protein

Assumptions:

.Infants receive 200 ml. of milk each day, if any. This is the amount received by both bottle-fed and breast-fed infants.

.It is assumed that an infant receives a "normal" portion each serving which is either approximately 1/2 egg, 2 teaspoons fish, meat or poultry or 1 tablespoon pulses with 2 tablespoons of cereal.

Classification Rules:

1. If an infant receives milk plus (egg, fish, meat, poultry or pulses) 14 or more times per week, his diet is "probably adequate" in protein.

2. If an infant receives milk plus (egg, fish, meat, poultry or pulses) 7 to 13 times per week, his diet is "probably inadequate" in protein.

3. If an infant receives milk plus (egg, fish, meat, poultry or pulses) less than 7 times per week, his diet is "grossly inadequate" in protein.

III. Vitamins and Minerals

Assumption:

It is assumed that an infant receives a "normal" portion each serving which is either the 60 grams of juices from one whole fruit or 1/2 egg, 2 teaspoons of pulses, 2 tablespoons of cereals or a few (15g.) leafy vegetables per serving.

Classification Rules:

A. Iron

1. If an infant receives milk plus cereal and (meat or pulses) 21 or more times per week, his diet is "probably adequate" in iron.

2. If an infant receives milk plus cereal and (meat or pulses) 7 to 20 times per week, his diet is "probably inadequate" in iron.

3. If an infant does not receive, or receives milk plus cereal and (meat or pulses) less than 7 times per week, his diet is "grossly inadequate" in iron.

B. Vitamin C.

1. If an infant receives juices and leafy vegetables 7 or more times per week or if an infant receives juices 11 or more times per week, his diet is "probably adequate" in vitamin C.

2. If an infant receives juices and leafy vegetables 1 to 7 times per week or if an infant receives juices 1 to 11 times per week, his diet is "probably inadequate" in vitamin C.

3. If an infant does not receive or receives only occasionally juices and/or leafy vegetables, his diet is "grossly inadequate" in vitamin C.

C. Other Vitamins and Minerals (phosphorous, calcium, vitamin A, riboflavin and niacin) One serving of a food that fulfills more than one of the food group conditions (the groups in parens) in the rules below is sufficient to fulfill each of those conditions and additional servings are not necessary.

1. If an infant receives (milk, eggs, meat, fish, poultry, pulses or cereal) and (milk, leafy vegetables or pulses) and (eggs or leafy vegetables) and (milk, eggs, meat, pulses or leafy vegetables) and (poultry, fish, meat or pulses) once a day in the case of milk and once a week or more in the case of other foods, his diet is "probably adequate" in other vitamins and minerals.

2. If an infant receives (milk, eggs, meat, fish, poultry, pulses or cereal) and (milk, leafy vegetables or pulses) and (eggs or leafy vegetables) and (milk, eggs, meat, pulses or leafy vegetables) and (poultry, fish, meat or pulses) only occasionally, his diet is "probably inadequate" in other vitamins and minerals.

3. If an infant never receives (milk, eggs, meat, fish, poultry, pulses or cereal) and (milk, leafy vegetables or pulses) and (eggs or leafy vegetables) and (milk, eggs, meat, pulses or leafy vegetables) and (poultry, fish, meat or pulses) his diet is "grossly inadequate" in other vitamins and minerals.

Appendix I. Nutritional Requirements of Infants

A. Protein Requirements of Infants

Table A.1 NAS-NRC Daily Dietary Allowance of Protein for Infants[1/] (grams)

Age Group	
0-3 months	8.8
3-6 months	14.0
6-12 months	16.2
1-2 years	25.0
2-3 years	25.0
3-4 years	30.0

1/ Protein equivalent in quality to human milk is assumed. Annual temperature of 20°C (68°F) is assumed. These figures provide, as well, an estimate of actual intake, assuming breast feeding by a healthy well-nourished mother with normal lactation or bottle feeding with cow's milk formula in adequate supply.

Source: National Academy of Sciences, "Recommended Dietary Allowances", Washington, D.C., 1968.

Table A.2 Usual Quantities of Protein Consumed in Milk by a Healthy Infant[1/] (grams)

Age Group	
Breastfed:	
0-3 months	6.0-10.0
3-6 months	10.5-17.5
6-12 months	N.A.
Bottlefed:	
0-3 months	10.0-14.0
3-6 months	17.5-24.5
6-12 months	18.0-27.0

1/ Normal weights of infants by age and sex as reported by H.C. Stuart in Nelson's Textbook of Pediatrics are assumed.

