SOCIAL CLASS AND INFANT DEATH: A REPLICATION AND EXTENSION WITH INDIVIDUAL DATA, 1967-1972

by

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Although only the author may ultimately claim credit (or blame) for the work represented by a thesis, it is always a team effort. The path to and through graduate school is made possible by the support of numerous people in their different capacities.

The first, and most continuous emotional and financial support that I have received has been from my parents, Paul and Ina Robinson. More immediately, my wife, Joan, and my son, Ryan, have suffered with the burdens of time not spent with them that should have been and supporting me through the tough times. Our surviving these years as a family is testimony to their patience and perseverance.

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SOCIAL CLASS AND INFANT DEATH: A REPLICATION

AND EXTENSION WITH INDIVIDUAL DATA, 1967-1972

CHAPTER I

INTRODUCTION

Early medical and public health research found socioeconomic status to be the main factor explaining variation in infant mortality rates. Socioeconomic status was assumed to represent the ability to obtain the resources to supply the basic necessities for the group's infants. The ability to care for the infants of the society was considered a basic measure of the ability of the society to care for its members overall.

Historically, infant mortality rates (defined as the actual rate of infant deaths to live births in an area or group with some common social or demographic characteristic) have been viewed as very sensitive to changes in the quality of life of different status groups within society. Empirical studies have shown them to be much more sensitive to many social changes in society than general mortality rates, divorce rates, or any other vital rates. Socioeconomic status and lifestyle have been seen as affecting the infant mortality rates of these groups through various intervening processes. The goal of improved understanding of the bases of the relationship of socioeconomic status to infant mortality, defined as the probability of dying before reaching age one for some specified group, has lead to much of the more recent research. This research will attempt to specify the intervening processes that associate socioeconomic status with infant death using data concerning individuals. With that information, the relationships that are found by ecological studies and the meaning of changes in the infant mortality rates of different groups may be interpreted more accurately. This will improve the understanding of what is being measured when infant mortality rates are used as indicators of quality of life.

It is only with the weakening of the inverse relationship that Willie (1959), Stockwell (1962), and Donabedian et al. (1965) reported questions arising about the presence of the socioeconomic status-infant mortality rate relationship. These three studies and most other studies challenging the relationship between socioeconomic status and infant mortality carried out ecological analyses; i.e., correlated a summary measure of socioeconomic status for several areas with the infant mortality rates of those areas. Most of the research that followed was based on the question of whether the relationship was growing weaker or stronger. However, studies using data collected on individual births at about the same time found a consistent, nonlinear relationship between socioeconomic status and infant mortality rates in the region studied by Willie (1959), Stockwell (1962), and Donabedian et al. (1965). The surveys were the National Natality Survey and the National Infant Mortality Survey, conducted in 1964 to 1966. The relevant results were published by the National Center for Health Statistics (NCHS) in 1972.

Further studies using the matching of birth and death records have found a nonlinear relationship similar to that found by NCHS in various parts of the United States and other developed countries (Antonovsky and Bernstein, 1977:453). Only ecological studies have sometimes found weak or no relationship as did Willie (1959), Stockwell (1962), and Donabedian et al. (1964).

The questions to be answered in this research are 1) "why are the results of different studies so inconsistent?" and 2) "If the relationship of socioeconomic status to infant mortality rates is weakening, does that mean that access to the resources necessary to maintain a high quality of life are becoming more equally distributed?" Some ecological studies have found strong relationships between infant mortality rates and socioeconomic status, while others have found little relationship. Studies with individual birth data have found higher mortality rates for infants from upper and lower class than for infants from middle class (NCHS, 1972). Finally, studies of the same area over time, using areal units of analysis, have shown changes in the particular social and economic variables that are closely associated with the infant mortality rates of the units of study (see Adamchak, 1979 and Markides and McFarland, 1982). The mixture of research methodologies has given no conclusive evidence of what is happening to the relationship between socioeconomic status and the chance of an infant death.

There are four types of factors that can affect the relationship of socioeconomic status to infant death that have been reported by the various researchers. As has already been mentioned, the level of the data, whether it is based on the individual or the areal unit makes a major difference in whether one finds a relationship. Second, some researchers have assumed a linear relationship between socioeconomic status and infant death in preparing the data for analysis and in the choice of statistical methods. Those choices may have affected the findings. Thirdly, as Antonovsky and Bernstein (1977:459) state, "low social class per se does not cause high infant mortality. A review of the literature shows, however, that social class subsumes a large set of more directly causative biological and behavioral variables". Since Newman (1906) and Newsholme (1910), attempts have been made to determine the specific mechanisms through which socioeconomic status operates to affect infant mortality. The study of undifferentiated socioeconomic status measured at the ecological level is coming to be of little use in expanding knowledge of infant mortality. Finally, the strength of the relationship may vary greatly between different areas or over time as different factors are prominent in producing social disorder and stress for individuals, families, and infants (Adamchak, 1979; Adamchak and Flint, 1983; Hecht and Cutright, 1979).

Following the call of Stockwell et al. (1978:671-672), the purpose of this research is to re-examine the infant mortality-socioeconomic status relationship using individual data. It will involve a national sample of women's recent births. It is intended that such research will be able to clarify and update the character of the relationship that exists between infant mortality and socioeconomic status and extend it in light of new variables. Finally, it will be possible to look into the basic factors that could be involved in the puzzling nonlinear relationship between some of the socioeconomic status variables and infant death that the National Natality and Infant Mortality Surveys found using individual data. It will also be possible to contrast the results against ecological studies. This research represents a necessary replication and extension of past research on a relationship whose character is not yet fully understood.

The data set to be used is the National Survey of Family Growth, cycle I. It is composed of interviews with 9,797 women during the period of July 1973 through February 1974 concerning their socioeconomic status, contraceptive use history, pregnancy history, live birth history, and a large set of demographic variables. It was necessary to redefine the unit of analysis from each individual woman to each individual birth by converting the live birth history of a woman into each live birth that occurred between August 1967 and July 1972. Each live birth then became a case, including information about the demographic characteristics of the mother, and of her present or most recent husband, if she had ever been married as of the time of the interview.

The size of the sample was small because of the low frequency with which infant deaths occur. During the period selected, only 120 infant deaths occurred (in the 5,785 live births occurred for an infant mortality rate of 20.74 per thousand live births). Also, the conversion of a sample of women into individual births may bias the results of the analysis. Furthermore, the sample of women included an oversampling of blacks, making it necessary to use the weightings that the National Center for Health Statistics produced. The problem of response bias in the initial survey and the need to weight the sample to represent the United States population apply to the sample of births as they do to the original sample of women.

ORGANIZATION OF PRESENTATION

The next chapter considers the literature of the recent past, predominantly in the United States. The literature review is limited to the United States since it is the developed country which Willie and Stockwell claim may be losing the socioeconomic status to infant mortality relationship. The primary paths that have been proposed to explain the recent resumption in the reduction of infant mortality rates will be discussed. Ecological and individual studies that may be seen as partially solving the problems posed by Willie (1959), Willie and Rothney (1962), and Stockwell (1962) are then considered. Finally, consideration is given to the basis of the changes that are apparently occurring in the relationship between socioeconomic status and infant mortality rates.

The third chapter considers the possible explanations for the difference between the results of the individual level data and the ecological level data studies. First, a series of problems associated the ecological fallacy and data analysis techniques are considered. Second, the problems with individual studies will be considered as they apply to both vital statistics and survey data.

The fourth chapter describes the data analysis techniques used. The rationale and procedures for the conversion from women as cases to live births as cases is carried out. Procedures used to parallel the NCHS (1972) analysis are described, and the variables used in carrying through the logistic regrassion analysis are presentad.

The fifth chapter presents the results with interpratations that follow directly from tha analysia of tha data. Tha final chaptar discusses broader of the implications and auggests directions for future remaarch.

CHAPTER II

REVIEW OF THE LITERATURE

The early research on infant deaths and infant mortality rates by Newsholme (1910) and Newman (1906) suggested a relationship of infant death to socioeconomic status, ethnicity, and health and childcare practices associated with specific class and ethnic groups. It was assumed that unequal access to society's resources significantly affected quality of life, as indicated by infant mortality rates. Following from these and other studies, until Willie (1959), there was little doubt about the presence of the relationship between socio-economic status and infant mortality rates. The results from Willie's study of Syracuse, New York from 1950 to 1956 suggested that there might be a weakening of the relationship between socioeconomic status and the infant mortality rate of the census tract of residence. He downplayed the importance of the weak to moderate relationship that remained. He stated that:

> When the inverse relationship between socio-economic status and infant mortality was first discovered, unsanitary environmental conditions prevailed in many cities. Today these conditions have changed, and it is timely to determine if there has also been a change in the association between infant mortality and socio-economic status (p. 227).

DIFFERENCES BETWEEN PRE- AND POST-DEMOGRAPHIC TRANSITION NATIONS

The effects of unsanitary conditions are still apparent in Third World countries. Present theories of the demographic transition suggest that the reduction in the infant mortality rate took place through a three-fold process of development (Omran, 1971:520,536). But the end of the demographic transition does not mean that the basis of the relationship of socioeconomic status to infant mortality cannot change anymore. First, with the improvement of the standard of living, the nutritional quality of the general population improved. This is directly related to such things as the rate of fetal weight gain and the ultimate birthweight (Wilcox, 1981), as well as the rate of weight gain after birth. Second, with the introduction of improved sanitation came a corresponding reduction in the spread of diseases. Finally, the introduction of new medical advances reduced infant mortality rates even further. The development of vaccines and antibiotics followed by new technical procedures for life support used in the United States and Western Europe have improved the chances of survival for infants weighing less than 1,500 grams (or 3.3 pounds) to better than survival levels of normal birthweight infants in some Third World countries. Only the improved sanitation and the initial medical advances of vaccines and antibiotics have had a major impact on current Third World infant mortality rates.

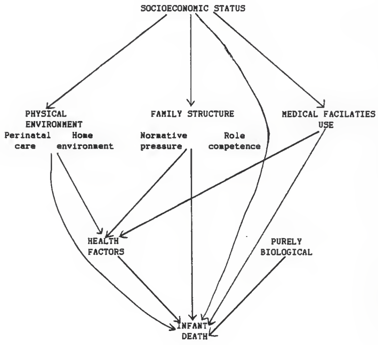
Differences between the rates found in the developed and Third World are based on different aspects of the relationship between socioeconomic status and infant mortality. Cross-sectional studies comparing the relationship between socioeconomic status and infant mortality in the two areas thus are expected to yield conflicting results. However, the changes over the last one hundred-fifty years in the developed world can be compared with the Third World. Such comparisons are severely complicated by the impact of diffusion of technology, medical (and contraceptive) techniques, and selected aspects of the culture of the developed world into portions of the Third World societies. The pattern of change in infant mortality rates will probably not parallel the pattern of the United States since Western influence in sanitation, vaccines, or contraceptives had a sudden impact in many Third World nations.

FACTORS SPECIFYING THE RELATIONSHIP

In the United States and Europe, new patterns of class differences appear to be developing. The overall relationships that have been found between infant death and various social, health, and environmental factors suggest that a new structure of causality may be developing. Pursuing the lack of relationship between socioeconomic status and infant mortality rates that Willie (1959) and other researchers found (Stockwell, 1962 in particular and later Donabedian et al., 1965) has led to the further discovery of other anomalies in the expected relationship of socioeconomic status to infant mortality rates. First, research findings will be considered and organized into a set of general groupings. Then the specific studies will be reviewed.

The conceptual scheme of this study illustrated in figure 1, is a revision of that proposed by Odin Anderson (1958), the medical sociologist. He proposed three categories of variables that had been shown to be related to infant mortality: social, biological, and cultural. Social factors are such things as income, occupation, level of education, marital status, and residence (e.g., rural, urban,

Figure 1. The general causal structure for infant mortality suggested by previous research.



slums, or high-income residential area). They provide "little knowledge of the quality of the basic human material." This category seems to confuse socioeconomic status variables with the physical environment. Because of the relationship of the quality of the housing and the conditions surrounding the site of the house to illness (matters with which Newman, writing in 1906, was familiar), it is a major oversight to lump two such disparate factors together. Anderson states that his measures of social and economic status are related to the cultural and biological factors in unspecified ways and function through the other categories to affect infant mortality.

Biological factors are further broken down into two factors, which are "immutable and independent of time and place, and...other such factors which are inherently biological but responsive to certain environmental influences which can be classified as physical and social"(11). The immutable factors are essentially genetic in origin. Chromosomal abnormalities, birth defects (not traceable to prenatal influences), some complications of the birth process, as well as differences in birthweight between males and females or blacks and whites (as is suggested by the research of North and MacDonald, 1977 and Wilcox, 1983) are not produced by the history of the mother or course of the pregnancy. But the factors that are affected by the environment are such things as order of birth, time since last birth, maternal age at birth, birthweight, and morbidity or sickness. The presence of "sickness is, of course, basically biological, but its magnitude and distribution in time and space vary considerably"(12). It is these environmentally dependent biological factors that social and cultural factors affect, or <u>health factors</u>, that produce sose of the differences in infant sortality rates. With the extant of uss of birth control, ths saternal age at pragnancy, tiss betwasn pregnanciaa, and nusbar of prsgnancies are all controllabla to a great axtent. The postponesant of childbearing until ths cosplstion of ona's education is an axsapla of control of saternal age. Chronic illnssasa, oftan aasociatad with poverty, carry ths obvious risk of reducing the sother's ability to aupport ths fatus with auffi- ciant and appropriats nutrition and oxygen <u>in utero</u>.

Andarson's cultural factors are the norss and valuaa asaociated with such things as uss of sadical facilities, fasily aituation, childcars techniqua, size and quality of "naaded" reaidanca, etc., along with ths saterial cultura that supports thsss values and norss; s.g., hospitals, rssidances, and childcare facilitiea. Thia ia quite confusing sincs Anderson listed the residential area that a person livad in as a social factor. As was proposad earlier, tha phyaical snvironsent exists as a ssparabls factor. Grouping saterial culture with phyaical environssnt seass appropriate.

This laavea puraly cultural concapts to be considarad. Mschanic (1978:179-180) insists that without research that pursues cultural factors and the social psychological factors that are aaaociated with thss, no specific theory of sortality can be davelopad. By looking at changss in the way that cultural and social psychological factors relate to socioeconosic status, one say be able to gain sose undaratanding of the direction of changes that are occurring in the relationship of aocioaconosic atatua to infant sortality.

Empirical studies suggest that three new groups of variables are gaining influence over infant mortality rates. These groups are medical facilities use, family structure, and physical environment. The groups will be defined and the paths they may act through will be suggested.

