Antecedents of Three Year-Old Child Health Status

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at George Mason University.

By

Candice Cook Bowman
Bachelor of Arts
San Diego State University, 1972
Bachelor of Science in Nursing
Creighton University, 1979
Master of Science
University of Colorado, 1982

Director: Jean Moore, Associate Professor
College of Nursing and Health Sciences

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George Mason University
Fairfax, Virginia
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ABSTRACT

ANTECEDENTS OF THREE YEAR-OLD CHILD HEALTH STATUS

Candice Cook Bowman, R.N., B.A. (San Diego State University, 1971), B.S.N. (Creighton University, 1979), M.S. (University of Colorado, 1981)

Dissertation Director: Dr. Jean Moore

This study sought to assess a set of factors that were proposed to influence child health status at 3 years of age. The sample (N=4940) was drawn from the 1988 National Maternal Infant Health Survey and the 1991 Longitudinal Followup, conducted by the National Center for Health Statistics. Only mothers who gave birth to live, singleton infants in 1988 and whose children were still alive and living with them in 1991 were used in the analysis (N=4940). Relationships were specified between the following latent variables: maternal social advantage to birth outcomes and from birth outcomes to child health status, measured by multiple dimensions of health.

It was hypothesized that positive prenatal health practices would mediate the influence of maternal social advantage on birth outcomes and that positive infant health practices would in turn mediate the effect of birth outcomes on preschool-age child health status. Results indicated a good fit of the overall
model with the data, using a LISREL structural equation modeling analysis. It was concluded that maternal social advantage and health practices are important precursors of subsequent health and significantly influence the health of young children; that measurement of multiple dimensions of health status in young children are required to capture the full influence of antecedent factors; and that positive health practices successfully mediate the effect of social and health factors on future health status of children.
Chapter One

Introduction

It is a generally accepted view that enhancing our understanding of what contributes to health is a worthwhile endeavor. For instance, it is now well-known that health status is directly affected by the structure and process of a health care delivery system. Measurement of health status then becomes a necessary endeavor to evaluate the quality of that system. However, assessing health status is broader than just critiquing clinical interventions. Despite the fact that early efforts in health status measurement sought to identify direct linkages with a distinct resource or process, authors such as Rutstein and associates (1976) took a broader view. They suggested that dimensions of poor health status, including preventable disease, disability, and untimely death, are likely to be the result of a long, complex chain of antecedent events that may even be attributable to such seemingly obscure circumstances as those created by sociopolitical, attitudinal, and religious characteristics. It is important to study such associations, they asserted, because that type of search could lead to better health by identifying, and eliminating, those early influences that subsequently contribute to undesirable health later in life. This investigation sought to illuminate a more distinct understanding of the relative importance of preceding factors.
that are thought to influence the health status of young children, especially those that can be modified by nurses.

Health status assessment reflects fundamental changes in care modalities (Bergner & Rothman, 1987). The idea that healthy practices produce healthy people underpins the somewhat recent redirection towards health promotion. However, health behaviors do not impact one’s health exclusively. In their early health assessment research, Belloc, Breslow, and Hochstim (1971) found that “...ways of living (i.e., social and demographic characteristics, personal habits, familial, cultural and environmental factors)...affect and (are) affected by physical, mental and social health.” (p.329). This implies important interactions between a wide array of environmental and biological components.

Something that has become problematic in assessing health status, however, is that the concept of health historically has been and remains poorly defined (Ware, 1995). Within the health care arena, early attempts at evaluation of health outcomes focused almost solely on the occurrence of mortality and morbidity as indicators of the effectiveness of health care delivery. Although easy to measure, these indicators tended to restrict the view of health to just the absence of disease. The more progressive view allows more positive features to be considered, such as optimal functioning within the constraints of one’s capabilities. As early as 1952, Lembcke described the requisite outcomes of medical interventions as those
"...prolonging life, relieving distress, restoring function and preventing disability" (p. 276). Following the logic of Rutstein et al., if negative health states result from a web of formative factors, then positive health states, such as those proffered by Lembcke, must do so as well.

At present, no one would argue that a satisfactory definition of health has to be multidimensional. The work by Belloc et al. (1971) supported not only the existence of several separate dimensions, but also that mortality and morbidity were hardly specific enough to measure that huge portion of the health spectrum that exists between presence of disease and optimum vigor. However, the sheer number of general surveys now available that measure health status (see Ware, 1995) suggests a lack of agreement as to what dimensions comprise a true definition. Furthermore, the paucity of health status measures designed for young children emphasizes the difficulty in establishing a core set of variables that are indicative of a child’s level of health, while considering the modifying effects of developmental age and environment. So, a broader definition of child health is needed, combined with a better understanding of the interrelatedness of longitudinal factors that contribute to it.

The part that social advantage plays in not only facilitating access to health care, but also in improving health status, is only now becoming fully realized. This adds further complexity to the array of determinants of a young child’s health. Jamrozik and Sweeney (1996) caution child health
providers that assessing the individual out of his or her social context risks misunderstanding the actual causes of their maladies.

Significance. Studying factors in a child's milieu that may impact his or her health is an important task in light of disappointing sociopolitical and health-related trends. Several recent reports have highlighted indicators that show inadequate progress or actual declines compared to health either nationally or worldwide (Maternal Child Health Bureau, 1994; Coiro, Zill, & Bloom, 1994; and Children's Defense Fund, 1996). Comparitively high levels of infant mortality and low birthweight, low levels of prenatal care and immunization rates, and low incidence of breastfeeding, especially past the early postpartum, are just some of the indications that the health status of infants and young children in the United States is not commensurate with its relative wealth as a nation.

Further, the most current National Center for Health Statistics (NCHS) report on the status of American children's health (Ciro, Zill, & Bloom, 1994) describes disparities on overall health ratings by parents on the children's supplement to the 1988 National Health Interview Survey, based on race, as well as other demographic, geographic, and economic characteristics. These findings emphasize the presence of significant influences from contextual and behavioral factors in a young child's environment (e.g., living with a smoker or using seatbelts) that predict his or her health. Some of the highlights of that NCHS report include:
(a) a positive relationship between overall health ratings of children and higher levels of parent education, higher household income, and older maternal age at first birth;
(b) a favorable health status rating for proportionately fewer black than white or Asian children and for fewer Hispanic than non-Hispanic children;
(c) significant associations between routine health care and children whose families are in the higher income brackets and more frequent hospitalizations for children in poverty;
(d) an increased likelihood for health problems or limitations in daily activities in children with developmental, learning, and emotional disorders compared to children without those disorders; and
(e) better health and a decreased likelihood for developmental, learning, or behavioral problems in children living with both biological parents.

These conclusions defy a simplistic explanation of determinants of child health and emphasize the need for a better understanding of its complicated web of factors that include the social context and even the gestational environment.

Investigating health status for any age group from a nursing standpoint has much value. Nurses, more than any other health care professional, regard their clients from a decidedly holistic perspective. Ware (1995) reports empirical evidence that shows that the majority of physicians rarely, if ever, ask patients, even those with chronic conditions, about limitations in their
abilities to perform activities of daily life. In Ware's words, "...patient functioning and well-being affected by disease and treatment are unlikely to be discussed during a typical medical visit" (p.345). Because these assessments fall squarely within the domain of nursing, multidimensional health status and its antecedents are perhaps most effectively understood and, therefore, studied by nurses.

**Purpose.** Evaluating events that predate child health at a given age may be the only strategy that will lead to not only a better comprehension of the complex intertwining of influences that have the potential to affect that health, but also to improve interventions designed to mitigate those negative influences. McGauhey, Starfield, Alexander, and Ensminger (1991) argued for the use of multivariate methods to "...identify combinations of factors that significantly increase the risk of poor health experienced by young children" (p.944). Therefore, the purpose of this study was to test a multivariate model of antecedent relationships, beginning in prenatal life, hypothesized to influence health status in early childhood.

Chapter Two of this study presents the theoretical issues that inform the discussion of health status and its measurement in children, the possible factors of antecedent cause (i.e., social factors and health practices), and the empirical evidence that supports specification of the model's relationships. Research hypotheses and definitions are also presented. Chapter Three describes the surveys from which the data used in this secondary analysis
were derived and details the analytic method used in the modeling process. Chapter Four describes the sample of mothers and their children that were used in the analysis and the results of the modeling procedure, both with the total sample and separately with homogeneous racial groups. Finally, Chapter Five discusses the results in the context of others' work and their application to theory and practice. Limitations regarding generalization of these findings and recommendations for future investigations are given due consideration.
Chapter Two

Literature Review

The following review of the literature provides background information that supports the factors constructed for the model. The first section addresses the range of issues that surround the definition of health status that are still being debated and how these issues were approached in this study. The second section examines current trends in crude measures of child health status in the United States, as well as, methodological issues concerning the adequacy of measuring child health status and how those issues were addressed in this study. The third section discusses the impact of health practices on eventual health. The fourth section describes empirical evidence that supports specification of the model's relationships. The final section describes variable definitions and specific hypotheses tested.

Defining Health Status

Issues central and tangential to the measurement of health status are rife. Most authors who write and conduct research in this area would agree that there is no consensus in regard to operationalization of the concept of health and, hence, health status (Bergner & Rothman, 1987). Larson (1991) discusses the concept of health taken from several different perspectives. In the medical approach, for example, health is measured by prevalence of
serious disease in an individual or community, often qualified with crude measures of functional disability. The holistic perspective, on the other hand, regards health more positively by including items such as a sense of well-being and willingness to work; just being free of disease is not enough in this view. From a cultural perspective, how health is defined largely determines how one perceives the status of their health. Americans tend to have high expectations for their health, probably due to easy access to health care and low levels of morbidity and mortality relative to many other countries. As a result, they tend to rate their own health accordingly.

Strickland (1991) claims that the term functional status focuses on a person's capabilities and limitations. She cites three dimensions, physical, psychological, and social, that are often used to define health status. Ware (1995), in a comprehensive update on the progress of health assessment, refers to the oft-cited World Health Organization dimensions of physical, mental, and social well-being as a useful framework for evaluating general health. Stein and Jessop (1984) enumerate three essential modes of measuring health status: (a) a person's perception of their own health status, (b) a clinical examination of levels of health and illness, and (c) an assessment of manifestations of health and illness. They hold that functional status, or "...behavior or performance in relation to societal expectations of appropriate behavior for a person of a given age" (p. 163) is of the latter type.
Bergner and Rothman (1987) reason that the difficulty in assessing health status will only increase as the definition of health broadens to include health-related quality of life components. In their review of commonly used health status measures, they cite appropriateness of the instrument to the goals of the study as being the most important criterion for choosing a particular measure. They argue for a broad definition of health and illness to provide the most accurate and complete picture of prevalence.

Stein and Jessop (1983) concisely sum up the controversial issues and conceptual problems that underlie any measure of health status. They are: (a) what definition of health should be used and on what aspect of the health spectrum the measure should focus; (b) whether health should be measured as a single index or retained as separate domains and what domains should be included; and (c) what the measure is intended for and whether it should assess outcomes of the structure or process of health care.