Source: Derived from data provided in The Heinz Handbook of Nutrition on usual milk consumption of infants according to body weight and normal weight of infants by age and sex.

Protein is required for maturation of tissue and growth of new tissue during infancy as well as for maintenance of tissue. These protein needs are fully met in early infancy by breast milk or cow's milk when its supply is adequate. Usual quantities consumed by nursing infants indicate an intake of about 1.5 to 2.5 grams of protein per kilogram of body weight during the first 6 months. Usual quantities consumed by arifically fed infants show an intake in the range of 2.5 to 3.5 grams of protein per kilogram of body weight from 2 to 6 months and 2.0 to 3.0 grams per kilogram from 6 to 12 months. If you convert into grams the average intake figures and the figures on recommended daily allowances assuming normal weight and length and compare them (recommended daily protein allowances and average consumption of protein are shown in Table A.1 and A.2), you confirm that protein needs are met by breast milk or cow's milk for at least the first 3 months. However, the amount of protein needed increases with age despite a slowing rate of growth because of increased size and activity. Although it is conceivable that an infant could consume sufficient quantities of milk to satisfy these increased needs, it is generally agreed to be wise to to introduce other sources of protein such as egg, meat, fish, poultry or cereal at 3 months.

B. Fat and Carbohydrate Requirements of Infants

Table B.1 NAS-NRC Recommended Daily Dietary Caloric Intake for Infants (CALS.)

Age Group	
0-3 months	480
3-6 months	770
6-12 months	900
1-2 years	1100
2-3 years	1250
3-4 years	1400

An infant appears to require small amounts of fat as a source of essential fatty acids as well as a source of calories. The amount of fat in the usual intake of breast milk or cow's milk formula fulfills this requirement. An infant's additional fat requirements and his carbohydrate requirements depend on his caloric needs, for fat and carbohydrates are the major source of calories. For a healthy active infant an allowance of 120 kcal/kg at birth decreasing to 100 kcal/kg by the end of the year is recommended by the NRC-NAS. Assuming normal weight and height, this means an intake of about 480 kcal. at birth, increasing to 1100 kcal. at 1 year. An infant will determine his own caloric intake by accepting or rejecting the breast, bottle, or solid foods. Assuming adequate supplies of milk, an infant is likely to have sufficient caloric intake at least during the first three months from milk alone. After three months it is usually necessary to supplement this source of calories with other sources of fats, such as meats, eggs and other dairy products, and with other sources of fats, such as meats, eggs and other dairy products, and with other sources of carbohydrates such as cereal, fruit, roots and tubers. (Recommended daily caloric intake is shown in Table B.1.)

C. Other Nutritional Requirements of Infants

Table C.1 NAS-NRC Daily Dietary Allowances of Other Nutrients For Infants

	Months			Years		
	0-2	3-6	7-11	1-2	2-3	3-4
Fat Soluble Vitamins						
Vitamin A (IU)	1,500	1,500	1,500	2,000	2,000	2,500
Vitamin D (IU)	400	400	400	400	400	400
Water-Soluble Vitamins						
Ascorbic Acid (mg)	35	35	35	40	40	40
Niacin (mg)	5	7	8	8	8	9
Riboflavin (mg)	0.4	0.5	0.6	0.6	0.7	0.8
Thiamin (mg)	0.2	0.4	0.5	0.6	0.6	0.7
Minerals						
Calcium (g)	0.4	0.5	0.6	0.7	0.8	0.8
Phosphorous (g)	0.2	0.4	0.5	0.7	0.8	0.8
Iron (mg)	6	10	15	15	15	10

In addition to sufficient quantities of protein and calories an infant needs water, calcium, phosphorous, iron, vitamin D, vitamin A, vitamin C, thiamin and riboflavin. (Recommended daily allowances of these additional nutrients are shown in Table C.1.) Quantities of breast milk or cow's milk formula which satisfy an infant's protein and caloric requirements will ordinarily also meet these additional nutritional needs, except for iron and vitamin D, for at least the first 3 months. If the mother's prenatal diet was adequate with respect to iron, the infant will be born with sufficient iron to last about 3 months. If not, iron enriched cereal, egg yokes, meat or green leafy vegetables are required daily from the start. Vitamin D can be supplied with the formula normally consumed if the infant is bottle fed by adding canned evaporated milk fortified with vitamin D. Or it can be supplied in the form of cod-liver oil or multivitamin supplements. Or daily exposure to the sunshine will allow adequate endogenous Vitamin D synthesis.