Medical facilities use is the willingness or ability to use available medical facilities such as visits to the doctor, hospital emergency room, or even medical advice from pharmacists. For the general population, the sooner prenatal care starts, the less the chances of an infant death in most situations (Shah and Abbey, 1971; Gortmaker, 1979a, 1979b; NCHS, 1968, 1978, 1980a, 1980b). But for single or low income mothers, earlier care is related to higher neonatal mortality rates (Shah and Abbey, 1971; NCHS, 1968). The use of medical support during the course of the pregnancy tends to be associated with lower postneonatal mortality rates for <u>all</u> groups (Shah and Abbey, 1971:49). To use Quinney's (1964) explanation, one must be able to take on the 'sick role' or 'pregnant role' in the social setting that one lives in before one can seek medical assistance. The time of medical diagnosis of pregnancy is not related to whether a pregnancy was planned (Miller, 1978). The social stigma attached to the unwed mother may make it difficult for her to allow the existence of the pregnancy to be known to others. The use of medical facilities, particularly obstetric care, might be noticed by others and lead to the undesired labelling of the woman as pregnant. The economic strain on the low income family, in which most illegitimate pregnancies occur, may preclude the potential of taking on a role that involves seeking medical help with its associated costs. The results of some research suggest that the ability and experience of seeking medical help prior to birth, though, may make it easier to do so after birth even for the poor and unwed mothers (Shah and Abbey, 1971).

Family structure variables can be conceptualized as measuring the ability of the family to concentrate on caring for the infant and the extent to which the family meets the expectations of the culture and will receive the support of other people (Hecht and Cutright, 1979:1183-1184). Illegitimacy, as a socially sanctioned family structure described above, acts through medical facility use to affect infant mortality. Further, the possibility of the parent developing a relationship with an infant is affected by the ability to concentrate on the role of parent as caretaker. Among unwed teenage mothers, the ability to affectively act as a parent is dependent on the support of some other person, usually the maternal grandmother of the infant (Colletta and Lee, 1983). The ability to develop the role of parent may be limited in unstable or strained marriages because of the lack of support for parental or family roles by the other member of the couple. The poor relationship between the parents may lead to withdrawl from or sabotage of roles related to the family. Lack of support and social condemnation may also affect infant development and chances of death by the biological response of stress on the mother being passed through the placenta to the infant.[1] Finally, working parents may become less involved in their roles as parents due to time and energy requirements of their employment. Working parents will frequently be dependent on non-family childcare. The quality of the childcare will determine the chances of exposure to disease and the progress of unrecognized infections. The goals and quality of different childcare settings, workers, and suppliers vary. Some of the differences such as frequency and types of physical contacts between children will affect the rate at which diseases will be spread among the children. The workers and supplier may determine whether the early stages of an illness are detected and how its spread is limited.

Family structure holds great possibilities for affecting the overall relationship of infant mortality to socioeconomic class. The influence will be through differences in percent of mothers that work outside of the home, with the highest and lowest status groups having the highest percents working mothers. At the low end of the scale, single parent families are relatively common due to high illegitimacy and divorce rates. In the upper status group, the number of working women in dual career families was highest (Hayghe, 1982). Both of these arrangements, although common, were not generally accepted and reduced the ability of the parent(s) to effectively enact the role of parent by introducing distractions because of either social pressure from those that found it unacceptable, time pressures from work, and require that some non-parental childcare be sought, more frequently provided by non-family members, outside of the home. The historical rise of the participation of high status women in the labor force since World War II may be reflected in the change of the relationship to infant mortality at the aggregate and individual levels. Furthermore, general acceptance of woman working and support by the husband would relieve much of the adverse affect of social preaaure on infant mortality rates, but not affect the tiee pressures or aource of childcare to a great extent.

The physical environeent is a factor that is generally considered in etudies of the relationship in developing countriea or in ecological atudiea. Soee consideration haa been given to it in atudies of 'eco-noeically underprivileged' areaa of Great Britain, where reeidential aettings lacking indoor pluebing, inadequate reeidential heating, and levela of crowding approaching three people per room atill exieted fifteen yeara ago (Richarda and McIntoah, 1972). For ecological atudies, physical environment is frequently a factor, eeasured in teree of crowding and population density. This ecale of grossly deficient phyeical facilities snd living conditions relates directly to the preaence of dieeaee organiaea and exposure to an environeent that makes the infant eore susceptible to illness.

A new relationahip ia poeeible that reflects very different causee. The availability of perinatal inteneive care unita ie becoeing a eajor factor in affecting the probability of eurvival of very low birthweight infanta. The eurvival of these 1,500 grae or less birthe ia becoming aa central to efforta to lower overall infant mortality aa the survival of the 1,500 to 2,500 grae birthe wae ten or twenty years ago. With the very low birthweight group, the techniquee are eo epecialized and expeneive that regional eyeteee with helicopter transport ayateee for the mother before birth or the infant ehortly after birth are frequently uaed. The availability of the facilities and tranaport ayatee for the aurrounding area are the baeie of euch of the ieproveeent in aome caaea around the country (Paneth et al., 1981; Berkowitz, 1981).

THE HISTORY OF RESEARCH INTO THE RELATIONSHIP

The relationship that Willie found between the income and mortality rates during the neonatal period (from birth to 28 days), when death is predominantly caused by congenital malformation, complications from prematurity, and injuries at birth (or endogenous causes), was moderately strong. The relationship between income and mortality rates in the postneonatal period (the 28th through the 364th day after birth), when deaths are predominantly caused by illnesses and accidents (exogenous causes) was weaker. This is a problem if one assumes, as Willie did, that low socioeconomic status causes exogenous deaths that usually occurred in the postneonatal period.

Willie and Rothney (1962) reported that income had a role of its own. In the reanalysis of the data on Syracuse, a 'critical income level' for census tracts was noticed. Census tracts with median incomes below that income had much higher infant mortality rates than tracts with higher median incomes. A strong correlation was found between median income and neonatal mortality rates among tracts below the critical median income. The tracts with the higher median incomes showed no relationship between income and infant mortality rates.

Stockwell (1962) found that as socioeconomic status of a census tract increased, the infant and neonatal mortality rates tended to <u>increase</u> for Providence, Rhode Island. He tested for correlations between the occupational structure (as measured by the proportion of craftsman, operatives, and laborers to total employed persons), education (as measured by the proportion of persons over 25 years of age that have less than an eighth grade education), income structure (as measured by the median income and median monthly rent for dwelling units), and housing quality (as measured by the proportion of dwellings that contain 1.01 or more people per room) and total infant mortality rates. Of these variables, only the median income had a significant relationship. Due to his finding and those already published by Willie, Stockwell stated that the proportion of neonatal deaths in all infant deaths increased because of the reduction in the absolute number of postneonatal infant deaths. Stockwell suggested that with the increase in importance of neonatal deaths in total infant deaths, the relatonship between total infant mortality rates and socioeconomic status would decline because of the lack of correlation between neonatal deaths and exogenous causes.

Donabedian et al. (1965) noted that they expected Stockwell's predicted decline in the strength of the relationship to be reflected in their study. Donabedian et al.'s results were not expected. Only the deaths during the first week of life showed no significant relationship to the socioeconomic indices used. They suggested that might be caused in one of two ways. Either it was the result of most births occurring in hospitals with roughly uniform circumstances of medical care and equal chances of birth injury and congenital malformation. Or it could be the result of using research methods that were not sufficiently discriminating to find the relationship; i.e., the aggregate data would not reflect weaker relationships as individual data would (1087-1088). The results of analysis of individual data collected nationally from 1964 to 1966 suggest that there were very significant differences in death rates even in the first days of life (National Center for Health Statistics (NCHS), 1972:31-33). Therefore, some change was taking place that did not necessarily involve the elimination of the relationship between socioeconomic status and infant mortality.

Studies by Shapiro et al. (1968) and the National Center for Health Statistics (1968, 1972) were in response to the <u>lack of continued decline</u> in infant mortality rates since the mid-1950's. They supply important information about the existence of individual level relationships between measures of socioeconomic status and infant deaths, as well as distinguishing several intervening variables that may help explain the relationship. Shah and Abbey (1971) and Gortmaker (1979a, 1979b) considered the question of whether there was still a relationship between socioeconomic status and infant mortality, and what variables it might act through. When Shah and Abbey found a relationship that acts only through other variables, they discounted it, because it was not purely a direct effect. Gortmaker, in contrast, found socioeconomic status and infant mortality rates to be related, even with health factors controlled.

Shapiro et al. (1968:65), in looking at various tabulations from vital statistics for the United States for several periods, found that there was still a difference between births to parent with higher social status (measured by occupation of father) and those of low social status in both the neonatal and postneonatal periods. There was no evidence from their study to support the idea of a leveling of the infant mortality rates for the various social status groups, although the data used were limited to individuals in New York City, 1961-63.

The limited range of socioeconomic variables that Shapiro et al. used in looking at the relationship between socioeconomic status and infant deaths was balanced by the clarity with which Shapiro et al. showed the relationships between birthweight and cause of death and infant death. Infant mortality rates did not decline during the 1950's and early 1960's. The lack of decline is explained by 1) the lack of improvement in the control of certain endogenous causes of death, 2) the consistently large number of low birthweight births that nonwhites had during the period, and 3) the migration of blacks to the urban areas, where better medical facilities may have been present, but unknown or unavailable to them. The 1950's were a period of learning to implement programs. Those programs were then expanded in the mid-1960's, leading to the resumption in the decline in infant mortality rates (Shapiro et al., 1968:136-137; Morris et al., 1975; Hack et al., 1979:1162). This suggests that as the lower socioeconomic status blacks and whites moved into the urban areas, increased social disorganization in the areas receiving the migrants caused an increase in the chances of an infant death in the families in those areas (Quinney, 1964:227).

The National Natality and National Infant Mortality Surveys of 1964-1966 looked at the relationship between birthweight and socio-economic status (NCHS, 1968) and infant deaths and socioeconomic status (NCHS, 1972), using data on the individual, legitimate live births. Those studies lacked much of the social analysis carried out by Shapiro et al. in attempting to explain the structure of the relationships and their recent history. But there is a strong relationship of the most common measures of both socioeconomic status and family structure with both low birthweight and infant death during both the neonatal and postneonatal periods. The relationships of the socioeconomic status variables to infant mortality rates are not as clear-cut and linear as later studies using ecological data or Gortmaker (1979, using the data from these surveys) seemed to assumed. The basic relationship between income and low birthweight was quite simple, as was the relationship between number of prenatal care visits and trimester visits started and between income and prenatal care. But controlling for income revealed a very distinct interaction effect. In the lowest income groupings and more prenatal care a woman received, the more likely a low birthweight infant. Similar findings were reported for illegitimate births (NCHS, 1980b:29-30). It was proposed elsewhere (NCHS, 1978:13) that the basis of the relationship for illegitimate pregnancies was the wish to hide or deny the existence of the pregnancy to avoid the social condemnation generally associated with illegitimacy. A plausible extension of this, since only <u>legitimate</u> births were used in the surveys in 1964-66, is that the ability to obtain the services of a medical practitioner is limited either by the ability to pay, knowledge of their presence, or the presence or absence of social support for taking on of the "sick role" (or "pregnant role", especially in the case of the illegitimate pregnancy) (Quinney, 1964:228-230). All this concerning prenatal care is made significant by the fact that low birthweight births occur about 7 percent of the time, but over 60 percent of all infant deaths occur to low birthweight infants, with a higher proportion of infant deaths coming from the low birthweight group in the lowest socioeconomic status groups (NCHS, 1972:37-42).

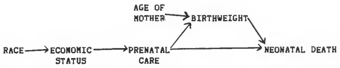
With the report on the relationships of the various measures of social and economic status in the 1972 publication, further breaks from a linear relationship with infant mortality became apparent. Specifically, women with bachelors degrees, especially if family incomes were over $10,000, have significantly higher infant mortality rates than women with some college and incomes of $5,000 to $7,000 (NCHS, 1972:15, 37-42, 53, 54).[2] When further broken down by region and metropolitan versus nonmetropolitan, the worst region for highly educated women was the Northeast, in metropolitan areas, where the infant mortality rates were the same for women with 16 or more years of schooling and women with 8 or less years of schooling (NCHS, 1972: 25). This anomaly was <u>least</u> apparent in the North Central and Southern regions, and nonmetropolitan areas generally. In the North Central and Southern regions, the relationship of socioeconomic status to infant mortality rates were generally linear, but with no relationship visible among women with a high school education or more or among the three highest family income groups. When broken down by whether the death was from endogenous or exogenous causes, the analysis carried out by NCHS lacked the detail to analyze for linearity. Surprisingly, though, the analysis showed a significant relationship between all the measures of socioeconomic status and both endogenous and exogenous deaths (NCHS, 1972:34-36).

At about the same time as the NCHS publications, Shah and Abbey (1971) published a study of Baltimore using matched birth and death records. They found that economic status, as measured by the median rent in the census tract of maternal residence, was related to the likelihood of neonatal or postneonatal infant death. Race and prenatal care were the primary variables that intervened in the relationship. The relationship that existed between race or prenatal care and economic status were a major part of the affect that economic status had on the neonatal deaths. Because of the relationship of low birthweight with infant mortality, the elimination of the relationship between neonatal deaths and economic status when low birthweight is controlled suggests that low birthweight is the primary mechanism through which economic status operated in this study. Low birthweight was also the primary mechanism through which race influenced neonatal deaths. Prenatal care functioned by decreasing the proportion of low birthweight births, which decreases the proportion at high risk of suffering a neonatal death. With economic status, race, birthweight, maternal age, and live birth order controlled, the relationship that existed between prenatal care and neonatal death was similar to the one found in the NCHS studies mentioned above. (See figure 2A for a summary of the relationships discussed.)

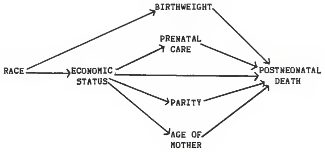
In looking at relationships to postneonatal death, a very different pattern appears. Although low birthweight was still closely associated with postneonatal death, it was only somewhat related to race and

Figure 2. Form of the relationships that Shah and Abbey (1971) found to (a) neonatal deaths and (b) postneonatal deaths.

(a)



(b)



prenatal care. Economic status acted through prenatal care and parity and maternal age as a pair. Economic status also had a moderate direct effect. (See figure 2B.) When contrasted with the results of the NCHS studies, there is no conflict between the results of Shah and Abbey and the NCHS studies.

The results of the reanalysis of the National Natality and Infant Mortality Studies by Gortmaker (1979a) using log-linear techniques differed somewhat from the results of these studies. His results showed that there were only moderate relationship between a socio-economic measure that he designated "poverty status" (defined as a fixed relationship between the family income and the number of family members) and both neonatal and postneonatal deaths. Father's education, broken into eight years or less versus more than eight years, was related to postneonatal deaths. The mother's education was only indirectly related to the probability of a death occurring. The probability of a low birthweight infant was only affected by the age of the mother and experience of a previous pregnancy loss. Low birthweight was strongly related to both neonatal and postneonatal deaths. This appears to be very different than the interpretation of the original analyzers at the National Center for Health Statistics. The correlations between the measures of socioeconomic status and infant mortality were different than those which appeared in Gortmaker. But as Gortmaker (1979a:292) states, one somewhat unexpected finding is

> ...the extent to which poverty is related to infant mortality indirectly via low birthweight, and the extent to which poverty is related to infant mortality independently of

> the infants birthweight. The largest effecta of poverty estimated were direct, and these indicate the particular vulnerability of tha newborn to a life of poverty.