It is clear that measurement of multiple dimensions of health provides a snapshot view of the health status of a population. Furthermore, a one-time general health status assessment reflects the broad brush stroke-type changes made to a health care delivery system. However, individual health status is the sum of a person's health history and behaviors over time, not to mention the social and environmental contexts that have influenced it. Developing a better understanding of the influential life events that precede that point in time has merit.
Health Status of Children

Several reports on the status of infant and child health in the United States reveal little progress on crude measures. The mid-decade review of Healthy People 2000 (Public Health Service, 1995) proclaims some progress in prenatal health of pregnant women although some backsliding from the targets was charted for low and very low birthweight and fetal alcohol syndrome. While declining 35 percent in the 13 years prior to 1990, infant mortality, a rather gross indication of a nation's health, continues to be a problem compared to rates in other industrialized countries. Furthermore, the infant mortality rate for African Americans was more than double that of whites in 1992. Some progress was shown in the review for the basic immunization series for children aged 19 to 35 months but rates of ear infections under 4 years nearly doubled since the baseline was established in 1990. The Children's Defense Fund (CDF) (1996) claims that American children's health at the present is unacceptably poor, based on their own trend tracking of prenatal care, infant mortality, low birthweight, and immunizations. They cite disproportionate poverty in some racial/ethnic groups as a strong correlate of these trends. While recognizing that some progress has been made in mortality rates, the CDF finds it to be largely attributable to advances in neonatal medical technology rather than overall improvements in health care delivery or health of mothers and their young children.
Based on the issues enumerated above regarding difficulties and multiple views of defining health status, child health status, for the purpose of this study, is defined toward the positive end of the health spectrum in order to reflect the high expectations for health in the American context. The physical, developmental, and functional domains of health should be measured separately to be consistent with the literature. Because antecedents of health status may impact one of its domains and not others, a single index would not have much specificity. The purpose of measuring child health status necessarily has to be broad to fully capture the effects of contributing factors. As a result, this measurement should reflect neither the structure nor the process of health care delivery, but the sum of its influence on eventual health, as well as factors external to that system.

In spite of the wide use of certain indicators that are used to gauge trends in child health status, few valid and reliable measures of general health in children have ever been offered (Stein & Jessop, 1983). Special difficulties arise from the lack of a consensus definition of health and its dimensions in measuring child health status, although a poor understanding of what are the age-specific roles and functions of children has confused the issue.

Stein and Jessop (1983) argue for a functional health definition that yields a single-index, multipurpose but sensitive-to-change measure of a child's ability to perform within the expectations of what a culture considers
to be the norm appropriate for a particular age, however loosely construed that may be. McGauhey and Starfield (1993) measured seven dimensions of child health status in 8,661 2 to 11 year-olds. Their definition was composed of functional health status (measured by bed days, school-loss days, and activity restricted days), school performance, behavior problems, and mother's assessment of her own child's health, although no particular rationale was provided for their choice of variables. Keltner (1992) operationalized the construct by dichotomizing and summing the results from a physical exam, a hematocrit/hemoglobin count, height and weight measurements, a dental exam, and a vision screen for 110 children from 3 to 5 years old. By the author's own admission, this definition provided only a "gross estimate" of child health and a questionable one at that (p.131).

Starfield (1987) addresses the unique conceptual issues of child health that are secondary to their dynamic development, such as the wide variability of illness manifestations between 0 and 20 years of age. She alludes to an array of methodological concerns in measuring children's health:

1. There are limitations to using parents as proxy respondents.
2. Most child health status variables are not normally distributed.
3. Variability within clusters of characteristics are rarely shown.
4. Use of data derived solely from providers tends to bias the general picture because children, compared to adults, utilize services less.
5. Because families are frequently mobile, there is greater difficulty in tracking children through their health experience so longitudinal pictures of how they react are rare.

No one would argue that using parents' assessments are quite appropriate for the preschool-aged child. Some conventional measures, such as physical growth parameters and developmental milestones, are even standardized to the population. Concern for skewed distributions cannot preclude the use of available, nonstandardized measures if none currently exist. This merely emphasizes the need for developing better measures. Examining longitudinal data measuring a multitude of factors that are known to influence health, as well as health status itself, may ameliorate some of these potential methodological concerns.

**Health Practices, Social Factors, and Health Status**

Despite what motivates health behavior or creates disincentive, the practice of healthy behaviors will improve health status, given enough time for an effect to take place. The seminal work by Belloc and Breslow (1972) conclusively demonstrated the association between daily personal health practices and good health outcomes. Other reports are not so clear in demonstrating a simple association between health practices and health status. Lawrence and Schank (1993) asked 76 university women about their health status, how much value they placed on good health, and what health-protective and stress management practices they employed. Although the
majority were found to be in good-to-excellent health, placed a high value on good health, and generally had good health practices, many admitted to drinking and driving, frequently skipping breakfast, and exercising irregularly. While these findings reflect typical behaviors and attitudes of this age group, they actually emphasize the resilience of youthful health. The point is then, given youthfulness combined with a reasonable level of maintained health, one can escape the occasional minor indiscretion.

The deleterious consequences of protracted poor health practices may not be so easy to avoid. This makes public health efforts to educate individuals about the risk of poor health outcomes due to the lack of positive health practices paramount. Evidence regarding the success of public health campaigns is abundant. For example, Higgins, Frank, and Brown (1994) found that 49% of the 115 pregnant women they interviewed named 18 positive changes made in health practices since knowledge of their pregnancies. On the other hand, the majority of the 13 million recent postgravid women questioned in the 1990 National Health Interview Survey who ever smoked, continued to smoke during their pregnancies, about 15% of the total sample (LeClere & Wilson, 1997). It is apparent from these findings that there is more work to be done in public health education.

Furthermore, it would be helpful to know to what extent that positive health practices can alter the ill effects on health from other sources, especially those of a social nature. The confounding influence of some
socioeconomic factors on the health practices-health status relationship has been investigated. Ungemack (1994), in studying gender differences in personal health practices, found that more education made a difference in positive health practices, at least in adult men. In a large Canadian study, Hirdes and Forbes (1993) found a connection between the healthy practices of not smoking and moderate alcohol use with good self-rated health in 2,000 45-year old males. Not unexpectedly, their findings also showed a significant association between higher levels of education and income with good health. Pill, Peters, and Robling (1993) investigated factors linked with health behaviors in a British sample of 360 lower socioeconomic women. They found that only housing tenure (whether one rents or owns their home is a strong indicator of socioeconomic status in Great Britain) predicted positive health practices, keeping in mind that the entire sample was from the lowest income groups.

The link between social disadvantage, irrespective of the social structure that produced it, and numerous aspects of poor health, has been well established (Pappas, Queen, Hadden, & Fisher, 1993; Bennett, 1992; Kempe et al., 1992; Mangold & Powell-Griner, 1991; Rutter & Quine, 1990; Williams, 1990; Gould & LeRoy, 1988; Morgan & Chinn, 1983; and Paneth, Wallenstein, Kiely, & Susser, 1982). If both health practices and social factors impact health, attempting to change the former would be the easier task for health professionals, given the relative resistance to change. Improving the
knowledge about this interplay is then warranted.

**Antecedents of Health in Early Childhood**

Schorr, Miller, and Fine (1984) contend that measurement of childhood morbidity and mortality are important sentinel endeavors in shaping health policy and controlling the direction of flow of resources. Nevertheless, they parry their own defense of using these negative indicators by suggesting that, in the future, child health must be viewed as more than just a medical issue. It should be seen as a phenomenon occurring within a complex context of multiple influences.

**Maternal characteristics.** Certain demographic and socioeconomic characteristics of mothers are known to be associated with poor birth outcomes. Lee, Ferguson, Corpuz, and Gartner (1988) investigated the independent effect of maternal age on low birthweight in 184,567 singleton, term infants. They found a curvilinear relationship where the highest risks were in those mothers aged under 17 and over 35. Cnattingius, Forman, Berendes, and Isoltalo (1992) reviewed singleton births to 173,715 nulliparous, over 20-year old Swedish women and found that the older age groups were at increasing risk for the poor pregnancy outcomes of low birthweight and prematurity. Lieberman, Ryan, Monson, and Schoenbaum (1987) investigated a number of risk factors for premature birth in 8903 black and white women and found that those women, regardless of race, who were younger than 20 years of age, single, on welfare, and without having
completed high school were at greatest risk for delivering early.

Ahmed (1990) studied 36,608 Black singleton births in the District of Columbia and found a 34 percent higher incidence of low birthweight (LBW) and a 35 percent higher infant mortality rate in infants of unmarried mothers. Bennett (1992) challenged what she considered to be an oversimplified relationship between marital status and low birthweight and infant mortality. She summarized earlier research findings that indicated that the effect of marital status actually varies by maternal age and race, where the greatest negative impact was found in white women over 19 years of age. However, the overall risk of poor outcomes for out-of-wedlock births seems to persist over time, regardless of what covariates are measured.

Starfield et al. (1991) analyzed race and family income as risk factors for low birthweight in a national probability sample of young women, both black and white, who delivered live singleton infants between 1979 and 1988. Their analyses revealed that the influence of maternal race on low birthweight is greatly reduced in the poor. Apart from the poverty influence, they found that the risk for bearing low birthweight infants for black mothers was significantly higher in every socioeconomic category, such as education, age, and marital status. Furthermore, there was increased risk for both racial groups for those unmarried and with only a high school education or less. An Australian study of 8,556 consecutive pregnancies showed an even farther downstream relationship of family socioeconomic disadvantage with the
health of children followed to age 5 (Bor, Najman, Morrison, & Williams, 1993). Their findings showed that children of mothers from the lowest socioeconomic strata used more health care services, had more chronic disorders, and had more dental problems.

**Influence of prenatal health practices.** A pregnant woman’s health and health habits are known to influence pregnancy outcomes. For example, Nandi and Nelson (1992) studied an Illinois data set of 26,767 births and found that women over 30 years of age, who also smoked and were underweight at conception, were at the greatest risk for delivering LBW babies. However, analysis of the interactions revealed a strong combined effect for only smoking and advanced age.

Purfield and Morin (1995) sought to determine whether excessive weight gain during a low-risk pregnancy for 104 primigravid women would increase problems during the intrapartum. Those who gained more than 25% of their pregravid weight experienced longer second stage labor and had more deliveries requiring use of vacuum, forceps and cesarean section, thereby increasing the risk to their newborns. Marshall (1991) also investigated the relationships of certain prenatal health practices to incidence of intrapartum and neonatal problems. She found excessive gravid weight gain to be a predictor of intrapartal complications as well. Among other behaviors, Marshall measured exercise frequency, although prior to pregnancy, which had no effect on outcomes. By her own admission, the
short-term benefits of preconfinement exercise would be unlikely to have a protective effect at delivery anyway. Thus, it is still possible that frequency of exercise during pregnancy may have a positive influence on birth outcomes.

Fox, Koepsell, and Daling (1994) noted that both young and old maternal age and cigarette smoking during pregnancy separately are known factors associated with low birthweight. When birthweights of the newborns of smokers and nonsmokers were compared in 347,650 singleton births in the state of Washington, the differences increased with advancing maternal age. When these results were adjusted for race, marital status, parity, adequacy of prenatal care, and urban/rural residence, these differences were diminished but not abolished, especially for the older mothers. However, the relative risk of low birthweight persisted with increasing age. The investigators speculated that the effect was either due to increasing physiological susceptibility, to dose-response or cumulative exposure, or to the fact that smoking serves as a marker for an array of other unhealthy prenatal habits in the younger women that were not measured.

The effects of alcohol consumption during pregnancy have been thoroughly described. Budd (1995) cited the incidence of fetal alcohol syndrome (FAS) as 3 to 5 per 1,000 live births. Although it is usually associated with heavy drinking, or at least three drinks a day, FAS has also been seen in infants of women who consumed as little as two drinks daily. The diagnostic features include pre and postnatal growth retardation, low
birthweight, neurobehavioral and developmental disorders, motor abnormalities, and facial dysmorphology. While smoking was shown to have a decisive effect on length of confinement in 30,596 northern California women, alcohol consumption did not (Shiono, Klebanoff, & Rhoads, 1986). However, birth weight, length, and head circumference were found to be influenced by intrauterine alcohol exposure in 500 offspring of women who were oversampled for heavy consumption (Sampson, Bookstein, Barr, & Streissguth, 1994). This investigation also showed that effect on later growth disappeared. Neurobehavioral pathology, a well-known outcome of intrauterine alcohol exposure, was not measured.