Appendix II. Introduction of Solid Foods into an Infant's Diet

There have been many trends regarding the introduction of solid foods into an infant's diet. It is currently agreed that they should not be given later than the third to fourth month when the infant's prenatal iron reserve is usually depleted and they can be introduced as early as 6 to 8 weeks. Some advocate the introduction of foods immediately, but infants seem to do as well whether solids are introduced at once or after 2 to 3 months.

The initial solid food is usually one of the precooked infant cereals. The enriched cereals, such as incaparina, peruvita, pochito and fortifex have iron and B vitamins as well as protein and carbohydrates. After cereals, strained fruits and vegetables, and strained egg yolks and meat are usually added. But any strained solid food can be digested, absorbed and utilized immediately. As teeth come in and the infant is capable of chewing, minced or chopped foods are added. By the 18th to 24th month, most infants can eat an "adult" diet.

Time Table for the Introduction of Solid Foods

Juices	4 weeks
Cereals	2 months
Meats, Poultry & Fish	3-4 months
Eggs	3-4 months
Fruits	3-4 months
Vegetables, Pulses, Roots & Tubers	3-4 months

Appendix III. Nutritional Composition of Selected Types of Food

The following is a table of the average nutritional composition of selected food types. Only foods common to Latin America were used. Information on the nutritional composition of these foods was taken from Moises Behar and Susana Icaza, Nutrition, Mexico, 1972, and averages for each food type were calculated. It does not take into account the effects of harvesting, transporting, storing, processing and final preparation on the nutritional value.

Nutritional Composititon of Selected Food Types
(Constituents of 100g of Edible Portion)

	Water (g)	Protein (g)	Calorie (g)	Carbo-hydrate (g)	Fat (g)	Calcium (g)	Phos-phorous (mg)	Iron (mg)	Riboflavin (mg)	Niacin (mg)	Ascorbic Acid (mg)	Thiamine (mg)	Vitamin A (mg)
Cow's Milk	87.4	3.5	61	5.5	3.0	160	91	0.3	.21	0.1	1	.04	24
Eggs	75.3	11.3	148	2.7	9.8	54	204	2.5	.37	0.1	0	.14	100
Meat	70.1	15.4	180	1.3	12.4	19	145	6.6	.42	3.1	2	.27	*
Fish	71.0	20.5	139	0.7	5.9	42	230	1.2	.10	4.7	-	.04	17
Poultry	62.1	18.1	246	0.0	18.7	10	201	1.8	.14	7.7	2	.06	16
Cereals	15.7	9.1	354	69.5	4.3	50	180	2.4	.11	.2	0	.22	6
Pulses	11.4	22.2	372	55.2	2.8	93	336	6.0	.22	4.6	3	.61	6
Roots & Tubers	77.7	1.3	82	19.7	0.3	31	44	1.4	.05	1.0	19	.07	*
Leaf & Stem Vegetables	89.0	2.8	35	6.6	0.5	131	49	2.6	.16	0.7	55	.11	282
Fruit Juices	89.4	0.7	37	9.3	0.2	28	16	0.6	.04	0.4	44	.06	28

*There is a large range.

Source: Calculated from data provided in Behar, M. & Icaza, S., Nutrition, Mexico, 1972.

Appendix IV.

RECOMMENDATIONS OF THE PROTEIN ADVISORY GROUP OF THE UNITED NATION SYSTEM RE: SUITABLE AND SUFFICIENT QUANTITIES OF FOOD GIVEN EACH FEEDING TO INFANTS BY AGE*

0-3 months:	
Breast milk should be given on demand	550 cals.
Artificial feedings should be given at 4-hour intervals 5 times per day	11.5g protein
4-5 months:	
850 ml. milk per day	770 cals
1-2 tbs. porridge per day	12.6g protein
6-8 months:	
550 ml. milk per day	900 cals.
2-3 tbs. porridge 2-3 times per day plus fruit	12.6g protein
9-11 months:	
200 ml. milk per day	1150 cals.
3-4 tbs. porridge 3 times per day plus fruit	12.2 g. protein

*Suitable refers to the limit placed on the quantity of food an infant is capable of consuming per feeding by his stomach size. Sufficient refers to the number of feedings which maximize nutrient utilization, as well as providing the nutritional requirements. The equivalent caloric and protein requirements for a healthy infant for optimum growth are also given.

Source: Extracted from Cameron, Margaret and Yngave Hofvander, Manual on Feeding Infants and Young Children, Protein Advisory Group of the United Nations Systems, 1971.