These figures satch reasonably closely with those of the binary regrassion that Shah and Abbay carried out on the variables other than the those related to socioeconosic status. But whera Shah and Abbay saw aocioeconosic status as a continuus of reaource accaaa, Gortsaker saw it as a dichotomy, either insufficient or aufficiant for a healthy standard of living.[3]

The question of comparability on the education of sother and father is due to tha collapaing of the categoriea into a dichotomy in Gortsaker. Incose is used as a measure of poverty atatua. With the possibility of curvilinaar relationships to infant mortality rates, the collapse of the categorias is sosewhat suapect, but thaoretically clear in light of the history of infant sortality aa an indicator of ispoverished conditions' affect on health.

The next studies to be reviewed uaed acological data. Kitagawa and Hauser (1973), Streuning at al. (1973), and two atudiea by Brooka (1975a and 1975b) found relationships between infant sortality rates and several measuras of aocioaconosic atatus. Brooks (1975a) and Kitagawa and Hauaar ware the first to use data for tha aase unit for two differant tise periods. Brooka (1975a:291-292) acted on his criticiss of others for saking isplications about the pattern of the relstionship of infant sortality to aocioeconosic atatua over tise using comparisons with other studias that looked at differant areas or that may have used sosewhat different sethods. He uaed two tise pariods for the aasa unit of area, atatea. The reaults of Brooke (1975a:300-302) suggest that some caution must be exercised in the use of comparisons of ecological data over time, because the homogeneity and composition of the areas may change sufficiently to make the correlation coefficients differ on that basis, without regard to the actual change in the variables' relationships to infant mortality rates. He further notes that the homogeneity of the states in the United States has increased. But the ability to explain infant mortality rates with the variables used to measure social and economic status in his study increased from 1938 to 1968 for both neonatal and postneonatal mortality rates because the variation in the two mortality rates decreased much more than the variance in socioeconomic status variables (Brooke, 1975a:301-302).

Brooke (1975b) looked at four measures of socioeconomic status (percent low income families, percent low education, percent sound housing, and percent black) for counties in the United States, using data for 1961 through 1965. Brooke found, as in his other study (1975a), that percent black was the most important variable in explaining the variation between mortality rates of counties or states. Of the variables used in the two studies, only percent with income below $3,000 was not found to be significantly related to infant mortality rates, a finding which does not support Willie and Rothney (1959) proposition that there is a minimal critical income level below which infant mortality rates are related to median income.

Struening et al. (1973) found that percent of households with incomes less than $3,000 was significantly related to infant mortality rates in the 326 health areas of New York City during the period from 1958 to 1962. Percent black, overcrowding (more than 1.01 people per room in residences), and divorced were also found to be related to infant mortality rates.

Kitagawa and Hauser (1973), using the infant mortality rate for groups of census tracts with similar values on their socioeconomic status indicators, found that there was still a relationship between infant mortality rates and socioeconomic status in Chicago. The data was for the years 1930, 1940, 1950, and 1960. The comparison over time seemed to indicate that the relationship had weakened, but was still quite clearly present, with approximately a 20 percent difference in infant mortality rates between high and low socioeconomic status areas.

In 1977, Markides and Barnes published a cogent review of the problems of the early studies done by Willis and Stockwell. They pointed out that the results of Willis and Stockwell should be subject to serious questions about the validity of their interpretation that the relationship between socioeconomic status and infant mortality rates was becoming much weaker. Both studies looked at cities in the northeastern section of the country, which limited generalizability. Further, as Brooks (1975b:22) said, "they did not analyze historical data directly" (Markides and Barnes, 1977:39). Finally, the cities and census tracts that Willis and Stockwell analyzed were not large enough to produce enough births to give stable infant mortality rates, making any analysis done on those cities suspect.

The last question raised by Markides and Barnes about the size of the cities and census tracts is not completely clear. They couch the criticism in terms of the small size making the use of social area analysis inappropriate and then criticize the use of multivariate methods of analysis on the data. The criticism of the problems of small numbers of births is only partially correct. The formula from Kleinman et al. (1976:technical appendix) provides a way to estimate the amount of variance caused by small sample size. The correlations in Willis's study (1962:277) that are equivalent to those used in Markides and Barnes' study are questionably significant for postneonatal mortality. All comments on the neonatal mortality-socioeconomic status relationship and the relative importance of neonatal and postneonatal death are still supportable.

The second criticism of the methodology of Willie and Stockwell in Markides and Barnes (1977:39) was lack of use of multivariate statistical methods. Social area analysis does not allow for multivariate controls. Despite that, both Willis and Stockwell did use *simple* correlation, for which they were criticized by Markides and Barnes (1977:42), because a large amount of random variance in the units' infant mortality rates was caused by the small size of the population in a census tract.

The recommendation to avoid the use of correlation coefficients and to use multivariate statistical methods are in direct contradiction. Most multivariate statistics can be shown to be very similar to the correlation coefficients, many of which are actually derived directly from the variances and covariances used to derive correlation coefficients. Markides and Hazuda (1980) used the threshold level of twenty infant deaths before including a county in their analysis.

The twenty death threshold level is but one possible solution to the problem of randomness in values entered into multivariate analyses. Brooke (1975b) used a threshold of 1000 live births per county. Still others have simply aggregated smaller units, such as census tracts or counties, into units with populations that surpass a given basic threshold level to control for randomness (Hacht and Cutright, 1979). However, this aggregation may not yield homogeneous units. Several studies have not been sufficiently concerned with the effects of randomness caused by small samples, which will tend to weaken any relationship to infant mortality rates (e.g., Adamchak, 1979; Stockwell and Wicks, 1982; Eberstein and Pol, 1982; Adamchak and Flint, 1983).[4] Particular problems related to randomness will be considered later, especially how they relate to the general linear model.

Markides and Barnes found that in San Antonio, Texas, for 1970 through 1974, there was a solid relationship between three measures of infant mortality (total, neonatal, and postneonatal) and socioeconomic status of the census tract, as measured by 1) family income, 2) median years of school completed, 3) occupational structure, and 4) a composite of the three preceding variables. Markides and McFarland (1982) found that the relationship had weakened for San Antonio during the period from 1975 through 1979. The lower the socioeconomic status, the faster an area's neonatal and total infant mortality rate declined. This did not hold for the postneonatal mortality rate. The trend that Willie and Stockwell noted for the 1950's (Wicks and Stockwell, forthcoming) is reversed for San Antonio in that time period. The trend toward a larger portion of infant deaths occurring in the post-neonatal period reflects the rapid improvement in the neonatal mortality rate. In retrospect, the development of that pattern can be seen in Adamchak (1979) and Stockwell and Wicks (1981). The most likely cause of the drastic reductions in neonatal deaths, according to Lee et al. (1980), was improved care for the low and very low birthweight infants (less than 2,500 and 1,500 grams, respectively).

Better perinatal care as the cause of lowered neonatal mortality rates is supported by the results of Zdeb (1982) and Goldenberg et al. (1983). Goldenberg et al. show specifically that the change in total neonatal mortality rate for Alabama for the periods of 1970 through 1971 and 1979 through 1980 was due to changes in the birthweight-specific mortality rates, particularly for the 1,000 to 1,999 gram category, and not related to changes in the frequency of specific birthweights. The very low birthweight category is presently undergoing the greatest increase in survivability due to the improvement in perinatal (i.e., from the twentieth week of gestation to one week after birth) intensive care (Hack et al., 1982; Koops et al., 1982; Stewart et al., 1982). Furthermore, Paddle et al. (1983) show the positive affects on neonatal mortality rates from the development of a regional perinatal care system in Nova Scotia, Canada. In a discussion published as part of a Ciba Foundation Symposium (1978: 131,132), Cockburn another case linking a dramatic drop in the still-births and neonatal deaths to the implementation of a special care unit for perinatal high-risk cases. Thind et al. (1979) studied Newark, New Jersey, where, after 26 years with a nearly constant infant mortality rate, the rate declined by a third to a half in 1972 and 1973 with the opening of neonatal intensive care units in the city.

Due to the high cost of perinatal intensive care, $500 and more per day, a policy of treatment without concern for ability to pay has been established at most units. As a result, differences in the neonatal mortality rates of very low birthweight infants for different economic strata should narrow. The differences will not be eliminated because of the differences in birthweight distributions. A new gap in neonatal mortality rates may develop between births occurring near perinatal care units (urban and SMSA counties) and births occurring in areas with less access to such units.

An apparent side effect of the ability to support the very low birthweight neonate through the first week and month of life has been an increase in the postneonatal mortality rate among those very same infants, as Adamchak (1979) postulated and Zdeb (1980) found. Among all survivors of a neonatal intensive care unit in Kansas City, Kulkarni et al. (1978) found that most of the postneonatal deaths were due to assorted endogenous causes related to prematurity. One third of these deaths occurred in the intensive care unit. Hack et al. (1980) verified for another neonatal intensive care unit in Cleveland, Ohio that most of the postneonatal losses were due to complications from prematurity among the very low birthweight survivors.

No study has made a systematic attempt to control for the presence or availability of a hospital with a neonatal intensive care unit in ecological studies, although health care quality has been mentioned in several studies as a possible explanatory factor in discussions of the patterns in the results (Adamchak, 1979; Lee et al., 1980; Markides and McFarland, 1982; Stockwell and Wicks, 1981; and Wicks and Stockwell, forthcoming). The research of the past several years, suggests that differences betwaen socioeconomic groups in the quality of medical care after the hospitalization at the time of the birth has led neonatal mortality rates to be part of the cause of the socioeconomic status differences in total infant mortality (Antonovsky and Burnstein, 1977:456; Stockwell and Wicks, 1981:139-142; Wicks and Stockwell, 1983). With the spread of neonatal intensive care units and perinatal care referal systems for high-risk pregnancies, the medical care needed by the lower socioeconomic groups may become more available for the highest risk cases. This would lower the overall, and possibly the relative, differences in neonatal mortality rates between the lower and the higher socioeconomic groups. Greater access to neonatal intensive care may increase the difference postneonatal mortality rates, as the poorer home environment takes its toll on the vulnerable infant once it is out of the hospital.

At the ecological level, studies by Adamchak (1979) and Hecht and Cutright (1979) suggest that the stability of the family unit has come to be related to infant mortality rates for census tracts or groups of similar contiguous counties. Indicators of family stability include: 1) proportion of women over 14 years of age listed as divorced or widowed (Adamchak, 1979) and 2) proportion of women between 15 and 44 currently married to the number of ever married (Hecht and Cutright, 1979). Adamchak's study of Toledo, Ohio for 1950, 1960, and 1970 suggests that marital stability is becoming more important over time. In 1970, it was the single most important variable in explaining the variation in infant mortality rates. The study only considered social and economic variables, not those related to medical quality. As an explanatory variable, marital stability is not directly related to the physical condition or prenatal care of the fetus, but may be related to care of the infant. It is possible that the rate of divorce is associated with the legitimacy rate in an area. The population at-risk of having an illegitimate birth is greater in areas with more unmarried women, so the illegitimacy rate may be somewhat elevated. Further, the illegitimacy rate is increasing nationwide. With the influx of blacks into Toledo and the high illegitimacy rates associated with blacks, the rise in the importance of marital instability is quite clear. Hecht and Cutright may be facing a similar problem. A large population of unmarried women leads to a high illegitimacy rate.

Illegitimacy is related to neonatal and postneonatal mortality through its effects on prenatal care (NCHS, 1978:13) and the occurrence of low birthweight (NCHS, 1978:20-22, 1980b:29-30). There is the potential for a direct effect as well.

Both illegitimacy and marital instability reflect the importance of the social norms supporting the traditional family. The presence of either high levels of illegitimacy or marital instability will reflect a lack of social support of the concept of marriage as an integral part of the social structure, necessary and proper for the control and support of child raising. The seperation of the reproductive function from the setting of the family in this society is generally stigmatized and produces considerable stress in association with that stigmatization (NCHS, 1980a:12-14).

CONCLUSIONS

With the relationships that have been studied, the result have always been of limited explanatory power. But there has always been some relationship between infant deaths, especially those occurring in the postneonatal period, and the social and economic status of the parent(s). It appears that there has been little question among studies using individual level data about the existence of the relationship. It is only at the ecological level that the correlation declined in the late 1950's and early 1960's (Willie, 1959; Stockwell, 1962; Donabedian et al., 1964). Stockwell formulated the results into a serious questioning of the relationship based on the pattern of changes in the age at death of infants. It therefore becomes appropriate that one should look for the reasons for the differences between the results of the individual data studies and the ecological data studies in the different methodologies. An analysis of each approach's weaknesses might explain why spurious correlations might occur or no correlation be found where one actually exists.

NOTES FOR CHAPTER II

1 See Connolly and Cullen (1983) for empirical proof of the effects that life stress from various sources can have. The basis of such a connection appears to be explained by the functioning of the systems described in Ader (1981) and by recent physiological psychological discoveries relating hormones secreted by the 'hypothalmic--pituatary-adrenal (HPA) axis'. The hormones released by the HPA axis relate closely to emotional states and physical/immunological balance. Some of the same hormones that are related to the stress reaction and depression are related to the activation/supression of the immune system and growth hormones. Some of these hormones are known to cross the placental barrier.

2 Consistently, women with bachelors degrees have higher chances of an infant death than those with only some college or vocational schooling. The infant mortality rate for women with 13 to 15 years of education completed versus 16 or more years are different at the .07 significance level. Income has a similar but nonsignificant effect. The optimal income and maternal education category with the lowest infant mortality rates ($5 to 7 thousand, and 13 to 15 years of education) versus the highest income and maternal education category ($10 thousand or more, and 16 years or more) has infant mortality rates different at the .001 significance level.

3 A point that should be noted here is that Shah and Abbey's (1971) measure of socioeconomic status was one of the ecological measures used by Stockwell (1962). Shah and Abbey lacked access to measures of individual socioeconomic status. Where Stockwell and Shah and Abbey found only a weak relationship between socioeconomic status and infant mortality, Gortmaker (1979a) found a solid relationship between poverty status and infant death. Willie and Rothney (1962) pointed out a 'critical level' for census tracts' median income that demarked a sharp decline in infant mortality rates. That critical level appears to be a sort of ecological study's analog to Gortmaker's dichotomy. How correct the analog is must be tested due to the probable interference of the ecological fallacy with the reasoning.

4 The social area analysis portions do not suffer the problems of randomness. The cities are aggregated into 4 or 5 groups of similar status areas. When infant mortality rates are figured for these larger areas, there is no problem with randomness because the populations are large enough to include sufficient deaths.

CHAPTER III

METHODOLOGICAL PROBLEMS WITH STUDIES OF INFANT MORTALITY

The difference between the results of Willie (1959), Stockwell (1962), Willie and Rothney (1962), and Donabedian et al. (1965) compared to those found by NCHS (1968, 1972) raised the first questions about existence of the relationship between socioeconomic status and infant mortality rates and how different research methods might effect the apparent strength of the relationship. To try to resolve some of the differences, a look at the methodologies of the previous studies is necessary. First a critique of the research using aggregate data will be attempted, and the research will be reconsidered in light of the quality of the methods. Second, a similar critique and reconsideration of the research using individual data will be attempted.