The adequacy of prenatal care is well-known for its effect on newborn health. Goldfarb (1991) found low rates of prenatal care with resulting high rates of LBW births in 434 deliveries to urban poor mothers. This study also revealed a disturbingly high incidence of prenatal smoking as well as alcohol and illegal drug use in the same group. Kotelchuck (1994), in testing a new prenatal care adequacy index, demonstrated that the highest scores were associated with prenatal care being initiated in the first half of pregnancy and with at least 50 percent of the recommended number of visits. Using data from the 1980 National Natality Survey, his findings showed that only 61 percent of this nationally representative sample of women received adequate care, with whites more than blacks, and higher rates of LBW associated with inadequate care measured by the new index.
Factors that restrict access to adequate prenatal care are largely demographic or socioeconomic. Lia-Hoagberg et al. (1990) compared three racial groups of low-income women on what motivated or prevented them from receiving adequate prenatal care. Although race was not found to be an issue, striking similarities of motivators and barriers for women within the three categories of care received (adequate, intermediate, or inadequate) were found. Inadequate care was more likely to be received by those under age 20, unmarried, without a high school education, unemployed, and with more children. Meikle, Orleans, Leff, Shain, and Gibbs (1995) investigated the reasons given for seeking no or late prenatal care by 606 low-income postpartum women in a large urban hospital in Colorado. Their sample, which was nearly half Hispanic, as well as generally adolescent, poor, unmarried, and undereducated, demonstrated significant differences along racial and ethnic lines for why adequate care was not sought, varying between financial, attitudinal, and personal reasons.

**Birth outcomes.** Outcome studies of LBW and very LBW, preterm and extremely preterm neonates are numerous (e.g., Achenbach, Howell, Aoki, & Rauh, 1993; Hack et al., 1993; and Rantakallio & von Wendt, 1985). However, few follow normal births into infancy, although normal developmental and physical growth parameters are well-established for the first year of life.

Friede et al. (1987) reviewed over 2.5 million national birth records for black and white singletons born to mothers between the ages of 10-29 years in
1980. One purpose of this study was to analyze the effect of birthweight, maternal age, and race on neonatal and postneonatal mortality. Babies born to teenagers and blacks were at an increased risk for dying after the neonatal period. Also, babies born to the very young mothers had a higher prevalence of low birthweight, although these authors concluded that maternal age alone is probably not as important as prenatal behaviors associated with young age, such as weight gain, substance use, and inadequate prenatal care. The role of low birthweight leading to later infant health then appears to be inextricably linked with factors antecedent to the birth.

Gennaro (1995) followed 224 preterm, low birthweight infants for 6 months following hospital discharge to measure infant health and family functioning outcomes. By 6 months (mean length of initial hospital stay was 32 days), 25% had been rehospitalized at least once for a mean length of stay of 8 days, 50% had made acute health care visits for illness at least once, almost all had received adequate well-child care, but only 55% were fully immunized. These findings were reported to be consistent with other studies.

The Infant Health and Development Program (1990) reported on the results of a multisite trial of an educational and support intervention to reduce the health and developmental risks of being low birthweight and preterm. Eight clinical sites yielded 985 infants who were randomly assigned to either the intervention or follow-up only groups. At 36 months of age
corrected for prematurity, the intervention group had significantly higher IQ scores, fewer behavioral problems, but no difference in amount of serious health problems. However, a multiple regression analysis revealed that more hospitalizations, outpatient procedures, injuries, and illnesses were experienced by white males who had lower birthweights and more neonatal morbidity and whose mothers had higher levels of education, regardless of the intervention effect. One explanation for this curious result is that survival of the smallest, sickest neonates may indeed be a function of race and maternal education which distracts from the overall finding that adverse birth outcomes predict poor health in childhood.

McGauhey, Starfield, Alexander, and Ensmiger (1991), in an analysis of 8,661 children from the Child Health Supplement of the 1981 National Health Interview Survey, concluded that children who were low in birthweight and living in high-risk social environments were at increased risk for poor health outcomes and that this effect is long-lasting. In comparing LBW and normal birthweight (NBW) children, behavior problems were found to be three times more likely to occur for LBW children from low-income households while lower levels of maternal education increased the likelihood for behavioral problems in NBW children. They concluded that a healthy social environment is very important for achieving favorable child health, especially for children who were LBW. Overpeck, Moss, Hoffman, and Hendershot (1988) measured the health of 57,525 children up to 18 years old
from the NHIS child health supplement who were LBW. Their findings suggest a strong link between this particular birth outcome and later morbidity measured by numbers of chronic conditions and hospitalizations, activity limitations, poor or fair health status, bed days, doctor visits, and school-loss days.

Apgar scores, assigned at one minute and five minutes after birth, have been widely used for more than four decades as an accepted measure of a newborn's physical status and adaptation to extrauterine life. Although these scores were originally thought to be predictive of long-term neurologic health, Jepson, Talashek, and Tichy (1991), in a review of the literature, found that they may not accurately forecast health outside of the first month of life, especially in premature, LBW infants. However, low scores in term, normal birthweight infants are strongly predictive of mortality within the first year. The real advantage of the Apgar scoring system, according to the conclusions reached by this group, is that, because of the high specificity, a healthy newborn will not receive a low score. Following this logic, if adverse birth outcomes are known to predict future health problems, then favorable outcomes should be able to predict better health later on.

Influence of infant health practices. Links between infant health and eventual preschool health for any category of children have not been well-substantiated empirically. Although health outcomes were not studied, Richardson (1988) found that the majority of parents of children enrolled in
day care followed a wide array of health-promoting practices for their children. Documentation of trends in a number of positive health indicators appropriate for this age group is more available.

Although the Healthy People 2000 midcourse evaluation (Public Health Service, 1995) indicated substantial headway toward the projected 90 percent immunization coverage of American children by 2000, Zell, Dietz, Stevenson, Cochi, and Bruce (1994) found that only 11 to 58 percent of children in 60 large urban areas had been adequately immunized by 2 years of age. The importance of immunization as it directly relates to child health is well-established, both for the individual child, as well as for the community of children. Furthermore, the indirect importance of being adequately immunized, as described by Orenstein and Bernier (1994), is that it provides opportunities for other aspects of well-child care. Pantell and Lewis (1987) further emphasized the importance for early well-child health care as an opportunity to impact parenting and development of children's health attitudes and behaviors.

Because of the known benefits of breastmilk, the proportion of infants who still breastfeed at 5 to 6 months is a widely accepted positive indicator of infant health. Quarles, Williams, Hoyle, Brimeyer, and Williams (1994) found that 115 women from one large teaching hospital breastfed their infants for a mean of only 2.4 months, although intervention with a lactation specialist involving 46 women at another hospital produced a significance
increase in duration, albeit to a mean of only 3.1 months. Hawkins, Nichols, and Tanner (1987) found that longer duration was predicted by older age, higher education, being married, and having fewer pregnancies in low-income women. They also found that infants with higher birthweights were breastfed longer. Despite a small but growing number of mothers who initiate breastfeeding, no gains were observed in the number of those still breastfeeding at 5 to 6 months in the Healthy People 2000 midcourse review.

The predictive value of levels of health in infancy on health farther downstream is not frequently the subject of research. However, one older study correlated events from the prenatal, neonatal, and infancy periods to development measured at 2 years of age (Littman and Parmalee, 1978). These investigators followed 126 preterm, low birthweight infants from birth and found no significant relationships with prenatal and neonatal events. However, they did find that medical events in later infancy, such as growth problems, illnesses, injuries, and hospitalizations, were significantly associated with low 2-year old development scores for the same group. These authors concluded, on the basis of their findings, that the effects of early insults at birth were more transient than was earlier thought and that events later in infancy were more predictive of future development.

In summary, this body of literature, for the most part, implies the existence of multiple relationships between factors that, in all likelihood, eventually impact later child health. Some studies have taken the long,
although narrow, view of earlier influences on child health in specific
groups, such as LBW, preterm infants. Others, in spite of limited perspective,
suggest an interaction between child health and other factors beyond those
under direct investigation. Notwithstanding, the question emerges whether
the impact of the more resistant factors, such as a mother’s socioeconomic
characteristics and problems that occur at birth, on the future health of a
young child can be attenuated through health promoting practices both
during gestation and infancy.

**Specification of a Model**

Multiple factors that influence child health have been previously
established, but investigating these factors through a model testing approach
provides verification as well as better insight into the predictive value of such
factors for child health. The National Center for Health Statistics (NCHS)
conducted the population-based National Maternal and Infant Health Survey
(NMIHS) in 1988 with a follow-up of the same respondents in 1991. The
information-rich material contained in these data sets provided an
opportunity to investigate these associations. Figure 2.1 specifies one possible
model of links between known antecedents of 3 year-old child health status,
including mediating influences of health practices, that was tested with this
sample.

The above review of the literature suggests a number of direct and
indirect pathways leading to preschool-aged child health status.
Figure 2.1. Model of antecedent factors of 3 year-old child health status, including the proposed mediating influences of health practices.
Structural equation modeling (SEM) is widely used in the behavioral and social sciences to explore the complexities of outcome antecedents in nonexperimental research. This approach is especially useful in gaining a more thorough understanding of existing data sets, expanding theory generated from other sources, and testing theory directly (McLaughlin & Marascuilo, 1990). These models schematically represent a set of interrelated hypotheses that propose a causal structure.

**Research questions.** The present research was conducted to address the following questions:

(a) Will an a priori specified model of antecedent factors significantly predict the outcome of child health status?

(b) Will positive prenatal health practices mediate the influence of maternal social advantage on birth outcomes?

(c) Will positive infant health practices mediate the effect of birth outcomes on preschool-age child health status? and

(d) Will the general model hold when tested with samples of homogeneous racial groups?

**Hypotheses.** For the overall model test in this study, it was hypothesized that the theoretical model, generated from previous studies, would not differ from the observed model, based on data extracted from the NMIHS surveys. Concerning specific pathways in the model, it was hypothesized that:
(a) differences in social advantage, defined by certain maternal characteristics, would predict birth outcomes (e.g., the more social advantage one has, the better the birth outcomes will be);
(b) the effects of social disadvantage on birth outcomes would be mediated by healthy prenatal practices;
(c) differences in birth outcomes would predict preschool-age health status;
(d) the effects of poor birth outcomes on preschool-age health status would be mediated by positive infant health practices.

Definitions. The following are conceptual and operational definitions of each of the model’s latent variables:

1. Maternal Characteristics. This construct, measured by maternal age, education level, household income, and marital status, reflects a mother’s degree of social advantage. Morgan (1983) suggested that groups which differ in their social status, economic resources, living and working conditions, and attitudes and behavior will also experience consequent effects on their health. Items selected to measure this construct are descriptors of social, economic, and demographic status.

2. Birth Outcomes. This factor, measured by gestational length, birthweight, and the 5-minute Apgar score, represents physiological features that are known to reflect not only proximal events that occur during labor and delivery, but also more distant effects, such as prenatal health and characteristics of mothers. In the U.S., poor birth outcomes are thought to be
linked to financial, administrative, and cultural barriers that limit care, especially to certain high-risk groups (National Commission to Prevent Infant Mortality, 1992).

3. **Prenatal Health Practices.** This latent factor, measured by adequacy of prenatal care, weight gain, exercise frequency, cigarette use, and alcohol consumption during pregnancy, manifests a woman's health-promoting and limiting behaviors during pregnancy that would have obvious effects on her unborn child's health. The March of Dimes (1993) has long campaigned for a more preventive approach to improve pregnancy outcomes through their endorsement of better perinatal care. Because social advantage is associated with a woman's access to prenatal care as well as her attitudes to and knowledge about prenatal health and its consequences, it was thought that her ability to make decisions about these behaviors also would be affected.

4. **Child Health Status.** This latent variable was measured by a functional health composite score based on level of activity, ability to get along with others, frequency of tantrums, and levels of cheerfulness and fearfulness; a developmental assessment score; and an evaluation of general health, all assessed by the mother. It incorporates the three widely accepted dimensions of health status. Physical health is a general estimation of child health status. Benson (1992) argues that because the patient is in the best position to assess his or her own health, this estimation is a more valid measure than one given by a health provider. As the mother acts as proxy for her small child,
her estimation of her child's health status should also be more valid. Developmental health assesses attainment of well-identified cognitive and physical milestones that reflect the rapid, dynamic pattern of growth that is characteristic of early life. Developmental progress can be impaired by previous and current physical health, as well as mental well-being. Events at birth and in infancy are also known to affect later development. According to Stein and Jessop (1984), functional health is the ability to carry out one's expected socioculturally-defined role constrained by the limitations of one's health. Following this interpretation then, young healthy children are expected to be happy, playful, and vigorous, but still somewhat dependent. This factor is necessarily defined by a mother's perception of how her small child functions in his/her age-appropriate role.

5. **Infant Health Practices.** This latent variable was measured by numbers of immunizations, well-child health care visits, and duration of breastfeeding. It represents recommended health practices that are known to affect the health of the older infant and would, therefore, capture the fullest effect of antecedent events.

**Model test with race subsamples.** Because maternal race and ethnicity decidedly influence factors within the theoretical model of child health status antecedents, the model was tested first with the total sample, and then separately with both the non-Hispanic white and non-Hispanic black subsamples. The aim of this procedure was to test whether the model fit
would hold for homogeneous racial groupings. This effectively separated race from indicators of socioeconomic status in an attempt to better understand the impact of social advantage on child health.
Chapter Three

Methods

A secondary analysis using structural equation modeling techniques was conducted to assess factors that directly or indirectly influence health status in early childhood. Items from both NMIHS data sets were selected as representative measures of the factors, based on existing theory and empirical findings. This chapter describes (a) the aims and methods of the NMIHS surveys, as well as other investigations that have reported results using NMIHS data and (b) the sampling, procedural, and analytic methods used in the present study.

The NMIHS Studies

The stated purposes of the original 1988 NMIHS survey were to study factors related to poor pregnancy outcomes and monitor progress toward the Department of Health and Human Services' goals for maternal and infant health set for the year 2000. The 1991 Longitudinal Followup was designed to obtain information from the same respondents about: (a) their child's care and safety; (b) their own health, including depression; (c) plans for adoption and foster care; and (d) the health and development of below-normal birthweight infants, in particular. A number of federal agencies assisted in the design and funding of the NMIHS surveys to access information of
particular interest to them. The inclusion of questionnaire items about participation in the supplemental nutrition program for Women, Infants, and Children is an example (Sanderson, Placek, & Keppel, 1991).

1988 sample. The 1988 NMIHS is comprised of data from four sources: vital records and questionnaires from mothers, hospitals regarding deliveries, and prenatal care providers. The survey included information for both live births and fetal and infant deaths. Questionnaires were mailed to mothers whose names were obtained from a stratified systematic sample of 1988 vital records from 48 states, the District of Columbia, and New York City. Two states withheld permission. Included in the national sample were certificates from 10,000 live births, 4,000 fetal deaths of 28 weeks gestation or more, and 6,000 infant deaths under 1 year of age. Urban Indian and Hispanic Texan mothers were separately represented in two supplementary surveys but not included in the national sample.

Black mothers, Texan Hispanic mothers, and mothers of live, below-normal birthweight infants were oversampled in the main survey to produce sufficiently sized subsamples for studying their particular outcomes. For mothers who had live births, the probability of selection was approximately 1 in 354, based on 3.9 million live births in the United States in 1988 (Sanderson et al., 1991; NCHS, 1988). The typical respondent in the final sample of 9,953 was white, married, over 30 years of age, and with at least a high school education (NCHS, 1991a).
1991 sample. The 1991 Longitudinal Followup (LF) included 9,440 mothers of the 1988 sample who gave birth to a live infant, agreed to be contacted again, and whose child was still alive in 1991. Of the mothers who qualified, 8,285 completed the survey. With mothers' consent, 6,606 pediatric care providers and 3,183 hospitals supplied medical record information for their children. Figure 3.1 depicts the sampling process used to select the final sample of 6,201 index children (NCHS, 1991a).

1988 questionnaire. The 35-page Mothers' Questionnaire was developed and tested with small samples in the NCHS questionnaire laboratory and subsequently pilot-tested in four states in late 1987. For the main survey, questionnaires were mailed with prepaid return envelopes. For nonresponses, a second questionnaire was mailed. If that attempt failed, mothers were then contacted by Bureau of the Census interviewers who obtained the questionnaire information by telephone or personal interview.

The instrument contains 57 items with sections regarding prenatal care and health habits, the delivery, other pregnancies, mother's characteristics, father's characteristics, family income, and baby's health. The response rate was 74% for mothers who had live births and 71% overall (Sanderson et al., 1991; NCHS, 1988).

1991 questionnaire. The Live Birth Survey (the mothers' questionnaire), composed of 11 parts, requested information about the following: child health and development; WIC and pregnancy information;
Figure 3.1. Depiction of the process that linked both NMIHS data sets
child safety; child care; child medical care and hospitalization; problems getting medical care; maternal health history; mother's background; and household composition, income, employment, and insurance. Sixty-four percent of the interviews were conducted using a computer-assisted telephone interview method. Respondents who could not be contacted by this means were interviewed in the field, either by telephone or in person. Only 1% responded by pencil-and-paper instrument (NCHS, 1991a).

Reliability and validity. Other NCHS followback surveys where vital records cases were used as a data source showed a high degree of consistency between information on birth certificates, mothers' responses, and providers' responses (Fingerhut & Kleinman, 1985). However, no reliability or validity information has been reported for either of the NMIHS questionnaires. For the most part, the bulk of the data collected was information-gathering and not measurement of attitudes or abstract concepts. The laboratory and field pilot-testing described (NCHS, 1988; NCHS, 1991b), most certainly necessitated extensive refinements in directions, wording, readability, and response-set structuring. The use of professional interviewers also would have strongly enhanced reliability for cases where data were collected by that method.

A compilation of studies to date that have reported results from NMIHS data, identified from the CINAHL, Medline, Sociofile, and Psychlit periodical literature databases, are listed in Appendix A. All studies, with the exception of one (Covington & Theut, 1993), are quantitative and most are
epidemiologic in design. Six studies used a multiple regression approach to demonstrate predictive value (Balcazar, Trier, & Cobas, 1995; Hummer, 1993; Kennedy & Visness, 1997; Schwartz, Popkin, Tognetti, & Zohoori, 1995; Singh & Yu, 1995; Swigonski, Skinner, & Wolinsky, 1995; Wang, Zuckerman, Coffman, & Corwin, 1995; and Zhang & Savitz, 1996). Only 4 out of 31 used the 1991 data set (Kogan et al., 1995; Kogan, Overpeck, & Fingerhut, 1995; Singh & Yu, 1995; and Kogan, Pappas, Yu, & Kotelchuck, 1994) and, most importantly, none have linked cases across both surveys for a longitudinal analysis.

Present Study

Both the 1988 and 1991 NMIHS data sets were merged into a final subset of linked cases from both timepoints. Only those data for respondents and their offspring who met the inclusion criteria and only those questionnaire items to be used as indicators were selected for analysis. Items were selected from both the 1988 Mother's Questionnaire and the 1991 Live Birth Survey to be used as indicators of the model's latent factors (see codebook in Appendix B for item source). In addition to information gathered by the 1988 questionnaire, birth certificates were also used as an information source. Some of the model's indicators were either taken directly from the questionnaire items or birth certificate information or derived from them. SPSS 5.0 for VAX/VMS was used to access and merge the data sets, construct new variables from pre-existing items, and isolate the
black and white racial subsets.

**Sample.** The sample for this study included only singleton births from the 1988 survey who were still alive and living with their mothers at the time of the 1991 survey. Multiple births were excluded because of the known influence on birth outcomes, such as lower birthweight. Births to other than United States residents were also excluded. There were 9,146 mothers of live singleton births who responded to the 1988 survey. Of the 8,285 index children whose mothers responded to the 1991 survey, approximately 7,406 cases (number varies by variable due to missing data) were available for this analysis after exclusions. This represents about 74% of the original sample of 10,000 live births and 89% of the 1991 respondents, whose children ranged in age from 27 to 50 months (80% were between 30 and 43 months). Mothers’ identification numbers were used to link all NMIHS data.

**Human subjects review.** Exempt status was granted by the university’s Office of Sponsored Programs in accordance with Exempt Category Number 4 of the Code of Federal Regulations, 45 CFR 46, Protection of Human Subjects. NCHS data sets that are available for public sale and use, as are the NMIHS surveys, do not contain any means that would permit identification of individual cases.

**Operationalization of the model’s constructs.** Table 3.1 lists the questionnaire and birth certificate source items used to operationalize the model’s latent factors. Mother’s age at delivery (*matage*), level of education
Table 3.1

Select NMIHS Survey Items: Measures of Indicators

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Item(s)</th>
<th>Survey question(s) that generated the indicator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternal age at delivery</td>
<td>207*</td>
<td>What is your birth date?</td>
</tr>
<tr>
<td>Education level</td>
<td>222*</td>
<td>What is the highest grade or year of regular school or college you have completed?</td>
</tr>
<tr>
<td>Household income</td>
<td>255*</td>
<td>What was the total income before taxes for the people living in your household during the 12 months before your delivery?</td>
</tr>
<tr>
<td>Marital status</td>
<td>205*</td>
<td>What is your marital status now?</td>
</tr>
<tr>
<td>Weight gain</td>
<td>211*</td>
<td>What was your weight just before you became pregnant with the baby named on the front of this questionnaire?</td>
</tr>
<tr>
<td></td>
<td>215*</td>
<td>What was your weight just before your delivery?</td>
</tr>
<tr>
<td>Prenatal care adequacy</td>
<td>13*</td>
<td>How many weeks pregnant were you when you went for your first prenatal visit?</td>
</tr>
<tr>
<td></td>
<td>80*</td>
<td>How many weeks did this pregnancy last?</td>
</tr>
<tr>
<td></td>
<td>23, 32,</td>
<td>How many times did you go to this place (places where prenatal care was received)?</td>
</tr>
<tr>
<td></td>
<td>36, 40,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>44, 48,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>52*</td>
<td></td>
</tr>
<tr>
<td>Exercise</td>
<td>88, 89*</td>
<td>Did you exercise or play sports at least three times a week after you found out you were pregnant (include walking briskly for 1/2 hour or more, jogging, aerobics, swimming, etc.)?</td>
</tr>
<tr>
<td>Cigarette use</td>
<td>111*</td>
<td>On the average, how many cigarettes did you smoke A DAY after you found out that you were pregnant?</td>
</tr>
<tr>
<td>Indicator</td>
<td>Item(s)</td>
<td>Survey question(s) that generated the indicator</td>
</tr>
<tr>
<td>---------------------------</td>
<td>---------</td>
<td>----------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Alcohol consumption</td>
<td>105*</td>
<td>On the average, how many drinks of alcoholic beverages did you have after you found out that you were pregnant (a drink is 12 ounces of beer, 4 ounces of wine, or 1 1/2 ounces of liquor)?</td>
</tr>
<tr>
<td>Length of gestation</td>
<td>80*</td>
<td>How many weeks did this pregnancy last (full term is 40 weeks)?</td>
</tr>
<tr>
<td>Birthweight</td>
<td>BCD</td>
<td></td>
</tr>
<tr>
<td>Newborn status</td>
<td>BCD</td>
<td></td>
</tr>
<tr>
<td>Immunization status</td>
<td>321, 323, 325*</td>
<td>What kind of vaccine or vaccinations did your baby get on that day (the first, second, and third times the baby received vaccinations)?</td>
</tr>
<tr>
<td>Well-child visits</td>
<td>312*</td>
<td>How many times did your baby go to the doctor for well-baby care when the baby was not sick during each of these months (first through sixth and most recent)?</td>
</tr>
<tr>
<td>Breastfeeding duration</td>
<td>270*</td>
<td>How old was your baby when you stopped breastfeeding?</td>
</tr>
<tr>
<td>Level of health</td>
<td>A19^</td>
<td>In general, would you say (CHILD'S) health is excellent, very good, good, fair, or poor?</td>
</tr>
<tr>
<td>Developmental assessment</td>
<td>A5a-n^</td>
<td>Next, please read this list of activities. Has (CHILD) ever . . . (14 items from the Denver Developmental Screening Tool follow)</td>
</tr>
<tr>
<td>Activity level</td>
<td>A10^</td>
<td>How would you describe (CHILD'S) usual activity level? Would you say very inactive, not very active, moderately active, very active, or too active, that is, won't sit still for meals or at other times for more than 5 minutes?</td>
</tr>
<tr>
<td>Cheerfulness</td>
<td>A12^</td>
<td>Not counting times when (CHILD) is very tired or sick, would you describe (him/her) as usually happy, occasionally irritable or unhappy, or irritable or unhappy most of the time?</td>
</tr>
<tr>
<td>Indicator</td>
<td>Item(s)</td>
<td>Survey question(s) that generated the indicator</td>
</tr>
<tr>
<td>-----------------</td>
<td>---------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Fearfulness</td>
<td>A13^</td>
<td>Most children have some fears. How fearful is (CHILD)? Would you say s/he has no fears or a few mild fears, a few strong fears, or a lot of strong fears?</td>
</tr>
<tr>
<td>Ability to get</td>
<td>A14^</td>
<td>How does (CHILD) get along when playing with other children? Would you say s/he gets along well all or most of the time, has some difficulty getting along (disrupts play at times), has great difficulty playing with other children (disrupts play frequently), or has no opportunity to play with other children?</td>
</tr>
<tr>
<td>Tantrums</td>
<td>A15^</td>
<td>How often does (CHILD) have temper tantrums, like shouting, screaming, banging, kicking? Would you say s/he has frequent tantrums, occasional tantrums, or never has tantrums?</td>
</tr>
</tbody>
</table>