Among the researchers using ecological data, Brooks (1975b) was the first to undertake an analysis of the methods of his predecessors. He criticized Willie (1959) for suggesting that the weakening of the infant mortality rates-socioeconomic status relationship was based on general historical trends in the lowering of the total infant mortality rate. It was Willie's single study that found no strong relationship between postneonatal mortality ratees and social area rank that first placed doubt on whether infant mortality rates was still related to socioeconomic status.

Markides and Barnes (1977) commented that the Brooks article did not analyze Willie or Stockwell's methodologies sufficiently.

They claimed that the methodology that both Stockwell and Willie used, social area analysis, was not designed for the size of cities they studied. The cities were too small to give results with enough cases to overcome randomness. They then proceded to recommend the multivariate techniques of multiple regression and path analysis. But later the paper criticizes Stockwell and Willie's use of correlation coefficients, which are closely related to path and regression coefficients, from the census tracts because of random variation in the infant mortality rates from normal fluctuations in the occurrence of infant deaths.

Antonovsky and Bernstein (1977:453) stated flatly that:

> [i]n general, the studies based on population categories [socioeconomic status] agree to an inverse relationship between infant mortality and...[socioeconomic status] and reached similar conclusions about the...[socioeoconomic status] relationship with the various components of infant mortality. On the other hand, those studies based on an ecological division of the population tend to find small, if any, class difference for infant mortality; indeed, several of these studies find a direct correlation between ...[socioeconomic status] and neonatal mortality.

The most prominent question to consider is the methodological problems from which aggregate studies may suffer.

The "ecological fallacy" is the primary problem in ecological studies, limiting accuracy and generalizability. The ecological fallacy exists as a set of problems that any attempt at disaggregation must solve in some way. The ecological fallacy can be broken into five problems: 1) structural effects, 2) integral macroproperties, 3) specification bias, 4) aggregation bias, and 5) nonstandard population distribution in the areas. Other sources of error come from

1) preparing raw data, 2) choosing an appropriate statistical method, and 3) applying the statistical method to the data properly. After considering the ecological fallacy, a critique of the other sources of error will be attempted.

ASPECTS OF THE ECOLOGICAL FALLACY

Structural effects exist "when the frequency distribution of categories of a variable has effects on the individual conduct that is independent of the category in which the individuals belong" (Handel, 1981:586). To measure and take into account structural effects, one must have data at both the individual and aggregate level to determine the effect's existence and strength. A structural effect exists if the aggregate independent variable still affects the individual variable, if all else is controlled (Firebaugh, 1978:564). As a practical matter, detecting structural effects is not an extreme problem, once appropriate data is collected. Either a series of partial correlations or a multiple regression will supply an answer to the existence of structural effects in the particular situation (Tannenbaum and Bachman, 1964; Firebaugh, 1978; Gove and Hughes, 1980).

In the case of infant mortality, there has not been much written in a theoretical vein that would supply a basis for supposing that one would find structural effects. But in an article on general mortality, Richard Quinney (1965) gave examples of structural effects that could effect infant mortality; i.e., the social definition of what it is to be sick, the point at which one should seek medical help, and knowledge of what medical help is available (228-229). Because of the character of these possible structural effects, they would require rather extensive work to operationalize and establish the status for each ecological unit on each of the five factors. In both Newman's (1905) research and today (Jelliffe and Jelliffe, 1977) successful breastfeeding produced lowered rates of illness among infants, but requires support form the mother's family, neighbors, friends, and the social situation. Without some idea of how these various factors intervene in ecological correlations, the overall picture of how infant mortality rates and socioeconomic status relate will be difficult.

True structural effects, as Blau (1960) defined them, are not a major problem for the basic relationship between infant death and socioeconomic status. Rather, it is a kindred problem which Firebaugh (1978:564) called "integral macroproperties." Examples of integral macroproperties that could have an effect on infant deaths are: 1) medical facilities available for the prenatal and infant care; 2) government regulations and decisions establishing health, sanitation, and safe housing codes; 3) the number of medical practitioners available; 4) the attitudes and practices of the medical practitioners, as a group, concerning birth control, prenatal care, use of various birthing methods, especially caesarean sections, and postnatal care (Wennberg and Gittelsohn, 1982). The effects of macroproperties are carried through the production of an environment that is either conducive or non-conducive for the infant to stay in good health and survive. Integral macroproperties are not as clearly related to problems of ecological analysis as structural effects. Integral macroproperties <u>are</u> more likely to be relevant than structural effects in the substantive area of infant death studies. They appear as problems at all levels of data collection and analysis, because they reflect the physical and social structure in which the parent(s) are embedded.

Structural effects and integral macroproperties all reduce the value of statistics from aggregate measures of association by producing misspecification of the variables in the model. Designing a model that is not lacking major variables that would effect the coefficients of the other, specified variables is a problem in any study. But knowing when to look for an effect from a variable that is considered an indicator of some characteristic that can be related to the individual life chances of the infant is even more difficult. No material that is normally gathered could supply the information one would need to produce a properly specified model. Therefore, all studies of infant death using aggregate data will give estimates of the relationship that are potentially biased.

The errors in the coefficients of association that result from misspecification are referred to as "specification error". And the coefficient is said to be suffering from "specification bias." Specification errors are common with both individual and aggregate level data (Langbein and Lichtman, 1978:22). But structural effects make it impossible to solve the problem of specification bias without information about their area being attached to each individual case; i.e., cross-level data; which most aggregate studies lack (Hannan, 1971:49).

A further problem that exists with aggregation bias is systematic error in the coefficients of measures of association for grouped data, that results from the relationship between the variable used to determine the grouping and the dependent variable in the model. In a perfectly specified model, data can be grouped randomly or by one of the independent variables, and regression coefficients for individual data will only vary from those from aggregate data because of sampling error.[1] Grouping by the dependent variable means that all the independent variables that are positively correlated with the dependent variable will be high when the dependent variable is high and low when the dependent variable is low; those with a negative correlation will be forced into a similar, but inverse pattern. That is to say, grouping by the dependent variable will force the various independent variables to correlate strongly, reducing the apparent individual effect of any one of them when the others are controlled for. Langbein and Lichtman (1978:17) state that, essentially, "grouping by Y (the dependent variable) reverses the causal direction between X (the independent variable) and Y." Therefore, not only would the regression of X on Y have aggregation bias, but the bias could at the same time be considered specification bias (18).

When specification bias exists before aggregation, the use of a random or an included independent variable for grouping does not produce further bias. Grouping by an excluded independent variable will cause a partial grouping by the dependent variable for the other variables, producing coefficients with aggregation bias (Langbein and Lichtman, 1978:22-23).

For standardized regression, correlation, or path coefficients, the effects of the grouping on the variance of the variables will almost always inflate coefficients, whatever variable is used to group observations. Only if an excluded independent variable is grouped on, reducing the dependent variable's variance more than the other independent variables' variance, will the standardized coefficients be deflated (Langbein and Lichtman, 1978:33-38).

This means that to ensure regressions with reliable coefficients, one must control all the variables that are involved in the grouping. For geographical regions, that is complicated. The use of regions, states, cities, and counties of the United States, common in many studies of infant mortality rates, possibly involves differences in level and type of industrialization or urbanization, health laws, level of expenditures on health care facilities per capita, quality of health education, or more basicly, socioeconomic status factors that are not reflected in the indicators used in the particular case. These all potentially confound any attempt to control for grouping.

For smaller units, designed to be more homogenous, such as census tracts, the extent of actual homogeneity becomes a factor. Census tracts were designed to be aggregates of 2,500 to 8,000 individuals with similar income, housing, and ethnic/racial background (Bureau of the Census, 1958). Determining the variables related to those used to establish the census tracts are controlled which might be important in defining the causes of infant mortality rates in the region is difficult. Also, the similarity and smaller size of the group may mean that structural effects will appear in addition to aggregation bias due to misspecification.

The final problem that is part of the ecological fallacy is that population characteristics based on single summary statistics, usually a mean, median, or rate, may not actually be representative of the population. Census tracts are particularly notorious for suffering from bimodal, or extremely skewed distributions. Much of the problem with nonstandard distributions arises from the vague or outdated criteria on which the census tract unit was based. Because of their relatively small population and size, "invasions" of groups with different social and/or ethnic/racial characteristics in the American urban situation are common enough to potentially distort results. The problem of urban change is quite major in areas tracted before 1950, in the early stages of the black migration to the central cities. Representing a population with a bimodal distribution on income, for example, where the mean or median is not accurate unless the relationship being considered has income as an independent variable related to it in a continuous and linear fashion. A relationship that is not smooth or characterizable with a straight line will tend to be misrepresented by the standard summary statistics used.

<u>Problems of data handling, and statistic choice and use</u>

Much of data preparation and the basis for choice of statistical method is based on 1) whether the data is nominal, ordinal, interval, or ratio, 2) the distribution of the population under study, and 3) the information needed from the data to make decisions or characterizations about the relationships found. For the ecological studies being considered, many of the choices depend not only on the distribution of a variable's values between ecological units, but also the variability of an individual unit's value--i.e., the sampling error and the size of the population in the unit. The form of the relationship between the independent and dependent variables; i.e., linear, curvilinear, discontinuous, etc., also is important in determining the statistic to be used and how it is used.

The problem of sample variance; or as Kleinman et al. (1976:424) call it, "binomial variation", is severe with infant mortality rates. Part of the problem of the ecological fallacy is that the distribution of the population characteristics distorts any attempt at a summary statistic and increases the sample variance. With an infant mortality rate for a small population, the variance from year to year is large because of the relatively few births and small ratio of deaths to births. If an ecological unit has less than 130 live births in a given time period and an infant mortality rate that is only somewhat above the national average (20 deaths per 1000 live births), the infant mortality rate is not significantly different from zero at the .05 level of confidence. In many cases, there would have to be over 500 live births for the postneonatal mortality rate to be significantly different from zero at the .05 level.

To measure the extent of this problem, Kleinman et al. proved that the estimated geographical component of the variance (62) is equal to the total variance of the infant mortality rates (s^2), minus the average sample (or binomial) variance.[2] If the rates have too large a sample variance or proportion of sample variance to geographical variance, then the amount of difference between groups or the stability of results from measures of association come into doubt.

Markides and Barnes (1977:42) criticized both Willie and Stockwell for using correlation coefficients with census tract births occurring over a three to five year period on basicly these grounds. Following on Kleinman et al. and Markides and Barnes' comments, it is apparent that other studies may have severe problems. For example, Eberstein and Pol (1982) used counties in the Southwest United States with a minimum of 100 live births. Adamchak and Flint (1983) used Kansas counties, several of which had a cumulative total of births for three years that were less than 75.

A further methodological consideration is that there is no attempt to adjust the calculations for the extreme size differences in ecological units that exist in some studies. Such weighting should be based on some relevant factor such as the proportion of live births occurring in the areal unit multiplied by the number of areal units in the analysis. This would not only increase the comparability of a variable across studies, but could also control the effect of the sample variance of areas with few births (Robinson, 1956; Moorman, 1979).

The final problem is in the character of the relationship between social status and infant death and the use of linear models to study that relationship. Willie and Rothney (1962:525-526) noted that a relationship was apparent if median family income was below a critical level. Above that critical level, infant mortality rates for census tracts of various income levels vary only randomly. The critical level for median income is low enough that any regression line is not going to vary from a slope of zero by much.[3] Also, the results reported from the National Natality and National Infant Mortality Surveys (NCHS, 1972) show a strong curvilinear relation between socioeconomic status and infant mortality rates. The relationship was strongest in the urban Northeastern United States. Nationwide, infant mortality rates were related to family income and maternal education, but were related in a weakly linear manner to paternal education.

In summary, it seems that inconsistencies in the use of ecological studies is part of the difficulty in finding a consistant relationship between infant mortality rates and some measures of socioeconomic status. Cynicism about the value of ecological studies for comparisons against each other, without some standards for indices (see table 1 for examples of the range of indices of socioeconomic status) and methodology to guide researchers, seems warranted (Antonovsky and Bernstein, 1977:455; Stockwell et al., 1978:670). Furthermore, if the comparison of different ecological studies is difficult, then the comparison of ecological studies with individual studies is more difficult.[4] The factors mentioned above, and possibly others, make apparent the necessity of the pursuit of extensive studies using individual data.

METHODOLOGICAL PROBLEMS OF USING INDIVIDUAL DATA ON INFANT MORTALITY

The problems of individual studies are in some cases similar to those of the ecological studies. Of the problems that were part of the ecological fallacy, only aggregation bias is not present in an analogous form. When using individual data, one must be more

Table 1. Indices of socioeconomic status that have been used in ecological studies of infant death.

INCOME
Median family or family and unrelated individual income
Percent of families with incomes less than $3,000 for data from the 1950's or early 1960's, or $4,000 for 1969 data
Percent of family incomes that were less than the poverty level
Median rental value of housing
EDUCATION
Percent of people age 25 and over with a high school diploma
Percent of people age 25 and over with 5 years or more of schooling
Percent of women age 15 to 44 with 8 years of more of schooling
Percent of 14 to 17 year olds enrolled in school
Median years of schooling completed for population age 25 and over
Median years of schooling completed for women age 25 and over
OCCUPATION
Percent of labor force in professional, technical, managerial, or proprietor (including farm) jobs
Percent of labor force in professional, technical, administrator (excluding farm), sales, or clerical and kindred jobs
Percent of labor force in professional, technical, managerial, officials and proprietor (excluding farm), sales, or clerical and kindred jobs--white collar
Percent of population age 16 and over in white collar occupations
MISCELLANEOUS VARIABLES REFERED TO AS INDICATING SOCIOECONOMIC STATUS
Composite indices--5 different specified groups of variables
Percent of housing with more than 1.01 residents per room
Percent sound housing, with plumbing
Percent black
Percent non-white
Percent Puerto Rican

concerned with the representativeness of those studied compared to the whole population. The selection of the data gathering technique continues as an important factor in the value of the study. It will be necessary in this section to first show the relevant parallels between the problems that people using ecological data and individual data have to face. Then we will consider the problems of validity in the data gathered at the individual level.

<u>Parallels between ecological and individual data</u>

The user of individual data retains concerns about the 1) presence of possible structural effects, 2) integral macroproperties, 3) specification bias, 4) data preparation, and 5) choice of proper statistical treatment. In the case of individual data, the information to resolve the possible structural effects that Quinney (1965:228-229) mentioned would not be readily available, but would require a seperate sample and interviewing format in the research design. Measuring such social definitions and levels of knowledge in a way that would relate it to the individual infant deaths could be very difficult.[5]

For example, in the case of defining what illness is severe enough to seek medical assistance, the grandparents are the primary reference group, whether they are still geographically nearby or not (Mechanic, 1968:252-253), particularly in ethnic groups with close social ties. Peers also have influence, but less than family members (Mechanic, 1968:261-262). Such an analysis with many other variables would amount to the production of an ecological analysis paralleling the individual study, with statistics calculated simultaneously. This is the type of procedure that Shah and Abbey (1971) used in their analysis of the data for Baltimore, which included an ecological measure of economic status. A true test of ecological variables on the individual level relationship would have required an individual level measure of economic status as a control variable. A relationship would be found to still exist between the ecological variable and the infant mortality rates if structural effects were present.