* Mother's Questionnaire (from 1988 NMIHS), ^ Live Birth Survey (from 1991 LF)
(mateduc), household income (hhinc), and marital status (wednow) were used as indicators of the factor, Maternal Characteristics (MC). For Prenatal Health Practices (PHP), weight gain (pgwgt), adequacy of prenatal care (apncu) (measured with the Adequacy of Prenatal Care Utilization index [Kotelchuck, 1994]; see Appendix C for calculation of this index), amount of exercise (pgexer), cigarette use (pgsmok), and alcohol consumption (pgalcoh) were used as measures. Gestational age (gestat), birthweight (bwgm), and Apgar score at 5 minutes (apgs5) were used to operationalize Birth Outcomes (BO). Infant Health Practices (IHP) was measured by number of well-child health care visits (wccvis), immunization status at 8 months of age (vacyes), and breastfeeding duration from birth (hfdur). The outcome factor, Child Health Status (CHS), was operationalized by mother’s assessment of the level of her child’s health (loh), developmental assessment (measured with the Denver Developmental Screening Test) (ddst), and functional health status (a composite score of levels of activity, cheerfulness, fearfulness, ability to get along, and frequency of tantrums) (fhs). See Table 3.2 for a list of these variables. Other items were deleted from the original proposed model based on screening and confirmatory factor analysis and are appended (see Appendix D for this and other details of the methods).

Analytic Procedure

Structural equation modeling (SEM) analysis was used to evaluate the fit of the theoretical model (Figure 3.2) with that of the observed data. PRELIS
Table 3.2

**Measures Of Latent Variables**

<table>
<thead>
<tr>
<th><strong>MATERNAL CHARACTERISTICS (MC)</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• age at delivery (<em>matage</em>)</td>
<td></td>
</tr>
<tr>
<td>• education level (<em>mateduc</em>)</td>
<td></td>
</tr>
<tr>
<td>• household income (<em>hhinc</em>)</td>
<td></td>
</tr>
<tr>
<td>• marital status (<em>wednow</em>)</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>PRENATAL HEALTH PRACTICES (PHP)</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• prenatal care adequacy (<em>apncu</em>)</td>
<td></td>
</tr>
<tr>
<td>• weight gain (<em>pgwgt</em>)</td>
<td></td>
</tr>
<tr>
<td>• exercise (<em>pgexer</em>)</td>
<td></td>
</tr>
<tr>
<td>• cigarette use (<em>pgsmok</em>)</td>
<td></td>
</tr>
<tr>
<td>• alcohol consumption (<em>pgalcoh</em>)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>BIRTH OUTCOMES (BO)</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• length of gestation (<em>gestat</em>)</td>
<td></td>
</tr>
<tr>
<td>• birthweight (<em>bwgm</em>)</td>
<td></td>
</tr>
<tr>
<td>• newborn status (<em>apg5</em>)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>INFANT HEALTH PRACTICES (IHP)</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• immunization status (<em>vacyes</em>)</td>
<td></td>
</tr>
<tr>
<td>• well-child visits (<em>wccvis</em>)</td>
<td></td>
</tr>
<tr>
<td>• breastfeeding duration (<em>bfdur</em>)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>CHILD HEALTH STATUS (CHS)</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• level of physical health (<em>loh</em>)</td>
<td></td>
</tr>
<tr>
<td>• developmental assessment (<em>ddst</em>)</td>
<td></td>
</tr>
<tr>
<td>• functional health index (<em>fhs</em>)</td>
<td></td>
</tr>
</tbody>
</table>
Figure 3.2. The theoretical model using LISREL notation to designate components and parameters in the model.
2.14/LISREL 8.14 software (Jöreskog & Sörbom, 1994) was employed for the analysis. Where clusters of measured variables indicate a latent construct, the SEM approach has two components: (a) the measurement model, which uses a factor analytic procedure to confirm the latent clusters and (b) the structural equation model, which uses a path analytic procedure to specify the causal relationships between the latent variables and to account for explained and unexplained variance in the system of causal links (McLaughlin & Marascuilo, 1990). The latter step tests the null model hypothesis that there is no difference between the theoretical model and the observed data.

Because non-normality was an issue, due to the use of both discrete and continuous indicators and skewed and kurtotic distributions of many of the variables, the weighted least squares (WLS) method was used to estimate the model's parameters. Hu, Bentler, and Kano (1992) carried out extensive Monte Carlo simulations of several parameter estimation techniques under varying conditions of normality violations (defined by kurtoses ranging between -1.001 to 7.770). Their findings revealed that estimators based on asymptotically distribution-free (ADF) theory, such as WLS which allows testing of model fit with covariance matrices that are asymptotically insensitive to distributions of observed data (Browne, 1984), performed very poorly with sample sizes below 1000 in their analysis of a three-factor model with 15 indicators. Yet, at samples above that and up to 5000, the estimators behaved well, similar to results from other estimators used in the normal
condition. After listwise deletion of cases due to missing values, required when modeling in the ADF mode, a final sample of 4,940 was retained (67% of the sample available before listwise deletion), permitting a high degree of confidence in the accuracy of the estimations.

Measurement properties of the model. Convergent validity of the item clusters was assessed by the magnitude of the item factor loadings in the measurement model (Schumaker & Lomax, 1996; Anderson & Gerbing, 1988). The factor loadings ranged from .60 to .82 for MC; .92 for PHP; .73 to .99 for BO; .92 for IHP; and .12 to .68 for CHS (all p<.01). The low loading for ddst is remarkable in that it is well below the conventional level of acceptance (e.g., .4) in spite of its wide use and known reliability and validity (Frankenburg, Fandal, & Thornton, 1987). Because the short form of the DDST is considered to be a screening tool and not diagnostic, it is quite simple to administer although it is possible that it was administered incorrectly. Burgess, Asher, Doucet, Reardon, and Daste (1984) were able to more closely predict full DDST results when the questions on the short form were read by a health care professional rather than when the answers were given by the mother without assistance. However, since all the factor loadings were significant, all items were considered to be valid measures of the constructs that they were purported to represent.

Convergent validity also was estimated by calculation of the Average Variance Extracted by each construct (Fornell & Larcker, 1981), an assessment
of the degree to which two or more measures of a construct agree. Those figures were .51 for MC, .76 for BO, and .27 for CHS. This implies that the measures for the factor, CHS, did not agree. Because two factors already were operationalized by fewer than the recommended minimum of three measures (Schmacker & Lomax, 1996), the weak indicator, ddst, could not be removed. Convergent validity can also be established by significance level of the individual factor loadings, so convergent validity was considered to be demonstrated for all factors.

Item reliability was assessed by squaring each factor loading, a measure of how much explained variance plus error variance is present in each item (Pedhazur & Schmelkin, 1991). Item reliabilities ranged from .01 to .98 (all \( p \leq .01 \)), with ddst again being outstandingly low. Internal consistency was measured by a composite reliability coefficient calculated for each factor, which is equivalent to coefficient alpha (Fornell & Larcker, 1981). Composite reliabilities for the model's factors were .47, .80, .85, .85, and .90. The lowest score was obtained for CHS but was close enough to the threshold criterion to conclude that all observed variables were reliable measures of the latent factors. Table 3.3 presents the factor loading and error variance for each item. Composite reliability and average variance extracted were calculated for each factor according to recommended formulae (see Note in Table 3.3). Acceptable levels for both of these measures are at or above .50 (Fornell & Larcker, 1981).
### Table 3.3

**Measurement Properties of the Model**

<table>
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<tr>
<th>Factor/indicator</th>
<th>Factor loading ($\lambda$)</th>
<th>SE</th>
<th>Error (e)</th>
<th>SE</th>
<th>Item reliability ($\lambda^2$)</th>
<th>Composite reliability</th>
<th>Convergent validity</th>
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<tr>
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<td>.99*</td>
<td>.020</td>
<td>.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>fhs</td>
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<td>.028</td>
<td>.54*</td>
<td>.043</td>
<td>.46</td>
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<td></td>
</tr>
</tbody>
</table>

*Note.* MC = Maternal Characteristics; PHP = Prenatal Health Practices; BO = Birth Outcomes; IHP = Infant Health Practices; CHS = Child Health Status; matage = maternal age; mateduc = maternal education; hhinc = household income; wednow = marital status; pnprac = prenatal health practices; gestat = gestational age; bwgm = birthweight; apg5 = Apgar score (5 minutes); infprac = infant health practices; loh = level of health; ddst = developmental assessment; fhs = functional health status. Composite reliability was computed as: \(\frac{(\Sigma \lambda^2)}{[(\Sigma \lambda^2) + \Sigma \text{var}(e)]}\); factor convergent validity was computed as: \(\frac{\Sigma (\lambda^2)}{[(\Sigma \lambda^2) + \Sigma \text{var}(e)]}\) (Fornell & Larcker, 1981). *t*-values determine significance when $\geq 2.58$ ($p \leq .01$) and calculated as variance/SE. *error variance fixed
**Goodness of fit indices.** Given the problems with large sample effects on chi-square significance and the consequent proliferation of alternative tests of goodness-of-fit, the following indices were used to assess overall fit, as well as incremental fit, of the nested models (Bollen, 1990):

1. **Goodness-Of-Fit index (GFI).** The GFI measures the amount of variance and covariance in the sample model matrix that is explained by the reproduced model matrix (Huba & Harlow, 1987). However, the Adjusted GFI (AGFI) is adjusted for degrees of freedom per number of indicators, which is more relevant with large samples (Schumacker & Lomax, 1996). Values range from 0 to 1 and are considered acceptable above .90.