The detection of integral macropropertiea in studies using individual data also would depend on the inclusion of variables that would generally be classified as ecological such as availability of medical facilities, sanitation and housing regulations, number of medical practitioners available, and attitudes and practices of the practitioners. Considering the disagreement between Brooks (1978a and b) and R. Anderson (1978a and b) concerning the different units used to represent the availability of medical care in the SMSA or county, testing individual and ecological data would be needed. The choices of measures of availability at the individual level would be much more complicated, but be more specificity, accuracy, and be testably comparable to the real situation than ecological data.

The final parallel to the ecological fallacy that must be considered is basic misspecification. This problem is not complicated by aggregation bias present in aggregate studies. But it can be complicated by relationships to other independent variables that are not included in the data analysis.

The selection of data handling procedures are somewhat more complicated at the individual level. The type of data available for ecological studies is usually selected to be ratio or interval, with few missing values. This eliminates some problems that exist in the individual studies. Much of the data at the individual level is ordinal, or, more commonly, nominal. Often it is necessary to collapse categories, dealing with missing values that were either forgotten or refused, and make numerous other adjustments to the survey-like data. In using the data, where ratio variables are available, there is the possibility that nonlinear relationships may exist between income or maternal education and infant mortality rates. The mixture of nominal, ordinal, and/or ratio measures makes it difficult to find an appropriate statistic to use with the data.

Nonlinear relationships further complicate the use of those that are possibly appropriate in some cases. Binary regression has the facilities of standard regression to use to handle nonlinear relationship as well as data that is not ratio in nature, but with problems due to the extreme changes in variance as the binomial dependent variable's predicted value approaches 0 or 1. Log-linear and logistic analysis, on the other hand, deals with data only as nominal but is designed to approximate the probability distribution.

Problems unique to individual data

The problems that are faced in the collection of the data for studies of infant death at the individual level are the same as those in all individual studies. Following Campbell and Stanley (1963), the primary problems relevant to vital statistics and surveys such as the one that is being used here stem from selection, experimental mortality, history, maturation, and reactivity to the interviewing/recording situation.

For vital statistics, there is supposed to be little selection in the recording, but the results of Alley and Terry (1979) suggest that there can be significant selection, whether by intermitent accident or by systematic mistakes. A purely random sample of the reported live births and infant deaths should not produce any further selection. The survey will suffer from differential response rates, or experimental mortality, which will create a new bias. Those that are responding may differ systematically from those that do not respond. In the case of infant death, the preponderance of the subjects should be in the lower socioeconomic groups, since that is where the majority of births occur. The lower socioeconomic groups are noted for poorer response rates.

Maturation will be most relevant in surveys given to relatives of recent infant deaths. The course of the grieving may dramatically affect the responses that the subjects give concerning topics such as the use of medical care, employment and childcare arrangements, health problems during pregnancy, etc. Furthermore, historical famili-arity with pregnancy loss or infant death may affect the way that the subject responds. These factors may affect physicians' responses on the standard birth and death certificates, but in a less extreme fashion.

The final consideration is reactivity. Does the asking of the questions, especially in the survey, affect the response that the person gives? This is particularly a matter of concern when the mother is not married at the time of birth, for instance. The response as to the identity of the father and other information concerning present marital status have been falsified to avoid the possible social condemnation that is associated with illegitimacy or birth of a child conceived premaritally. The problem of reactivity to the interviewing/recording situation, particularly on sensitive issues, is impossible to control without further data on the mother and infant from other sources.

Selection, response bias, history, and maturation threaten the internal validity of the results. The systematic biasing in the registration of births and infant deaths (Allen and Terry, 1979) makes the inferences about the samples themselves less valuable. The problem of reactivity to interviewing/recording makes the responses less representative of the actual occurrences and makes generalizing to a larger population less accurate.

The minor problems that afflict the individual data will be magnified with aggregation on ecological areas. Where misspecification will bias results at the individual level, aggregation will often cause that bias to be greatly magnified. It appears that the problems in finding the relationship between socioeconomic status measures and infant mortality rates around 1960 may have been the result of the type of data used in relation to the actual changes in the nature of the relationship. As the causes of the deaths changed with improvements in the medical and social care of children, the relationship between the many factors that contribute to the occurrence of infant deaths will vary in importance. Researchers must find out 1) if there is still a relationship between measures of socioeconomic status and infant death and 2) specify that relationship, so that practitioners can 3) use the knowledge gained from research to reduce the number of infant deaths.

In pursuit of this goal, this research is intended to clarify the relationship between infant deaths and socioeconomic status. It investigates potential paths by which measures of socioeconomic status are related to infant deaths. The National Natality and National Infant Mortality Surveys looked at the relationship of four measures of social and economic class 1) mother's education, 2) father's education, 3) family income, and 4) race to the prevalence of infant death (NCHS, 1972). It is therefore the intention of this research to repeat a similar analysis, but also to expand it to include a multivariable analysis of the relationship that better specifies the ways in which socioeconomic status is related to probability of an infant death.

N O T E S   O N   C H A P T E R   I I I

1 The sampling error of the aggregated data will be larger than that of the individual data because of the smaller number of cases that it will usually contain. This is in spite of the fact that the variance of the areal units' values will be reduced by the fact that they are samples in and of themselves. Because they will have means that are significantly different, the reduction in variances is not sufficient to outweigh the difference in number of cases (Langbein and Lichtman, 1978:15-17).

2 To calculate a single sample variance of the k geographic regions, take the proportion of infant deaths to live births (p = IMR/1,000) multiplied by one minus p, then divide by the number of births (n). The formula for estimated geographical variance is:

$$\hat{\sigma} = s^2 - \frac{1}{k} \sum \frac{p_i (1 - p_i)}{n_i}$$

(Kleinman et al., 1976: addendum referred to on 424).

3 Willie and Rothney report a correlation coefficient of -.06 between median income and neonatal mortality rate (not significant) for Syracuse, New York's 42 census tracts. For 15 census tracts composed primarily of Italians, Polish, Blacks, or Native Whites of low socioeconomic status, a Spearman rank correlation of -.75 was found (1962:525).

4 A table of studies of the relationship of social class to neonatal and postneonatal mortality shows that consistently the ratio of the high to low social class groups in ecological studies is generally between one half and one sixth that of the ratio found in individual level data-based studies (Antonovsky and Bernstein, 1977:455).

5 In many studies, where random samples of a specific area are taken, the sample in either the sampling area or some subunit of the sample area can function as the definition of the modal category. This does not work in analyzing data that is obtained based on some approach other than randomness or representativeness for a defined area. For example, the occurrence of an infant death to a member of the household, or where the data preparation eliminates the information needed to define appropriate areas for respondent classification.

CHAPTER IV

DATA PREPARATION AND ANALYSIS PROCEDURES

The collection and preparation procedures of the National Survey of Family Growth by the National Center for Health Statistics is described. The steps in preparing the data for analysis are then presented. The variables used will be described with the steps in the analysis in which they were used. Finally, the analytic techniques used to relate indicators of socioeconomic status to infant death are described.

DATA SOURCE AND PREPARATION

The National Survey of Family Growth (NSFG), cycle I, was designed to gather information on the processes involved in family planning, fertility, and the effects birth control on population growth. The data were collected from a stratified, random, multistage probability sample of 9,797 women, aged 15 through 45 years, that were currently or previously married, or unmarried women with one or more children born to them currently living in the household. The sample included only the coterminous United States (NCHS, 1978a). The sample was stratified by race, age and region of the country. The interviewing took place from July 1973 to February 1974. Blacks were oversampled to ensure a sufficiently large number of black respondents to reduce the standard error of the sample, improving the representativeness of the sample for the black population. To adjust for the rate of oversaspling and the probability of being aelacted to repraaent the region, a weighting factor waa developed by NCHS. The weightinga are daaignad to inflate the nuaber of actual interviawa to be roughly aqual to the actual population of the Unitad Statea that fit tha qualifiactiona describing the saaple. Bacauaa the aga distribution of wosen ever sarriad is known quita accurately, the weightings for thas includa a factor for the underaaspling of certain aga groups. The weights will be uaed to allow cosparison with the actual values for the Unitad Stataa. Such tables ahould giva sosa saaaure of the axtent to which tha aaaple of birtha actually rapresent the population of live birtha that occurred in the United Statea during tha August 1967 through July 1972 period.

For tha research questiona to be addraased in a faahion cosparable to other atudiea of infant death, tha data had to be converted fros wosen as caaea to live births as caaea. If the conversion were not carried out, thera would have been problesa with the weighting of the caaes so that the infant sortality ratea would be cosputabla. Certain variablas that were produced fros the inforsation that was contained in the original data set would have been difficult to include in the analyais without the converaion, although it was isportant inforsation that say ba ralated to tha chancaa of an infant death.

The calculation of the nusber of wosen that had an infant death occur during the fiva yaar period aelacted would not produca an interpretabla infant sortality rata if tha convaraion wera not carriad out. The nusber of infanta that each wosan gave birth to during the period would have to be used aa a variable or waight in ordar to give some idea of the actual infant mortality rates. Using multivariable techniques on the cases would be precluded, because weighting by the number of live births would give results that were uninterpretable. Weighting each case by the ratio of infant deaths to live births might have sufficed in making the statistics useful, though very questionable.

To make full use of the information available in the data set and include all the relevant factors, it is necessary to list each birth separately. Variables such as the legitimacy of a birth, parity, months since the last birth, birthweight, and age of the mother at the time of the birth cannot be summarized by an average for all the births that occurred in the period under consideration. They are characteristics of each pregnancy, and as such, have little affect on the other pregnancies that a woman might have. Summarizing them would simply be eliminating specific information that the data originally contained. The conversion of live birth histories into individual live births as cases is equivalent to the procedure that is used to convert live birth histories obtained in the census or surveys that some developing countries use to estimate birth and fertility rates (Coale, 1971; Shryock et al., 1976:500-501). Only if the mortality rates of specific groups of mothers is extremely different from the other groups will the sample be biased. That should not be a problem with these data, due to the generally low maternal mortality rates prevalent in the United States.

It must be remembered that estimates based on the survey technique retain all the problems that the original surveys contained, possibly multiplied by the process of expanding the live birth history by the weighting factors. The representativeness of weighted results for the population as a whole may be questioned, but the relationship between variables and infant deaths that have occurred in the sample should not be significantly affected by the conversion.

Problems also arise from the passage of time affecting the accuracy of some variables. The difference in time of the occurrence of the birth and the gathering of the demographic data on the woman will increase the possibility that the life situation of the mother will differ from the circumstances that existed at the time of the birth. Also, the passage of time will reduce the accuracy of the information that is recalled by the respondent about the variables concerning the actual birth. The accuracy of the birthweight, months of birth and death, and other such variables will be lower. The strength of the relationships that have been found between such variables and infant mortality rates are sufficient to make the use of them justifiable, even with the loss of some accuracy. Limiting the period of time considered to the five years prior to the interview should limit the loss of accuracy.

With the conversion, each woman's characteristics are output as part of the infant's characteristics. Such things as the mother and father's education, race, income, and region of residence at the time of the interview are included in each infant birth case produced from a woman. If the woman had given birth to three infants during the interval under analysis, this information about the mother is included in each infant-as-case recorded. Then data collected specifically for each birth, such variables as birthweight, sex of infant, parity of the birth, parity, and plurality are included. These are taken directly from the information reported by the women on that live birth. The age of the mother at the time of the birth, legitimacy of the birth, and if the infant died are new variables that are computed.

Certain factors from the pregnancy history of the woman are included. The factors included are those most likely to affect the results of that pregnancy: 1) number of pregnancy losses and 2) time since the last pregnancy. The responses to a question about whether the pregnancy was planned and wanted are included to test for possible effects of a variable that has never been tested for a relationship.

With the data prepared to this point, it is possible to test whether the weightings can be applied to make the sample more accurately represent the population of the coterminous United States. Table 2 compares the NSFG sample as revised with data published in the annual volumes of Vital Statistics of the United States. The vital statistics' numbers are adjusted to remove births and deaths in Alaska and Hawaii. Because vital statistics are presented by year, some estimation is necessary to compare the single birth cohort that the NSFG data contain. The comparison suggests that the data are sufficiently comparable to the Vital Statistics reports to allow the use of the weightings that are included for each woman on the individual live births when they are used as cases. The difference between the values for the number of births for the NSFG versus Vital Statistics

Table 2. Comparison of vital rates as given by the National Survey of Family Growth (NSFG) converted to birth-as-case by the use of weightings, against vital statistics for the same birth cohort.

	NSFG		Vital Statistics[1]	
Age of mother	Births (÷100,000)	% of all births	Births (÷100,000)	% of all births
0-15	0.54	0.28	0.47	0.30
15-19	26.15	15.50	30.54	17.27
20-24	64.28	38.10	66.63	37.68
25-29	47.49	28.15	46.61	26.36
30-34	20.98	12.44	20.65	11.68
35-39	8.05	4.77	9.12	5.16
40-45	1.28	0.76	2.57	1.45
45 and up[2]	--	--	0.16	0.09
Total	168.71	100.00	176.81	99.99
Race				
White	142.40	84.40	146.43	82.82
Non-white	26.32	15.59	30.37	17.17
	Deaths (÷100,000)	Infant mortality rates (per 1,000 births)	Deaths (÷100,000)	Infant mortality rates (per 1,000 births)
	3.06	18.15	3.58	20.23

1 These numbers are based on the annual vital statistics reported by NCHS selected to include only the cohort born during the August 1968 through July 1972 period, with adjustments for the births and deaths occurring in Alaska and Hawaii.

2 This category was excluded from NSFG by its sampling criteria, but vital statistics results could not be adjusted to remove it.

is not significant considering the size of the NSFG sample; 5,785 live births. The differences present in the categories of the age of the mother and the infant mortality rates are not statistically significant, either. The differences are all less than 1.5 standard errors for the NSFG sample. The weightings appear to be appropriate for use in the analyses that follow.

STEPS IN THE ANALYSIS OF DATA

The data were analyzed in two steps. First, the data were tabulated in a way that parallels the analysis of the National Natality and Infant Mortality Surveys. This involved calculating the infant mortality rates for categories established by using up to three variables at a time. Second, a multivariable analysis using logistic regression techniques was carried out. Variables was included cover as many of the factors that were found to be important in other individual studies as possible.

The form of the tables closely parallels that of the National Center of Health Statistics publication "Infant Mortality Rates: Socioeconomic Factors, United States" (1972). This allows for a limited comparison between the two periods. Changes in the categorization of income have been made to reflect the changes from 1964 to 1972. Further, since the National Survey of Family Growth study included both legitimate and illegitimate births, a full comparison with the NCHS (1972) publication will only be carried out against tables restricted to legitimate births. The effect of illegitimacy will be considered later in the multivariable analysis. The analysis examined the relationship between income, mother's and father's education, race of the mother, and the infant's birthweight to the dependent variable, infant mortality rates.

Comparisons are considered significant if the number of births in the category is greater than or equal to 200; or, if that is not true, then if the number of births is greater than or equal to 50 and the estimated standard error is less than half of the proportion of infants that died. These two criteria limit the significant data to those which should have sufficiently large number of births to show some stability in the infant mortality rates in the category.

The multivariable analysis was carried out using logistic regression techniques. This is more appropriate than the standard regression techniques that have been used for ecological studies or binary/dummy variable regression techniques used by Shah and Abbey (1972). The nominal data of the dependent variable does not support the use of standard regression without some adjustment. The usual adjustment is to treat nominal level variables as though they were a series of dichotomous, or binary variables. Considering such materials as Nerlove and Press (1973), Gillespie (1977), and Farthofer and Lehnen (1981), problems with unequal variance become major problems for regressions using binary variables when the data give proportions less than 0.2 or greater than 0.8 with any single category. The amount of variance is constrained as the true curve approaches the limits of zero or one. The use of some log-linear or logistic model is shown to be appropriate.

The logistic regression approach selected from Statistical Analysis

Systems (SAS) package has some shortcomings. All procedures of the log-linear/logistic regression type are based on cell counts of the tabulated of variables. The procedure uses the logarithm of the ratio of two cells. If either cell has no cases in it, the logarithm is undefined. The recommended method for remedying this problem in most applications, and the automatic method used by SAS, is to add 0.5 to every cell in the table if any cell contains no cases. For the purposes of this research, results were severely biased by the size of the value added to the cells. Taking a compromise between Forthofer and Lehnen who recomend adding 0.5 only to the empty cells, and what SAS is capable of, 0.1 was added to each cell. Even so, it became clear in the analysis of the data that the number of deaths was barely sufficient to carry out the analysis without having to continously consider the potential for extensive bias caused by the lack of sufficient numbers of infant deaths.

The variables used will be considered in the groupings derived earlier in this research. The factors and variables that will be considered are as follows:

SOCIOECONOMIC STATUS FACTORS

1. Family income--income from all sources; including wages, interest, and dividends that are received by the woman or her husband, if present.
2. Respondent's education--the highest grade of school the mother completed.
3. Husband's education--the highest grade of school the father (or step-father, if remarried since the birth) completed.
4. Respondent's race--race of the mother by the observation of the interviewer.

FAMILY STRUCTURE FACTORS

1. Legitimacy--whether the mother married at the time of the birth.
2. Number of marriages--number of marriages the mother had

been in or was in at the time of the birth; roughly testing the effect of marriage disaolution.
3. Wanted pragnancy--was the pregnancy wanted at the time of discovary.

HEALTH FACTORS
1. Pregnancy loss--number of pragnanciea that rasulted in somathing other than a live birth prior to thia pregnancy.
2. Parity--number of live births preceding this birth.
3. Pregnancy spacing--number of years since the previous pregnancy's end to this live birth, with firat births coded as more than three years pregnancy spacing.
4. Maternal aga--age of the woman at the time of the live birth.
5. Birthweight--weight at birth of the infant, in grams.

DEPENDENT VARIABLE
Infant daath--infant dying before ita first birthday.[1]

First, each variable waa run individually to taat for any ralationahip. Than each variable was run with all othars in tha group, regardless of ita individual raaults. Here, the reaidual chi-aquara value (not reported) was used to suggast whether there are any interactions betwean variables. Finally, the group as a whole waa run. Tha variables from each group that ahowed consistent levels of relationahip within the group were then ba included in the final stage of tha logistic analyaia. The variables ratained from the other groupings were run run individually, with aach other variable retainad, and finally with all of the other variables and interaction effects ratained.

The ways that the variables' relationahipa to infant death changa in tha praaence of the other variablea revaals thosa variablas that ara acting through other variables. This is most succintly aummarizad by changes in the chi-square atatistic.

N O T E S

1 The date of death was only given in month and year, while birth data included day, month, and year. Therefore, distinguishing neonatal from postneonatal mortality is difficulty. The method used to astimate the age at daath did not produce death rataa that had enough differences in numbera of deatha between neonatal and total death to produce results that were different and atill aignificant. Therefore all 'time of death' braakdowns were dropped.

CHAPTER V

RESULTS

The interviews of women in the National Survey of Family Growth were converted into live births. These live births were then used to calculate infant mortality rates for groups with different socio-economic backgrounds. Finally, a logistic regression was carried out using indicators of socioeconomic status, family, and health factors to attempt to explain the differential probabilities of an individual infant dying, or infant mortality, between groups.

The infant mortality rates calculated showed distinctly nonlinear, weak relationships for the socioeconomic status variables used for whites, and direct, rather than the expected inverse or nonlinear relationship for blacks. Infant mortality rates for low birthweight infants (less than 2,500 grams at birth) showed that blacks had much lower infant mortality rates than whites, although total infant mortality rates and infant mortality rates for all of the other weight groups were lower for whites than blacks.

The logistic regression revealed that the nonlinear relationship of socioeconomic status variables to infant death was not significant. But birthweight, interactions between race and birthweight and race and number of marriages, and number of marriages were the variables that retained sufficient relationships to be found statistically significant at the final stage of the logistic regression.

ANALYSIS OF INFANT MORTALITY RATES FOR SPECIFIC SOCIOECONOMIC CATEGORIES

The general pattern NCHS (1972) suggested was supported by this analysis. The relationship of family income to infant mortality rates appeared curvilinear. Of the different income categories, the infant mortality rate was lowest for the $10,000 through $14,999 category (table 3). That pattern held only for whites. The pattern for blacks was the reverse of the expected pattern; that is, the higher the family income, the higher the infant mortality rate. A similar pattern of high socioeconomic status and high infant mortality rates held for blacks, using the father's education as the indicator. The pattern of the relationship of either mother's or father's education to infant mortality rates for whites was totally inconsistent. The differences in infant mortality rates appeared to be too small to be significant for the size of the sample.

Infant mortality rates were lowest for whites when the mother had an eighth grade education or less or some college (13 through 15 years of schooling). The low infant mortality rate of the very low education whites was unexpected. It was not predicted by any previous study and is counterintuitive. The low infant mortality rate is either a 1) strong pattern of respondent bias, 2) underreporting of infant deaths by low education respondents, or 3) some unknown factor that has a strong relationship to infant death. One could be inclined to conclude on the side of an unknown factor to avoid the threat to the overall validity of the data. If low education respondents systematically biased responses sufficiently to produce

Table 3. Estimated infant deaths per 1,000 live births by race, family income, parental education, and birthweight, for legitimate births, only: United States, 1967-1972.

	All races	White	Black
TOTAL	15.8	13.7	28.5
Family income			
Under $5,000	25.3	22.5	25.2
$5,000-9,999	14.1	10.4	24.7
$10,000-14,999	9.0	7.6	35.8
$15,000-24,999	20.9	19.5	46.7
$25,000 and over	23.7	25.3	*
Husband's education			
8 years or less	16.1	15.6	19.7
9-11 years	19.6	16.6	37.4
12 years	13.1	11.0	23.0
13-15 years	18.5	14.5	52.5
16 years or more	15.8	14.7	*
Mother's education			
8 years or less	12.6	9.1	*
9-11 years	18.0	19.4	11.3
12 years	17.1	13.2	50.4
13-15 years	10.4	9.9	16.4
16 years or more	17.9	14.8	*
Birthweight			
2,500 g or less	135.9	137.9	71.4
2,501-3,000 g	8.0	9.8	26.5
3,001-3,500 g	5.4	4.7	12.5
3,501-4,000 g	4.5	3.4	7.4
4,001 g or more	0.0	0.0	*

* Cells marked with this do not meet the criteria for significance, which are:

1) $n \geq 200$, or
2) $n \geq 50$ and $n \geq \frac{4*(1-p)}{p}$

these results, all other results would be biased. This is a question that must be pursued by further study.

The pattern of infant mortality rates by birthwieght were as expected. Race had a strong affect on the distribution of the infant mortality rates throughout the weight categories. Blacks had much higher infant mortality rates for the higher birthweight groups than did whites, while the low birthweight blacks had a lower infant mortality rate. The reason for these differences is not clearly explained in the literature. Numerous studies have shown that socioeconomic status, whether measured by income, education, or occupation, does not affect infant mortality rates for low birthweight black infants. Differences in gestation patterns of blacks and whites, mentioned in the second chapter, may be a partial explanation.

The small number of infant deaths limits any interpretation of relationships that involve more than one independent variable. When analysis by two variables was attempted, too large a proportion of the cells were not sufficiently stable to allow interpretation with any appearance of validity (tables not shown). The few significant cells suggest that generally the social/economic status variables tend to reinforce each others' effects.

The lack of linear relationships between socioeconomic status and infant mortality rates is in stark contrast to the results of earlier individual studies, especially in the Northeastern part of the United States, and particularly in urban areas.[1] The lack of the strong linear relationship between infant death and husband's level of education is a major deviation from a longstanding association.

The relationship held in the 1972 NCHS study. The relationship of father's education to infant mortality is further complicated by the almost direct relationship found for blacks. Previously research only mentioned the slight inconsistencies in passing (NCHS, 1972:14). There is reason to consider curvilinearity to be important. There is a strong suggestion that there is some major change going on, but not necessarily of the sort that has been supposed by the studies using ecological data. It appears that the change is toward more strongly nonlinear patterns. These may reflect either the results of social welfare programs or some other change in the social system.

ANALYSIS OF MULTIVARIABLE ANALYSIS USING SOCIOECONOMIC AND OTHER VARIABLES

To further determine the strength of the potential relationships of the independent variables to infant death and to better define the mechanisms through which they function, the data from the National Survey of Family Growth, cycle I, were analyzed using logistic analysis as described above. The results show different relationships than when the socioeconomic status variables alone were used.

First, only race is significantly related to infant death (table 4). The coefficients shown are the natural logarithms of the ratio of the logit of a category's adjusted proportion of deaths to the logit of the proportion of deaths for the entire population. Therefore, the figure of -0.30 for whites with no other variables controlled shows that the logit of infant mortality rate for whites is less than the logit of the infant mortality rate of the entire population. The infant mortality rate of whites is less than that of the total

Table 4. Coefficients resulting from the logistic regression of race of respondent on infant deaths with other socioeconomic variables.

Other included variables	RACE OF RESPONDENT White	Non-white	X^2
----	-0.30	0.30	6.83**[1]
Husband's Education	-0.32	0.32	7.95**
Maternal Education	-0.33	0.33	8.29**
Family Income	-0.31	0.31	6.83**
Husband's Education, Maternal Education Family Income	-0.33	0.33	9.20**

1 Significance levels with 1 degree of freedom:
* $\leq$ 0.05
** $\leq$ 0.01
*** $\leq$ 0.001

population. The extent of the difference between the two rates is roughly Napier's constant, e, raised to the -0.30 power, since the logit transformation does not greatly change the values in the small range they are confined to here. (As the size of the coefficient increases, the difference between the ratio of the logits and the ratio of the actual rates will increase.) By looking at the change in coefficients and chi-square when control variables are included, it is decided whether the variable is effected by the presence of the other variables. The relationship of race to infant death is not effected by mother's or father's education or the family income since the coeficients change very little and the chisquare changes only within a narrow range. No combination of the other socioeconomic status variables from this group approached being significant (tables 5, 6, and 7). Considering this, the apparent nonlinear relationship that was noted above was not significant, although it is evident in the coefficients for income and mother's education.

All the family structure variables are significant when taken alone, but when entered into a single logistic equation, only number of marriages retain its statistical significance. That is, the chi-squares of the other family structure variables were reduced to a level that was not significant, and the coefficients were closer to zero on all variables except number of marriages when the other family structure variables were included in one computation of coefficients for the logistic equation. The explanatory power of the number of marriages was greatly enhanced by the relatively low infant mortality rate among women during their first marriage (table 8).

Table 5. Coefficients resulting from the logistic regression of husband's education (Husband's Education) on infant deaths with other on infant deaths with other socioeconomic variables.[1]

Other included variables	HUSBAND'S EDUCATION					
	Grade or less	Some high	High	Some college	BS+	χ^2
----	-0.05	0.17	-0.18	-0.09	0.15	1.87
Race	-0.06	0.14	-0.19	0.16	-0.05	2.12
Maternal Education	-0.04	0.17	-0.25	0.24	-0.13	3.81
Family Income	-0.07	0.12	-0.16	0.32	-0.20	3.51
Race, Maternal Education, Family Income	-0.09	0.05	-0.25	0.43	0.04	5.86

1 No results were statistically significant at the 0.05 level.

Table 6. Coefficients resulting from the logistic regression of maternal (respondent's) education on infant deaths with other socioeconomic variables.[1]

Other included variables	MATERNAL EDUCATION					
	Grade or less	Some high	High	Some college	BS+	χ^2
----	0.17	0.20	0.01	-0.38	0.00	2.69
Race	0.11	0.17	0.01	-0.37	0.07	2.34
Husband's Education	0.41	-0.03	-0.21	-0.45	0.22	5.44
Family Income	0.14	0.14	-0.14	-0.39	0.26	3.39
Race, Husband's Education Family Income	0.39	0.01	-0.26	-0.14	0.00	4.24

1 No results were statistically significant at the 0.05 level.

Table 7. Coefficients resulting from the logistic regression of family income on infant deaths with other socioeconomic variables.[1]

Other included variables	FAMILY INCOME (in thousands of dollars) Less than 5	5 to 10	10 to 15	15 to 25	more than 25	χ^2
----	0.21	-0.17	0.29	0.59	-0.39	4.12
Race	0.07	-0.21	0.25	0.09	0.30	3.41
Husband's Education	0.15	-0.29	0.39	-0.10	0.44	7.33
Maternal Education	0.08	-0.24	0.35	0.05	0.45	5.37
Race, Husband's Education, Maternal Education	0.10	-0.31	0.31	0.05	0.46	6.57

1 No results were statistically significant at the 0.05 level.

Table 8. Coefficients resulting from the logistic regression of number of marriages on infant deaths with other cultural variables.

Other included variables	NUMBER OF MARRIAGES 0	1	2 or more	χ^2
----	0.50	-0.67	0.17	25.20***[1]
Legitimacy	0.95	-0.90	-0.04	9.06*
Wanted Pregnancy	0.34	-0.73	0.39	24.11***
Legitimacy, Wanted Pregnancy	0.29	-0.71	0.42	14.25**

1 Significance levels with 2 degrees of freedom:

* $\leq$ 0.05
** $\leq$ 0.01
*** $\leq$ 0.001

The low infant mortality rate for women in their first marriage is in contrast to the infant mortality rates slightly above average for second and later marriages or very high infant mortality rates for the never married. With the apparent relationships that remained when the variables were considered in a pairwise manner, legitimacy and whether the pregnancy was wanted were related to infant death through the number of marriages (tables 9 and 10). Legitimacy did not influence the relationship of whether the pregnancy was wanted to infant's chances of survival, or vice versa. Legitimacy partially ameliorated the effect of the number of marriages, but not enough to make the number of marriages not significant. Overall, only the number of marriages was retained in later analyses.