2. **Root Mean Square Residual (RMR).** The RMR is the square root of the mean squared differences between the sample and reproduced covariance matrices (Schumacher & Lomax, 1996). In other words, the RMR is the average of the fitted residuals between the two matrices. It is interpreted in relation to the size of a specific sample's variances and covariances (Marsh, Balla, & McDonald, 1988) which ranged for this study's sample between .02 and 1.00 for the variances/covariances and -.42 and .10 for the fitted residuals. Jöreskog & Sörbom (1996c) advise using RMR either as a stand-alone index or as an indication of incremental fit.

3. **Root Mean Square Error of Approximation (RMSEA).** Where the chi-square statistic provides a measure of exact fit of the observed with the fitted covariance structure, the RMSEA provides a measure of close fit of the
covariance structures by calculating this discrepancy per degree of freedom. The RMSEA is bounded on the low end by zero, indicating a perfect fit. The upper limit conventionally is accepted to be .05 although up to .08 is still considered reasonable (Browne & Cudek, 1993; Jöreskog, 1993).

4. **Tucker-Lewis Index** (TLI, also called the Non-Normed Fit Index in LISREL). The TLI compares either a proposed model with a null model or alternative models with each other. The **Normed Fit Index** (NFI) compares subsequently restricted models with the null by rescaling the chi-square value to 0, meaning no fit, and 1, meaning perfect fit. Values for both range between 0 and 1 and are considered to be acceptable above .90, indicating incremental fit.

5. **Parsimonious Fit Index** (PNFI in LISREL). The PNFI is a version of the NFI that compensates for changes in the ratio of degrees of freedom between the null and the proposed model. **Parsimonious GFI (PGFI)** is a similar modification of the GFI. Parsimony indicates the number of estimated coefficients that are required to obtain a particular level of fit by comparing a restricted model with an overidentified one (Schumacker & Lomax, 1996). These measures are particularly helpful in judging nested models because they compensate for the increase in measures of fit when a less restricted model is obtained at the expense of a loss in degrees of freedom. These indices allow one to consider how efficient the model is in its use of the data in achieving a certain level of fit which is a qualitatively different
interpretation than goodness-of-fit. Values range between 0 and 1 and are necessarily closer to zero than their unmodified goodness-of-fit counterpart. The lower the value of a parsimony index, especially with correspondingly high goodness-of-fit, the more a good fit is unexplained by factors within the model (Mulaik et al., 1989). Therefore, interpretation is dependent upon all indications of fit taken in concert.

6. **Hoelter's Critical N (CN)**. CN was assessed in spite of criticisms of its use in determining either goodness of fit or power of the chi-square to detect significant departures. Bollen and Liang (1988) argued that using CN for either purpose favored large samples, making it a reasonable criterion for this sample. CN gives the critical sample size needed to accept a particular chi-square test of fit value, where 200 or greater indicates either goodness of fit or good incremental fit.

**Summary**

Kiecolt and Nathan (1985) specifically recommend using SEM to evaluate relationships when using pre-existing data because this method allows one to exclude items that are poor measures of a given concept, identify problems of multicollinearity, and correct for some amount of measurement error that is characteristic of surveys. SEM was particularly appropriate for this study because the variables were theoretically linked in a complex fashion, a secondary analysis of a previously existing data set was being undertaken, clusters of the observed variables suggested the presence of
a latent structure, the sample size was large, and the presence of measurement error was likely because the data were collected by survey.
Chapter Four

Results

This chapter presents the findings from model tests both for the full sample, hypothesized effects, and for differences in model fit using homogeneous racial groups. Results from the full model test are examined for fit of the data with the a priori specified structure and specific hypothesized paths.

Sample

Table 4.1 compares the sample demographics for the total sample (N=4940) with the black non-Hispanic (N=2431), and white non-Hispanic (N=2179) subsets. The size of the Hispanic sample was too small for a model test under ADF restrictions, even before listwise deletion. The typical respondent in the listwise deleted total sample was 25.57 (SD=5.74) years old, black (a consequence of oversampling by NCHS), married, had 12.57 (SD=2.08) years of education, with a median annual household income of $20,000-24,999. The typical black respondent was 24.20 (SD=5.66) years old with 12.12 (SD=1.91) years of education while the typical white respondent was 26.97 (SD=5.45) years old with 13.07 (SD=2.08) years of education. Of note is the substantial difference in percentages of married women between the two
Table 4.1

Demographic Distributions of the Total Sample and Race Subsets

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Total (white, black, and Hispanic)</th>
<th>Black, non-Hispanic</th>
<th>White, non-Hispanic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample size</td>
<td>4940</td>
<td>2431</td>
<td>2179</td>
</tr>
<tr>
<td>Maternal age [M (SD) years]</td>
<td>25.57 (5.74)</td>
<td>24.20 (5.66)</td>
<td>26.97 (5.45)</td>
</tr>
<tr>
<td>Maternal education [M (SD) years]</td>
<td>12.57 (2.08)</td>
<td>12.12 (1.91)</td>
<td>13.07 (2.08)</td>
</tr>
<tr>
<td>Household income [Min $/year]</td>
<td>20,000-24,999</td>
<td>6,000-7,999</td>
<td>30,000-34,999</td>
</tr>
<tr>
<td>Marital status [% married]</td>
<td>60</td>
<td>36</td>
<td>86</td>
</tr>
</tbody>
</table>

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groups although this phenomenon has been reported widely. The difference in household incomes, while surprisingly large, is most likely the consequence of fewer income earners living in unmarried households. However, the disproportionate representation of some minority groups, such as blacks, in the lower socioeconomic strata also would account for some amount of this income disparity (Bennett, 1992).

Correlations

Table 4.2 shows the mixed correlations for all pairs of indicators in the modified model (see Appendix D for discussion of mixed correlations). Although low in many cases, all intra-factor indicators were significantly correlated with each other, with the exception of loh and fhs in the CHS construct ($r=.17, p=.33$). Indicators within the significance levels of the polychoric and polyserial correlations were based on a chi-square test of fit with an underlying normal bivariate distribution (Jöreskog & Sörbom, 1996b). Only one out of 10 model tests rejected the chi-square null hypothesis that the correlation equaled zero ($p<.05$). However, only half of those relationships were even of interest to the model.

Table 4.3 shows the correlations among the model's latent factors. Coefficients ranged from .15 for MC-BO to .63 for BO-CHS (all $p<.01$), demonstrating healthy associations between the factors (e.g., not too low nor too high).
Table 4.2

Correlations, Means, and Standard Deviations of Indicators

<table>
<thead>
<tr>
<th></th>
<th>x₁</th>
<th>x₂</th>
<th>x₃</th>
<th>x₄</th>
<th>y₁</th>
<th>y₂</th>
<th>y₃</th>
<th>y₄</th>
<th>y₅</th>
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<td>.17</td>
<td>.20</td>
<td>.01</td>
<td>.21</td>
<td>.08</td>
<td>.04*</td>
<td>.07</td>
<td>.02</td>
<td>.15*</td>
<td>.17</td>
<td>.10*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>25.57</td>
<td>8.57</td>
<td>11.76</td>
<td>.00</td>
<td>.00</td>
<td>38.17</td>
<td>3055</td>
<td>.00</td>
<td>.00</td>
<td>.00</td>
<td>12.18</td>
<td>.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>5.74</td>
<td>2.08</td>
<td>5.47</td>
<td>1.00</td>
<td>1.00</td>
<td>4.05</td>
<td>830</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>2.75</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. x₁ = maternal age; x₂ = maternal education; x₃ = household income; x₄ = marital status; y₁ = prenatal health practices; y₂ = gestational age; y₃ = birthweight; y₄ = Apgar score (5 minutes); y₅ = infant health practices; y₆ = level of health; y₇ = developmental assessment; y₈ = functional health status. 

*p≤0.05, *p≤0.01, *p≤0.001
Table 4.3

**Correlation Matrix of Latent Factors**

<table>
<thead>
<tr>
<th></th>
<th>MC</th>
<th>PHP</th>
<th>BO</th>
<th>IHP</th>
<th>CHS</th>
</tr>
</thead>
<tbody>
<tr>
<td>MC</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PHP</td>
<td>.30 (.01)*</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BO</td>
<td>.15 (.01)*</td>
<td>.31 (.03)*</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IHP</td>
<td>.47 (.01)*</td>
<td>.32 (.02)*</td>
<td>.35 (.02)*</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>CHS</td>
<td>.26 (.03)*</td>
<td>.42 (.03)*</td>
<td>.63 (.04)*</td>
<td>.47 (.02)*</td>
<td>1.00</td>
</tr>
</tbody>
</table>

**Note.** Standard errors are in parentheses.

*Figures shown are covariances although covariances are identical to correlations when the latent factors are standardized, as in this case.*

*p ≤ .01*
Evaluation of the Overall Model

The aim of the overall model analysis was to test the null hypothesis that there was no significant difference between the covariance matrix generated from the data and the one produced by the theoretical model. Additionally, the magnitude and direction of the structural parameters were assessed to determine if significant causal effects existed between factors.

Anderson and Gerbing (1988) recommend testing nested models where models with restricted parameters as a result of modification are nested within the original hypothesized one. The spectrum of nested models is depicted as the fully restricted model, such as the null where there are no relationships, existing at one end and a fully relaxed one, such as the measurement model, existing at the other. The theoretical model of interest to a particular investigator exists somewhere around the middle and the modified models, depending on their number of degrees of freedom, exist to either side. Table 4.4 lists the parameter estimates for the final modified model while Figure 4.1 displays them in graphic form. All parameters were positive and significant, including error terms (significance was not determined for factor error variances, designated by the Greek symbol zeta, \( \zeta \)).

Modification indices for the theoretical model, \( M_r \) showed a large improvement of fit with the addition of a path between MC and IHP. Other large indices recommended adding paths between indicators and other factors but none could not be supported theoretically. As the latent constructs in the
Table 4.4