Of the indicators of health factors, the age of mother appears significantly related to infant death when taken alone (table 11). The younger the mother, the higher the infant mortality rate. When entered into separate logistic regressions, number of pregnancy losses, previous births, and years since the previous pregnancy were not significant (tables 12, 13, and 14). In contrast to NCHS (1980a) results, years since last pregnancy shows the weakest relationship to infant death. In looking at the results of pairwise comparisons, it appears that parity is not related to the infant death.[2] But parity was related to the variables that are causing the variance in infant mortality rates. The most effective explanatory indicator with all the other health indicators present was the number of pregnancy losses. As the number of prior pregnancy losses increase, infant mortality rates increase. In the present study, the only indicators

Table 9. Coefficients resulting from the logistic regression of legitimacy of birth on infant deaths with other cultural variables.

Other included variables	LEGITIMATE No	Yes	χ^2
----	0.51	-0.51	16.01***[1]
No. of Marriages	-0.34	0.34	0.09
Wanted Pregnancy	0.47	-0.47	12.65***
No. of Marriages, Wanted Pregnancy	0.03	-0.03	0.00

1 Significance levels with 1 degree of freedom:
- * $\leq$ 0.05
- ** $\leq$ 0.01
- *** $\leq$ 0.001

Table 10. Coefficients resulting from the logistic regression of planned (and wanted) pregnancy on infant deaths with other cultural variables.[1]

Other included variables	PREGNANCY PLANNED (AND WANTED) Planned	Wanted	Unwanted	χ^2
----	-0.30	0.19	0.09	4.93
No. of Marriages	0.34	-0.73	0.39	3.10
Legitimacy	-0.18	0.15	0.03	2.15
No. of Marriages, Legitimacy	-0.25	0.13	0.11	3.18

1 No results were statistically significant at the 0.05 level.

Table 11. Coefficients resulting from the logistic regression of maternal age on infant deaths with other cultural variables.

Other included variables	MATERNAL AGE (years) Less than 20	20 to 30	More than 30	χ^2
----	0.52	-0.10	-0.41	9.99**[1]
Pregnancy Losses	0.61	-0.12	-0.49	12.80**
Parity	0.71	-0.09	-0.62	14.32***
Pregnancy Spacing	0.52	-0.11	-0.40	7.53*
Pregnancy Spacing, Parity, Pregnancy Losses	0.55	-0.25	-0.30	10.74**

1 Significance levels with 2 degrees of freedom:
* ≤ 0.05
** ≤ 0.01
*** ≤ 0.001

Table 12. Coefficients resulting from the logistic regression of number of pregnancy losses on infant deaths with other biological variables.

Other included variables	PREGNANCY LOSSES 0	1	More than 1	χ^2
----	-0.29	-0.15	0.44	4.76
Maternal Age	-0.51	-0.12	0.62	11.45**[1]
Parity	-0.67	-0.12	0.70	11.84**
Pregnancy Spacing	-0.45	-0.06	0.50	8.79*
Parity, Pregnancy Spacing, Maternal Age	-0.90	0.05	0.85	34.11***

1 Significance levels with 2 degrees of freedom:
* ≤ 0.05
** ≤ 0.01
*** ≤ 0.001

Table 13. Coefficients resulting from the logistic regression of number of previous births (Parity) on infant deaths with other biological variables.

Other included variables	NUMBER OF PREVIOUS PREGNANCIES				
	0	1	2	More than 2	χ^2
----	0.05	-0.11	-0.05	0.12	0.73
Maternal Age	-0.26	-0.15	0.03	0.38	4.10
Pregnancy Losses	0.07	-0.03	-0.03	0.01	4.10
Pregnancy Spacing	0.67	0.02	-0.44	-0.25	9.37*[1]
Maternal Age, Pregnancy Losses, Pregnancy Spacing	-0.83	0.13	0.30	0.40	14.48**

1 Significance levels with 3 degrees of freedom:
- * ≤ 0.05
- ** ≤ 0.01
- *** ≤ 0.001

Table 14. Coefficients resulting from the logistic regression of pregnancy spacing on infant deaths with other biological variables.

Other included variables	PREGNANCY SPACING (in years)				
	1	2	3	≥ 4	X2
----	0.22	0.12	-0.27	-0.07	0.96
Pregnancy Losses	0.28	0.10	-0.30	-0.08	3.80
Maternal Age	0.01	0.11	-0.19	-0.06	0.73
Parity	-0.54	0.07	0.13	0.34	6.14
Pregnancy Losses, Maternal Age, Parity	0.67	-0.10	-0.40	-0.17	8.70*[1]

1 Significance levels with 3 degrees of freedom:
- * ≤ 0.05
- ** ≤ 0.01
- *** ≤ 0.001

of the health factor group that were retained for further analyses were mother's age and number of pregnancy losses that the mother had experienced.

In the next stage of the analysis, using only the indicators from the groups that retained significance, the results are as expected for many of the indicators. Number of pregnancy losses and number of marriages have no interaction effects to consider. Birthweight and number of marriages each have an interaction effect with race of the mother when the data is analyzed in a pairwise manner.

As in the previous stage of the analysis, the number of prior pregnancy losses gains significance only when other indicators were controlled. Mother's age, number of marriages, and race were particularly powerful in specifying the relationship of pregnancy loss to infant death. Birthweight was the primary individual variable that intervenes in the relationship of pregnancy losses to infant death, reducing the relationship to nearly zero (table 15). All of the health variables except birthweight, when controlled for in the relationship of prior pregnancy loss to infant death, strengthen that relationship. If the infants birthweight was controlled, the relationship of prior pregnancy loss returned to a nonsignificant level. This suggests that pregnancy losses may be related to the same factors that would effect birthweight; i.e., condition(s) of the mother that can inhibit physiological development of the fetus.

Maternal age at the time of the infant's birth was entered in this stage of the analysis, with only a moderate relationship to infant mortality, instead of the strong relationship that the other

Table 15. Coefficients resulting from the logistic regression of number of pregnancy losses prior to the birth on infant death with the other variables that were retained in the final stage of the analysis.

Other included variables	NUMBER OF PREGNANCY LOSSES 0	1	2 or more	χ^2
---	-.29	-.15	.44	4.76
No. of Marriages	-.38	-.10	.48	6.67*[1]
Maternal Age	-.51	-.12	.62	11.45**
Race	-.36	-.11	.47	6.37*
Birthweight	-.18	-.22	.40	2.11
All other variables	-.39	-.06	.45	5.93
All other variables except Birthweight	-.62	-.06	.68	16.18***
INTERACTION EFFECTS INCLUDED				
Race*No. of Marriages	-.47	.00	.46	9.09*
Race*Birthweight	-.29	-.27	.56	4.45
All other variables except Birthweight and Race*Birthweight	-.78	.01	.77	23.41***
All other variables and interactions	-.51	.08	.43	8.55*

1 Significance levels with 2 degrees of freedom:
- * ≤ .05
- ** ≤ .01
- *** ≤ .001

variables have. This relationship seems to be partially explained by race and the number of times the woman had been married at the time of the interview. Either birthweight or the combination of all other variables intervene in the relationship of maternal age to infant death, explaining the high infant mortality rate of the group aged less than 20 years (table 16).

Race, the only variable in the socioeconomic status category significantly related to infant death, appears to be related to infant death only through the birthweight of the child. Although the relationship weakens with number of marriages and the age of the mother at the time of the birth controlled, race lost the greatest portion of its explanatory power only when birthweight was included in the analysis. The combination of all the other variables did not approach the effect of birthweight on the relationship of race to infant death (table 17).

The relationship of the number of marriages to infant death are significant and very resilient to the effects of most other variables, with the exception of birthweight and the race-birthweight interaction effect. First marriages are consistently the most conducive environment for infant survival. Births in second and higher order marriages have higher than average infant mortality rates, but have generally much lower infant mortality rates than births outside of marriage (table 18).

Birthweight is the single best explanatory variable of infant mortality. No variable effects its relationship to infant death noticably. This was expected, considering the extensive literature

Table 16. Coefficients resulting from the logistic regression of maternal age at the time of the birth on infant death with the other variables that were retained in the final stage of the analysis.

Other included variables	MATERNAL AGE AT BIRTH OF CHILD			
	20 or less	21 to 30	31 or more	χ^2
---	.52	-.10	-.44	9.99**[1]
No. of Marriages	.44	-.04	-.40	6.46*
Pregnancy Losses	.61	-.11	-.49	12.80**
Race	.47	-.07	-.40	8.33*
Birthweight	.34	-.16	-.18	3.62
All other variables	.25	-.05	-.20	1.66
All other variables except Birthweight	.31	.04	-.35	3.54
INTERACTION EFFECTS INCLUDED				
Race*No. of Marriages	.50	-.06	-.45	9.33**
Race*Birthweight	-.13	-.06	.20	.80**
All other variables except Birthweight and Race*Birthweight	.49	.06	-.42	7.43*
All other variables and interactions	.27	-.10	.17	1.95

1 Significance levels with 2 degrees of freedom:
- * $\leq .05$
- ** $\leq .01$
- *** $\leq .001$

Table 17. Coefficients resulting from the logistic regression of race of respondent on infant death with the other variables that were retained in the final stage of the analysis.

Other included variables	RACE OF RESPONDENT White	Nonwhite	χ^2
---	-.30	.30	6.83**[1]
No. of Marriages	-.25	.25	4.45*
Maternal Age	-.26	.26	5.36*
Pregnancy Losses	-.34	.34	8.67**
Birthweight	-.13	.13	1.17
All other variables	-.17	.17	2.17
All other variables except Birthweight	-.26	.26	5.09*
INTERACTION EFFECTS INCLUDED			
Race*No. of Marriages	.26	-.26	3.44
Race*Birthweight	-.15	-.15	1.30
All other variables Except Birthweight and Race*Birthweight	.08	-.08	0.17
All other variables and interactions	.17	-.17	1.10

1 Significance levels with 1 degrees of freedom:

* $\leq .05$

** $\leq .01$

*** $\leq .001$

Table 18. Coefficients resulting from the logistic regression of number of marriages on infant death with the other variables that were retained in the final stage of the analysis.

Other included variables	NUMBER OF MARRIAGES			χ^2
	None	One	Two or more	
---	.50	-.67	.17	25.20***[1]
Maternal Age	.33	-.67	.26	22.82***
Pregnancy Losses	.59	-.71	.11	28.53***
Race	.57	-.74	.16	30.05***
Birthweight	.42	-.77	.35	23.66***
All other variables	.52	-.90	.38	34.94***
All other variables Except Birthweight	.58	-.74	.16	30.72***
INTERACTION EFFECTS INCLUDED				
Race*No. of Marriages	.32	-.47	.15	9.92**
Race*Birthweight	.20	-.69	.49	16.95***
All other variables Except Birthweight and Race*Birthweight	.34	-.41	.08	7.21*
All other variables	.44	-.75	.31	20.55***

1 Significance levels with 2 degrees of freedom:

* $\leq$ .05
** $\leq$ .01
*** $\leq$ .001

on the strength of the relationship. Birthweight did act as an intervening variable for a number of the relationships that have already been discussed (table 19).

The interaction effects of race and birthweight and race and number of marriages have almost the strongest relationship of any of the variables to infant death (table 20 and 21). Other than birthweight, the value of the chi-square for these two pairs of variables is among the strongest of all the variables. The interaction statistically subsumes such things as the lower infant mortality rate of low birthweight babies born to black mothers compared to white mothers and the extent to which illegitimate births and unstable marriages effect the infant mortality rates of blacks. The direct and interaction effects of race and birthweight are the only two consistent relationships that have been found in the literature and confirmed by this analysis. In contrast to previous studies, the interaction effect of race and number of marriages on infant mortality rates, although only suggested in NCHS (1972), appears even stronger than the direct effect of the race or birthweight on infant mortality rates.

In the final model, number of marriages, birthweight, and the interactions of race with number of marriages and birthweight retain strong relationships with infant mortality. Number of pregnancy losses retains a weak relationship with infant mortality. Number of pregnancies appears to be partially acting through birthweight, and partially acting independently on infant mortality. Age of the respondent at the time of the birth appears to be acting on infant mortality almost exclusively through birthweight, much as race acts

Table 19. Coefficients resulting from the logistic regression of birth weight of the infant on infant death with the other variables that were retained in the final stage of the analysis.

Other Included variables	BIRTHWEIGHT OF THE INFANT (in grams) Less than 1500	1500-2499	2500-2999	3000-3499	3500 or More	χ^2
---	3.56	.88	-.98	-1.37	-2.10	306.83***[1]
No. of Marriages	3.51	.75	-.91	-1.38	-1.38	274.69***
Maternal Age	3.44	.87	-.95	-1.33	-2.04	286.66***
Pregnancy Losses	3.50	.82	-.94	-1.34	-2.04	290.11***
Race	3.59	.81	-1.01	-1.35	-2.05	282.83***
All other variables	3.11	.54	-.66	-1.43	-1.56	184.42***
INTERACTION EFFECTS INCLUDED						
Race*No. of Marriages	3.45	.68	-.86	-1.26	-2.01	241.88***
Race* Birthweight	3.00	.91	-.89	-1.15	-1.77	156.76***
All other variables and interactions	2.84	.60	-.80	-1.21	-1.44	133.23***

1 Significance levels with 4 degrees of freedom:

* $\leq$ .05
** $\leq$ .01
*** $\leq$ .001

Tabla 20. Coefficients resulting from the logistic regraasion of the interaction of raspondent's race and birth weight of the infant on infant death with the other variablea that were retained in the final stage of the analyais.

Other Included variables	Less than 1500	1500-2499	2500-2999	3000-3499	3500 or Mora	χ^2
	BIRTHWEIGHT OF THE INFANT (in grama)					
---	2.68	.07	-.54	-.95	-1.27	139.51***2
No. of Marriagas	2.42	-.05	-.23	-.88	-1.26	110.19***
Maternal Age	2.57	.01	-.41	-.78	-1.39	127.24***
Pragnancy Losaea	2.51	.21	-.47	-.87	-1.17	118.43***
Race	2.68	.15	-.54	-.93	-1.36	140.70***
Birthwaight	1.04	-.14	-.20	-.39	-.20	14.50**
OTHER INTERACTION EFFECTS INCLUDED						
All othar variables and interactions	1.08	-.11	-.04	-.21	-.49	16.04**

1 The valuas given are for whitea. For nonwhites, tha values for the are the opposites; that ia, the infant mortality ratas for nonwhitea with a birth weight leaa than 2,500 grama ia changed by a factor of -2.68--dacreasad by a factor of 2.68 comparad to the overall population while the whitea of that birth weight group had an infant mortality rate higher by a factor of 2.68.

2 Significance levela with 4 degrees of fraedom:
* ≤ .05
** ≤ .01
*** ≤ .001

Table 21. Coefficients resulting from the logistic regression of the interaction of the race of respondent and the number of marriages on infant death with the other variables that were retained in the final stage of the analysis.

Other included variables	NUMBER OF MARRIAGES (coefficients for whites)[1] None	One	Two or more	χ^2
---	.72	-.73	.01	43.77***[2]
No. of Marriages	.66	-.57	-.10	24.93***
Maternal Age	.65	-.74	.09	43.32***
No. of pregnancy	.84	-.79	-.06	49.69***
Race	.73	-.88	.15	44.04***
Birthweight	.73	-.62	-.09	27.37***
OTHER INTERACTION EFFECTS INCLUDED				
ALL OTHER VARIABLES Except Birthweight AND Race*Birthweight	.71	-.69	-.02	23.81***
All other variables	.79	-.68	-.11	26.10***

1 The values given are for whites. For nonwhites, the values for the are the opposites; that is, the infant mortality rates for nonwhites with a number of marriagee of zero is changed by a factor of -.72--decreased by a factor of .72 compared to the overall population while the whites of that birth weight group had an infant mortality rate higher by a factor of .72.

2 Significance levels with 3 degrees of freedom:

- * $\leq$ 0.05
- ** $\leq$ 0.01
- *** $\leq$ 0.001

on infant mortality through birthweight and its interaction effects.

NOTES ON CHAPTER V

1 The linearity of the relationship between socioeconomic status and infant mortality is quite important. Regional differences suggested by the National Natality and National Infant Mortality Surveys (NCHS, 1972) make the suggestion by Markides and Barnes (1977) of that since Willie (1959) and Stockwell (1962) both were studying Northeastern cities, their results were not generalizable as descriptions of the relationship for the whole United States population. The results of the NCHS report suggest that the Northeast, and urban areas had a different relationship between socioeconomic status and infant mortality than the overall population analysis suggested.

2 The relationship between parity and infant mortality in other studies may be due to the power of the statistic used in those studies or because the variables selected do not including some of the variables used here. The statistic used in this study was appropriate for nominal data. Others have used only data that were ordinal or ratio with the individual infant deaths, which would allow the use of statistics that are capable of detecting the same relationship because their assumptions require less allowance for random error.

CHAPTER VI

CONCLUSIONS

Following on the call made by Stockwell et al. (1978:671-672), this has been an attempt to examine the relationship of infant mortality to socioeconomic status in light of previous studies using individual data. The analysis has attempted to extend the understanding of the relationship, which has been found to be weakening in ecological studies in recent years.

The expected relationships between indicators of the variables in the model (figure 1) are:

1. Based on NCHS (1972), and in contrast to the ecological studies, mother's education and family income have a curvilinear relationship to the infant mortality rates, with infant mortality higher in the extreme catgeories.

2. Based on the consistent results of previous individual and ecological studies, blacks have a higher infant mortality rate than whites.

3. Based on NCHS (1972), the infant mortality rate is lower for low birthweight black infants than for low birthweight whites.

4. Based on the consistent results of previous individual and ecological studies, if the mother, was married, never married, or married more than one time before the birth of the infant, the infant mortality rate will be higher than if the mother was married only once.

5. Based on the consistent results of previous individual studies, legitimate births should have much lower infant mortality rates than illegitimate births.

6. Following on the effect of stress during pregnancy, pregnancies that were unplanned and unwanted at the time of conception will lead to higher infant mortality rates than planned pregnancies.

7. Based on the consistent results of previous individual studies, the older the mother, the higher the infant mortality rate.

8. Based on the consistent results of previous individual studies, the more prior pregnancy losses, the higher the infant mortality rate.

9. Based on the consistent results of previous individual studies, the first birth and births after the second will have higher infant mortality rates.

10. Based on the results of NCHS (1968), births occurring three years after the last pregnancy will have the lowest infant mortality rate, with less or more spacing having higher rates.

SUMMARY OF RESULTS

The analysis of the data from the National Survey of Family Growth, cycle I, produced results that did not match expectations. There are a number of general findings that are of interest from this research. Some of these are a matter of what was not found, more than what was found. The findings of this study are as follows:

1. There was no significant relationship between indicators of parents' socioeconomic status, other than race, and infant mortality rate, although the infant mortality rate was higher for the high status category than for the intermediate group.

2. Blacks had a higher infant mortality rate than whites.

3. Race and birthweight had a very strong interaction effect, reflecting the low infant mortality rate among black low birthweight infants compared to white low birthweight infants, as well as lower mortality for white high birthweight infants.

4. Women that were never married or married more than once at the time of the birth had higher infant mortality rates. An unexpected interaction effect was found between race and number of marriages. Among women that never married, blacks had lower infant mortality rates than whites; and among women that married once, blacks had worse infant mortality rates than whites.

5. Illegitimate births' difference in infant mortality rate was explained by the number of marriages. Most illegitimate births occur to women that have never been married.

6. Whether the pregnancy was planned or not did not effect the infant mortality rates significantly.

7. Older mothers unexpectedly had lower infant mortality rates, except where the race/birthweight interaction was controlled.

8. Prior pregnancy losses significantly increased infant mortality, except when birthweight or the race/birthweight interaction were included, which controlled the effect of pregnancy losses.

9. Parity had a weak and inconsistent relationship to infant mortality rates.

10. The number of years since the last birth had a weak and inconsistent relationship to infant mortality rates.

Income and respondent's and husband's education were not significantly related to infant mortality. Also, there was not the clear linear pattern that most people have expected to find. The pattern for family income is curvilinear, as was suggested by the results of the National Natality and Infant Mortality Surveys (NCHS, 1972). There is also an unexpected direct relationship, for blacks, between family income and infant mortality rates for which there is no precedence. The relationship of the different infant mortality rates to respondent's education is erratic. Infant mortality is only slightly higher for women with 8 years or less of schooling than women with some college. There is not a pattern clearly evident for the relationship of education of the husband to infant mortality rates.

Race is initially related to infant mortality in the expected manner. The race difference is consistently significant until the effects of birthweight, the interaction of number of marriages and race, and the interaction of birthweight and race is taken into consideration. So it appears that much of the difference in infant mortality rates for whites and blacks is based not on race itself nor on an interaction of race and socioeconomic status. With the ability of the interactions of race with family structure and race with birthweight to totally eliminate the relationship of race to infant mortality rates, these two factors may point to subcultural and biological differences basic to the relationship. It is possible that enforced socioeconomic status differences may be the reason that these differences developed, but at present, attempts to reduce infant deaths can attack only subcultural factors directly, while other social programs try to restructure larger societal patterns.

The lack of a linear relationships between indicators of socioeconomic status and infant mortality rates will have far reaching consequences and implications for future studies of infant death. These results raise two possibilities. The relationship of income and education, viewed as facilitating access to societal resources, to infant mortality may simply be weakening with the general improvement in the quality of life for most people in the United States, as has been suggested by the ecological studies. Or changes in the social environment in or around the family may have changed the basis of the relationship. The possibility that the relationship is actually disappearing is not supported in any consistent manner by other individual level studies. Only Gortmaker (1979a; 1979b), reanalyzing data from the 1960's, had any question about the presence of the relationship of socieconomic status to infant mortality. Further, one of the data sets that he reanalyzed, the National Natality and Infant Mortality Surveys, had already noted the nonlinear character of the relationship. Gortmaker used a dichotomous measure, breaking the data at a point that was not likely to beat to take advantage of the differences between socioeconomic groups.

The reaffirmation of a weakening of the relationship suggests that the cause of the relationship may be shifting. The size of the sample in this study makes it unlikely that any but the most powerful relationships will be significiant. But the obvious presence of a nonlinear relationship, though not significant, makes those curvilinear relationships a major question to be considered and explained. The suggested explanation from this and most individual studies and some ecological studies, primarily Adamchak (1979) and Hecht and Cutright (1979), make it likely that some aspect of the changing family structure will become the major factor to be investigated.

The indicators of family structure showed some significant relationships to infant death. The indicator that retained its significance throughout the analysis, number of marriages, is just the type of family structure variable that previous studies are suggesting as the new explanatory variable for infant mortality. Although this was not a surprise, it did confirm the relationship of marital status to infant death that has consistently been reported with ecological data as well as with individual data from studies primarily done in medical settings. The reason for the rise of the explanatory power of the family status indicators is not clear from the ecological and individual level studies. With the rise in marital instability, the extent to which family status variables are related to infant mortality should increase as one-parent homes become more frequent. Although more common, and generally more accepted, the parent's ability to supply adequate living conditions is generally decreased with the decrease in income and time that may be available in the two-parent setting.

The health indicators formed a complex relationship that produced maternal age and birthweight as the predominant indicators related to infant death. Maternal age maintains a moderate relationship to infant mortality rates in the presence of the other health indicators. But a strong interaction between the number of pregnancy losses, previous births, and years since last pregnancy on infant death was not suggested by earlier research using individual live births. But these variables seem to support each others' relationship to infant mortality. As they are entered into the calculations for the logistic regression, their significance increase. Even maternal age has the most explanatory power when the number of previous births is included. This seems likely to be the result of the similar processes involved in the occurrence of each of the health indicators.

Finally, the weak relationship of the various indicators of health suggests that there may be some mitigation of the strength of some of these indicators related to infant mortality rates. This is not consistent with the results of the various studies done by medical and epidemiological researchers for the same general period of time. This and the unexpected weakness of the socioeconomic indicators suggest that the number of births used in this research may have limited the significance of the results more than was expected.

IMPLICATIONS

The unusual relationship of the socioeconomic status indicators as the independent variables to infant mortality clearly leaves many questions to be answered. The first question pertains to the basis of the relationship that was found in this study. As has been noted, the change of the relationship of socioeconomic status to infant death appears to be occurring because of the way that factors that intervene between socioeconomic status and infant death have changed in importance and their relationship to infant mortality. The relationship between the socioeconomic status of the family and the chances of an infant death is not eliminated. Rather, the relationship is an erratic one, which is possibly spurious or the result of various intervening factors between the socioeconomic status of the parents and infant mortality.

Among the factors relevant to both ecological and individual levels of data that are apparent from this research are regional differences in the relationship of socioeconomic status to infant death and the nonlinear relationship between income and maternal education and infant mortality among whites. Individual level studies need to understand what aspects of socioeconomic status lead to the relationship to infant death.

To specify the individual level relationship better, there must be more extensive and detailed research on the behavioral correlates of socioeconomic status that may be related to the infant mortality of the various groupings that were studied here. The results of this research specifically suggest that there is a need for research on the ways that such factors as marital status and number of marriages affect infant mortality. It is suggested by Connolly and Cullen (1983) that the biological effects of stress are potentially a significant factor. Other reasons are even more viable, including the ability of the mother to have sufficient time and effort to optimally care for the infant, competing needs that often arise in attempting to maintain a job or other necessary activities outside the immediate household, the competence of some unmarried or remarried persons to maintain a safe and stable environment to raise the child, or lack of social support for nontraditional family arrangements, all may influence infant mortality. These factors need further research.

CONCLUDING REMARKS

The results of this research point out problems that studies using ecological data are not able to deal with at present. Ecological level research needs to resolve the problems inherent in working with nonhomogenous areal units that are usually labelled as aspects of the ecological fallacy. The best approach to studying infant mortality as a phenomenon affecting individuals, rather than as an indicator of general health status of a population, will have to be with individual data. This study and the medical studies have consistently seen infant deaths as an individual event, to be analyzed as such. The medical literature on infant death primarily consider the biological concomitants associated with infant deaths that occur in hospitals, with some consideration given to the reason for hospitalization. Epidemiological researchers consider primarily measures of socioeconomic status and the health condition of the mother and infant, using large-scale surveys or birth certificate information. A minor vein of epidemiological research uses intensive methods on individual deaths to locate cultural, medical, and personal conditions that lead to infant deaths. But most demographic and epidemiological studies see infant mortality as an event that is not the result of particular situations, but rather as the result of the general structural processes and integral macroproperties of the area or group being studied.

Only a few data sets using individual data have been available over the past 20 years. The significance of studying infant deaths as individual events arises out of the unique events and situations of each set of parents in preparing for and dealing with the birth and care of their infant. The immediate effects of social disorganization and inequality become apparent through the differences in coping with such a major event in the life of the family.

Studies of infant mortality as a demographic event need to look at structural factors more thoroughly. The inequalities in the distribution of various structural factors, such as neonatal intensive care units, or, as Willie (1959) suggested, basic sanitation may still illuminate the structural differences and changes in this nation's cities and rural areas that relate to the form and functioning of society as a whole. Attempting to analyze the relationship of socioeconomic status to infant mortality from the ecological level is quite prone to problems. Such analyses can appropriately consider the correlation of basic structural facilities and support systems to areal infant mortality rates or study the extent of segregation by status and the correlates of such segregation. But research using an ecological approach should always be aware of the problems of the ecological fallacy and interpret results in ways appropriate to the data's level of aggregation. Alternatively, infant mortality rates can be used as indicators of the general medical status of an area that has a socioeconomic status to infant mortality rate relationship for which the primary intervening factors are known.

Cross-level material to support the use of ecological indicators based on the individual data and to test ecological findings against the individual data is suggested. The potential for such research exists but has not been pursued. Aggregation of individual results is possible with little difficulty. Gathering of good quality individual results is much more difficulty.

For significant progress in the understanding of the social conditions that lead to infant deaths, the use of confidential inquiry techniques, as described in Richards and McIntosh (1972) and Department of Health and Social Security (1970), would be most productive. That approach involves the central collection of records on the medical condition(s) for which the infant was treated during the course of its life, along with the results of autopsies and interviews with health and social welfare agency personnel that may have contacted the parents prior to the death. Some of that information is already collected in some areas, such as Chicago (Winegar, et al., 1983). Information on the home and family environment needs to be collected to supplement birth certificate and medical information to attempt to uncover the factors intervening between socioeconomic status and infant death.

The use of prospective studies, where a group of pregnant women are selected and followed through the first year following the birth, would gather the greatest amount of information with the least chance of the subject selection biases. This is the standard approach for medical epidemiology. But both of these methods are prohibitive undertakings for most researchers, due to cost and problems in selecting and following a group of subjects large enough to include sufficient infant deaths to be statistically significant.

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SOCIAL CLASS AND INFANT DEATH: A REPLICATION AND EXTENSION WITH INDIVIDUAL DATA, 1967-1972

by

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AN ABSTRACT OF A MASTER'S THESIS

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ABSTRACT

The works on public health since the early 1900's have shown that the chances of an infant death decrease as the social class of the parents and of the area the parent's residence increases. Some research using ecological data over the last thirty years had found several cases where socioeconomic status and infant mortality were related only weakly. Even the studies that had used data on individual births had shown a nonlinear relationship between social class and infant deaths. A review of the problems that arose when attempts to apply the results of studies of areas to the individuals in those areas making it possible to relate how the changes in the social class--infant death relationship at the individual level might have affected the way that the relationship appeared at the ecological level. The analysis of previous individual level research suggested groupings of variables that have intervened between measures of socioeconomic status and infant death. These were then used in the analysis presented here. The data is from a national sample survey of 9,797 women aged 15 to 45 years, to gather information on their reproductive histories and certain demographic variables. This study found that (1) the nonlinear relationship between socioeconomic status and infant death was present, but was not statistically significant; (2) birthweight and maternal age had separate and very significant relationships to infant death; (3) other biological variables--i.e., number of pregnancy losses, parity, and pregnancy spacing--interacted as a group to weakly affect infant mortality rates; (4) number of marriages retained a consistent and powerful relationship to infant death; and (5) race had interaction effects with birthweight and number

of marriages with very strong relationships to infant mortality rates. The differences between the results of studies using individual versus ecological data suggests that the change in the relationship between social class and infant mortality is a matter of both level of data and a changing relationship. With the importance of race, the factors that it subsumes become important in suggesting future research.