**Standardized Structural Parameter Estimates of the Modified Model**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate (t)</th>
<th>Parameter</th>
<th>Estimate (t)</th>
<th>Parameter</th>
<th>Estimate (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$x_1$</td>
<td>.59 (69.23)</td>
<td>$\delta_3$</td>
<td>.47 (19.64)</td>
<td>$\gamma_{31}$</td>
<td>.42 (30.76)</td>
</tr>
<tr>
<td>$x_2$</td>
<td>.80 (51.32)</td>
<td>$\delta_4$</td>
<td>.25 (9.26)</td>
<td>$\beta_{21}$</td>
<td>.28 (12.54)</td>
</tr>
<tr>
<td>$x_3$</td>
<td>.73 (80.72)</td>
<td>$\epsilon_1$</td>
<td>.15</td>
<td>$\beta_{32}$</td>
<td>.24 (13.23)</td>
</tr>
<tr>
<td>$x_4$</td>
<td>.87 (87.83)</td>
<td>$\epsilon_2$</td>
<td>.47 (18.26)</td>
<td>$\beta_{42}$</td>
<td>.52 (12.88)</td>
</tr>
<tr>
<td>$y_1$</td>
<td>.92 (75.03)</td>
<td>$\epsilon_3$</td>
<td>.22 (7.09)</td>
<td>$\beta_{43}$</td>
<td>.34 (14.18)</td>
</tr>
<tr>
<td>$y_2$</td>
<td>.73 (59.91)</td>
<td>$\epsilon_4$</td>
<td>.15</td>
<td>$\zeta_1$</td>
<td>.91</td>
</tr>
<tr>
<td>$y_3$</td>
<td>.88 (61.60)</td>
<td>$\epsilon_5$</td>
<td>.15</td>
<td>$\zeta_2$</td>
<td>.91</td>
</tr>
<tr>
<td>$y_4$</td>
<td>.92 (86.20)</td>
<td>$\epsilon_6$</td>
<td>.69 (26.14)</td>
<td>$\zeta_3$</td>
<td>.72</td>
</tr>
<tr>
<td>$y_5$</td>
<td>.90 (53.32)</td>
<td>$\epsilon_7$</td>
<td>.98 (47.66)</td>
<td>$\zeta_4$</td>
<td>.50</td>
</tr>
<tr>
<td>$y_6$</td>
<td>.55 (22.40)</td>
<td>$\epsilon_8$</td>
<td>.59 (19.26)</td>
<td>$\psi_{23}$</td>
<td>.14 (8.88)</td>
</tr>
<tr>
<td>$y_7$</td>
<td>.14 (8.06)</td>
<td>$\delta_{23}$</td>
<td>-.13 (-9.10)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$y_8$</td>
<td>.64 (21.77)</td>
<td>$\delta_{24}$</td>
<td>.22 (13.76)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\delta_1$</td>
<td>.65 (28.94)</td>
<td>$\gamma_{11}$</td>
<td>.29 (25.49)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\delta_2$</td>
<td>.36 (11.21)</td>
<td>$\gamma_{21}$</td>
<td>.07 (5.86)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note.** t values considered significant ≥2.58 (p<.01)
Figure 4.1. Modified model with standardized coefficients representing antecedents of child health status with mediating health practices.
measurement model were considered to be orthogonal, based on theory, no additional paths between indicators and factors were added. However, indices recommended additional fit improvements that could be made by allowing correlations between certain error variances. Because all three items came from the same questionnaire, errors between mateduc and wednow and mateduc and hhinc were permitted to correlate. Additionally, errors between PHP and IHP were allowed to correlate because not only were all items in both parcels taken from the same questionnaire but both factors most likely tapped the same attitudes or behaviors that would have affected all the responses.

Successive model specifications are judged by how well they account for the data with overall goodness-of-fit indices. Each modification to the theoretical or hypothesized model, \( M_r \), was made if the chi-square value could be reduced by a significant degree (Jöreskog & Sörbom, 1989, p.217) and if the indices indicated a good and/or improved fit. Table 4.5 shows indices obtained for the spectrum of models tested that were nested within the null or fully constrained model. \( M_r \) represented a substantial improvement over the null model with a reasonably good fit. \( M_1 \) added a path from MC to IHP. \( M_2 \) added a correlation between mateduc and wednow errors and \( M_3 \) adds a correlation between mateduc and hhinc errors. \( M_4 \) allowed PHP and IHP errors to correlate. Each successive model represented a significant improvement over the previous specification and was a good fit in its own
<table>
<thead>
<tr>
<th>Model</th>
<th>$\chi^2$</th>
<th>$df$</th>
<th>$\Delta \chi^2(df)$</th>
<th>RMR</th>
<th>RMSEA</th>
<th>AGFI</th>
<th>PGFI</th>
<th>NFI</th>
<th>PNFI</th>
<th>TLI</th>
<th>CN</th>
</tr>
</thead>
<tbody>
<tr>
<td>$M_0$ (null)</td>
<td>27412.71</td>
<td>66</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>$M_1$ (theoretical)</td>
<td>2273.22</td>
<td>51</td>
<td>25139.49 (15)</td>
<td>.18</td>
<td>.094</td>
<td>.94</td>
<td>.63</td>
<td>.92</td>
<td>.71</td>
<td>.89</td>
<td>169.15</td>
</tr>
<tr>
<td>$M_1 (+1$ path)</td>
<td>708.45</td>
<td>50</td>
<td>1564.77 (1)</td>
<td>.12</td>
<td>.052</td>
<td>.98</td>
<td>.63</td>
<td>.97</td>
<td>.74</td>
<td>.97</td>
<td>531.94</td>
</tr>
<tr>
<td>$M_2 (+ 2$ paths)</td>
<td>553.38</td>
<td>49</td>
<td>1550.07 (1)</td>
<td>.12</td>
<td>.046</td>
<td>.98</td>
<td>.62</td>
<td>.98</td>
<td>.73</td>
<td>.98</td>
<td>669.67</td>
</tr>
<tr>
<td>$M_3 (+ 3$ paths)</td>
<td>483.86</td>
<td>48</td>
<td>69.52 (1)</td>
<td>.12</td>
<td>.043</td>
<td>.99</td>
<td>.61</td>
<td>.98</td>
<td>.71</td>
<td>.98</td>
<td>753.13</td>
</tr>
<tr>
<td>$M_4 (+ 4$ paths)</td>
<td>409.34</td>
<td>47</td>
<td>74.52 (1)</td>
<td>.11</td>
<td>.040</td>
<td>.99</td>
<td>.60</td>
<td>.98</td>
<td>.70</td>
<td>.98</td>
<td>875.08</td>
</tr>
<tr>
<td>$M_5$ (measurement)</td>
<td>594.16</td>
<td>46</td>
<td>-</td>
<td>.13</td>
<td>.049</td>
<td>.98</td>
<td>.58</td>
<td>.98</td>
<td>.68</td>
<td>.97</td>
<td>592.87</td>
</tr>
</tbody>
</table>

Note. $\chi^2$=chi-square; $df$=degrees of freedom; $\Delta \chi^2$=change in chi-square from model to model; RMR=root mean square residual; RMSEA=root mean square error of approximation; AGFI=adjusted goodness-of-fit index; PGFI=parsimony goodness-of-fit index; NFI=normed fit index; PNFI=parsimony normed fit index; TLI=Tucker-Lewis Index; and CN=Critical N.
right. Parsimony indices were moderate to begin with, decreasing predictably when parameters were added. Fit measures for $M_4$ were $\chi^2=409.34$, df 47, $p=.00$; RMR=.11; RMSEA=.04; AGFI=.99; PGFI=.60; NFI=.98; PNFI=.70; TLI=.98; and CN=875.08. Overall, $M_4$ with one additional path and three correlations between errors fit the data most optimally.

**Analysis of residuals.** While the overall RMR was reasonable and showed a decrease with subsequent models, indicating a smaller difference between the sample and the reproduced matrices (i.e., a better fit), large residuals were still present in $M_4$ in spite of the strong indications of a good fit. Standardized residuals ranged from -4.81 to 5.46 ($\text{Md}_n=-.26$). Analysis of the Q-Q plot, which displays ordered standardized residuals plotted against their normalized deviates at corresponding percentage points along a 45-degree diagonal line, revealed only partial alignment with the diagonal line and a shallow departure near the bottom, suggesting some degree of poor fit (Jöreskog & Sörbom, 1996c; for further explanation, see Appendix D). Although, Hayduk's (1987) discussion of Q-Q plot linearity implies that alignment diagnostics are not always dependable.

Because the overall goodness-of-fit was quite acceptable and further modifications did not result in a significant drop in the chi-square value nor further improvement in fit, no more changes were made. However, the presence of large residuals are indications of measurement error or departures from normality. Since all further substantial modifications were
indicated only for correlations of error between pairs of indicators that were not of interest (e.g., between indicators of different factors), it was concluded that measurement error and presence of outliers were responsible. Alternatively, the large sample size and otherwise good fit of the model inferred stability of the model's parameters.

**Analysis of Hypothesized Effects**

To test the specific hypotheses stated in Chapter 2, the total, indirect, and direct effects between variables in the model were examined. Direct effects exist between two variables where there is no intervening variable. Indirect effects exist between two variables where there is indirect causality through at least one intervening variable. The total effect is the sum of the indirect and direct influence. The ramification of a mediated relationship is that changes in the intervening variable can modify a direct relationship (Loehlin, 1992) which is interpreted as the magnitude of the effect on the dependent variable by the mediator from an initial unit of change in the independent variable, disallowing the direct effect of the independent variable on the dependent variable (Hayduk, 1987, p.247). Table 4.6 displays a summary of effects for the study model, all of which were significant at or below a probability level of 99 percent. Hence, all paths were retained in the final model.

**Hypothesis One.** As hypothesized, maternal characteristics significantly influenced birth outcomes ($\beta_{MC,BO} = .07$, $p < .01$). This significant
### Table 4.6

**Decomposition of Standardized Total, Indirect, and Direct Effects**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Total effects</th>
<th>Indirect effects*</th>
<th>Direct effects*</th>
<th>Variables</th>
<th>Total effects</th>
<th>Indirect effects*</th>
<th>Direct effects*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\xi \rightarrow \eta$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MC$\rightarrow$HP</td>
<td>.29</td>
<td>-</td>
<td>.29</td>
<td>PHP$\rightarrow$pnprac</td>
<td>.92</td>
<td>-</td>
<td>.92</td>
</tr>
<tr>
<td>MC$\rightarrow$BO</td>
<td>.15</td>
<td>.08</td>
<td>.07</td>
<td>PHP$\rightarrow$gestat</td>
<td>.20</td>
<td>.20</td>
<td>-</td>
</tr>
<tr>
<td>MC$\rightarrow$IHP</td>
<td>.46</td>
<td>.04</td>
<td>.42</td>
<td>PHP$\rightarrow$bwgm</td>
<td>.24</td>
<td>.24</td>
<td>-</td>
</tr>
<tr>
<td>MC$\rightarrow$CHS</td>
<td>.23</td>
<td>.23</td>
<td>-</td>
<td>PHP$\rightarrow$apg5</td>
<td>.25</td>
<td>.25</td>
<td>-</td>
</tr>
<tr>
<td>$\eta \rightarrow \eta$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PHP$\rightarrow$BO</td>
<td>.28</td>
<td>-</td>
<td>.28</td>
<td>PHP$\rightarrow$loh</td>
<td>.09</td>
<td>.09</td>
<td>-</td>
</tr>
<tr>
<td>PHP$\rightarrow$IHP</td>
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<td>PHP$\rightarrow$ddst</td>
<td>.02</td>
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<tr>
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<td>.17</td>
<td>-</td>
<td>PHP$\rightarrow$fhs</td>
<td>.11</td>
<td>.11</td>
<td>-</td>
</tr>
<tr>
<td>BO$\rightarrow$IHP</td>
<td>.24</td>
<td>-</td>
<td>.24</td>
<td>BO$\rightarrow$gestat</td>
<td>.73</td>
<td>-</td>
<td>.73</td>
</tr>
<tr>
<td>BO$\rightarrow$CHS</td>
<td>.60</td>
<td>.08</td>
<td>.52</td>
<td>BO$\rightarrow$bwgm</td>
<td>.88</td>
<td>-</td>
<td>.88</td>
</tr>
<tr>
<td>IHP$\rightarrow$CHS</td>
<td>.34</td>
<td>-</td>
<td>.34</td>
<td>BO$\rightarrow$apg5</td>
<td>.92</td>
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<td>.92</td>
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<tr>
<td>$\xi \rightarrow y$</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>MC$\rightarrow$gestat</td>
<td>.11</td>
<td>.11</td>
<td>-</td>
<td>BO$\rightarrow$loh</td>
<td>.33</td>
<td>.33</td>
<td>-</td>
</tr>
<tr>
<td>MC$\rightarrow$bwgm</td>
<td>.14</td>
<td>.14</td>
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<td>BO$\rightarrow$ddst</td>
<td>.08</td>
<td>.08</td>
<td>-</td>
</tr>
<tr>
<td>MC$\rightarrow$apg5</td>
<td>.14</td>
<td>.14</td>
<td>-</td>
<td>BO$\rightarrow$fhs</td>
<td>.39</td>
<td>.39</td>
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</tr>
<tr>
<td>MC$\rightarrow$infprac</td>
<td>.41</td>
<td>.41</td>
<td>-</td>
<td>IHP$\rightarrow$infprac</td>
<td>.90</td>
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<td>.90</td>
</tr>
<tr>
<td>MC$\rightarrow$pnprac</td>
<td>.27</td>
<td>.27</td>
<td>-</td>
<td>IHP$\rightarrow$loh</td>
<td>.19</td>
<td>.19</td>
<td>-</td>
</tr>
<tr>
<td>MC$\rightarrow$loh</td>
<td>.13</td>
<td>.13</td>
<td>-</td>
<td>IHP$\rightarrow$ddst</td>
<td>.05</td>
<td>.05</td>
<td>-</td>
</tr>
<tr>
<td>MC$\rightarrow$ddst</td>
<td>.24</td>
<td>.24</td>
<td>-</td>
<td>IHP$\rightarrow$fhs</td>
<td>.22</td>
<td>.22</td>
<td>-</td>
</tr>
<tr>
<td>MC$\rightarrow$fhs</td>
<td>.15</td>
<td>.15</td>
<td>-</td>
<td>CHS$\rightarrow$loh</td>
<td>.55</td>
<td>-</td>
<td>.55</td>
</tr>
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<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
| Note. MC=maternal characteristics; PHP=prenatal health practices; BO=birth outcomes; IHP=infant health practices; CHS=child health status; pnprac=prenatal health practices; gestat=gestational age; bwgm=birthweight; apg5=Apgar score (5 minutes); infprac=infant health practices; loh=level of health; ddst=developmental assessment; fhs=functional health status.

*all effects are significant at p≤.01
Figure 4.2. Path models of hypothesized effects: (A) the mediated relationship of MC and BO by PHP, (B) the mediated relationship of BO and CHS by IHP, (C) the additional contribution of MC to IHP, and (D) the model's core pathway without mediating effects (MC=maternal characteristics, PHP=prenatal health practices, BO=birth outcomes, IHP=infant health practices, CHS=child health status).
positive relationship suggests that maternal social disadvantage directly contributes to poor birth outcomes, albeit that only 2.25% of the variance in BO ($R^2 = 0.0225$) was explained by this path exclusively.

**Hypothesis Two.** As hypothesized, prenatal health practices successfully mediated the relationship between maternal characteristics and birth outcomes. According to criteria reported by Baron and Kenny (1986), successful mediation is established when there is a drop from the total to the direct effect of the independent variable on the dependent variable. Complete mediation occurs when the direct effect drops to zero, otherwise the mediation is referred to as partial. The direct effect from MC to BO was smaller ($\beta = 0.07, p \leq 0.01$) than the total effect ($\beta = 0.15, p \leq 0.01$), signifying a substantial amount of mediation. This was calculated as

$$\beta_{MC,BO} = 0.07 + 0.29(0.28) = 0.15$$

(see Figure 4.2A). The amount of variance in BO explained by MC and PHP was 9.4% ($R^2 = 0.094$). This indicates that pursuing positive prenatal health practices can strongly enhance the weakly positive effect of social advantage in determining a better birth outcome.

**Hypothesis Three.** As hypothesized, child health status was significantly influenced by birth outcomes ($\beta_{BO,CHS} = 0.52, p \leq 0.01$). Thirty-six percent of the variance in CHS ($R^2 = 0.36$) was explained by this relationship.
This finding suggests that health at birth decidedly determines health status at 3 years of age.

**Hypothesis Four.** As hypothesized, infant health practices successfully mediated the effect of birth outcomes on child health status. This was calculated as

$$\beta_{BO,CHS} = .52 + .24(.34) = .60,$$

representing the total effects of BO on CHS, which is the sum of the direct effect of BO on CHS and the product of the indirect effects of BO on CHS through IHP (shown in Figure 4.2B). Using the same criteria as in Hypothesis Two (Baron & Kenny, 1986), the direct effect of BO on CHS ($\beta = .52$, $p \leq .01$) was less than the indirect effect ($\beta = .08$, $p \leq .01$), signifying partial mediation. The amount of variance in CHS explained by BO and IHP was 50% ($R^2 = .50$). This indicates that positive health practices during infancy significantly modify the strong determination of preschool-age health status by birth outcomes.

Providing a direct path from MC to IHP demonstrated that a significant direct relationship exists between those two variables, given the relative influence of the direct ($\beta = .42$, $p \leq .01$) versus the indirect ($\beta = .04$, $p \leq .01$) effects. Figure 4.2C demonstrates this relationship that was calculated as

$$\beta_{MC,IHP} = .42 + .29(.28)(.24) + .07(.24) = .46.$$
From a theoretical perspective, it is quite conceivable that maternal characteristics would influence infant health practices if those practiced prenatally were also significant, hence the addition of the path.

The model's overall squared multiple correlation was calculated as

$$R^2_m = 1 - (1 - R^2_1)(1 - R^2_2)(1 - R^2_n),$$

where each $R^2$ in the right-hand term was calculated for each endogenous variable in the model, taking into consideration both direct and indirect influences (Pedhazur, 1982). The overall $R^2$ was

$$0.7019 = 1 - (1 - 0.086)(1 - 0.094)(1 - 0.28)(1 - 0.50),$$

indicating that 70% of the variance in CHS was explained by the other variables in the model. However, the core pathway in the model, as shown in Figure 4.2D, explains only 41.6% of the variance ($R^2 = 0.4157$) in the outcome variable. This figure was calculated as

$$R^2_{CHS,MC,BO} = r^2_{CHS,MC} + r^2_{CHS,BO} - 2r_{CHS,MC} r_{CHS,BO} r_{MC,BO} \frac{1 - r^2_{MC,BO}}{1 - r^2_{MC,BO}}.$$

This implies that the mediating effects of health practices provide an improved explanation of variance in child health status. It should be noted that measurement error in either the independent or dependent variables can attenuate the overall squared multiple correlation (Pedhazur, 1982). Following this argument, the low reliability and validity established for CHS (see Table 3.2) may imply that the model's overall $R^2$ may be higher.
Model Test By Race

No changes to the model were proposed, based on race or ethnicity. The purpose of testing the model with homogeneous racial subsets was to determine if the model was a good fit to the data with race held invariant, in order to separate it from characteristics of socioeconomic status.

Results of the model test demonstrated little difference in model fit between the two samples. Fit measures for the optimum black model were $\chi^2=207.73$, df 47, $p=.00$; RMR=.05; RMSEA=.04; AGFI=.99; PGFI=.60; NFI=.98; PNFI=.70; TLI=.98; and CN=848.45. Fit measures for the optimum white model were $\chi^2=214.72$, df 46, $p=.00$; RMR=.18; RMSEA=.04; AGFI=.99; PGFI=.60; NFI=.99; PNFI=.69; TLI=.98; and CN=723.24. Modifications to the models included the addition of the path between MC and IHP and error correlations between mateduc and wednow and matage and pnhlth for the black model. The same path was added to the white model although errors were permitted to correlate between wednow and ddst, mateduc and infprac, matage and ddst, and mateduc and pnhlth for an optimum fit. Parameter estimates for each model (Figure 4.3), demonstrates that all paths are positive and significant in both models. Testing significance of these differences was beyond the purpose of this study.

These findings support the hypothesis that the theoretical model fits for these two racial groups. This suggests that social advantage, health
Figure 4.3. Comparison of parameter estimates from the black and white race submodels. The asterisk designates significance (p>.01).
practices, and birth outcomes are significant predictors of child health status, despite mother's race.

Summary

In this analysis, the preliminary test of the measurement model established, for the most part, that the indicators chosen to operationalize the model's latent factors were reliable and valid measures. Therefore, to the extent that the underlying assumptions of structural equation modeling were met, the model based on data obtained from the NMIHS surveys was found to confirm the proposed theoretical model with several minor modifications. While this conclusion is based on criteria other than the traditional chi-square test of likelihood, confidence in the rigor and power of the alternative indices to determine a good fit was high.
Chapter Five

Discussion

This chapter reviews the findings of this study in comparison to work reported by others' and within the context of the major issues that have been previously addressed. Possible sources of bias are discussed that may limit the interpretation and usefulness of these results. Recommendations are made for future research as a natural outcome of this endeavor. In addition, importance of the findings for nursing providers of health care to mothers, infants, and children are elucidated.

Review of the Findings

The present research was conducted to address the following questions:

(a) Will an a priori specified model of antecedent factors (maternal characteristics, prenatal health practices, birth outcomes, and infant health practices) significantly predict the outcome of child health status? (b) Will positive prenatal health practices mediate the influence of maternal social advantage on birth outcomes? (c) Will positive infant health practices mediate the effect of birth outcomes on preschool-age child health status? and (d) Will the general model hold when tested with samples of homogeneous racial groups? Results from this model test indicated that the overall model fit was good and that the predictors explained a substantial amount of
variance in the outcome variable of preschool-age child health status. This suggests that most of the antecedent influence on a young child’s health has been accounted for in this model. The findings also showed that the relationship between maternal characteristics and birth outcomes was mediated by positive prenatal health practices. Likewise, the relationship between birth outcomes and child health status was mediated by positive infant health practices. Further model testing demonstrated that the theoretical relationships also were valid for homogeneous racial groups of mothers and their children.

Although significant, the effect of social advantage on birth outcomes was found to be the weakest direct relationship in the model. A number of events or characteristics preceding a pregnancy are known to have substantial influence on birth outcomes. For instance, longstanding poverty and prior LBW births (Starfield et al., 1991) and a mother’s own birthweight (Wang, Zuckerman, Coffman, & Corwin, 1995; Sanderson, Emanuel, & Holt, 1995) have been previously reported to determine outcomes of pregnancy. While there are surely more factors that exist outside the boundaries of this model, it is unlikely that they would explain the small effect of maternal characteristics on birth outcomes found with this sample.

The indirect path from maternal characteristics to birth outcomes, through prenatal health practices, was found to be marginally higher than the direct path. This finding provides evidence for not only a mediated effect on
the primary relationship by the intervening variable, but also a small degree of actual suppression of that relationship (Cohen & Cohen, 1983). This explanation may account for the unexpectedly low magnitude of the path coefficient between maternal characteristics and birth outcomes. Based on this finding one could conclude that much of the effect of maternal social advantage on birth outcomes may actually be almost entirely transmitted through its strong association with prenatal health practices. Pappas et al. (1993) referred to the social maldistribution of behaviors that promote health risks as being one explanation for the inverse relationship between socioeconomic status and mortality that they found. While this interpretation presents an interesting perspective and greatly facilitates explanation of the mechanism, it nevertheless strongly affirms the importance of nursing intervention with pregnant clients, so any argument concerning direct causal relationship is moot.

Although not difficult to conceptualize, measurement of both types of health practices was troublesome. The low intra-factor correlations for both could be explained either as mere sample fluctuations or very real differences, implying that these indicators do not really manifest the latent constructs. Whether these items were actually ‘producers’ rather than ‘reflectors’ (per vernacular described by Pedhazur and Schmelkin, 1991, p. 54; see Appendix D for discussion of parcels), does not overcome the problems produced by single indicator factors in SEM. Eventhough a number of indicators were used to
measure each of the health practices factors, measurement error was only arbitrarily accounted for in each case. Regardless, the weight of the empirical evidence that supported the use of the items suggests that each of the parcels reasonably measured their construct.

Despite the measurement problems with the factor, child health status, the relationship between birth outcomes and child health status was found to be the strongest direct effect in the model. This finding provides some endorsement for a relationship that has a relative paucity of empirical evidence to support it (see Chapter 2). Although partial mediation by infant health practices was demonstrated, the relatively weak indirect relationship suggests that this set of positive health practices does not have the same potential to influence the primary relationship as those in the prenatal period. Considering that all three measures used to indicate the construct, Infant Health Practices, are markers of progress toward Healthy People 2000 goals (Public Health Service, 1995), their ability to influence the birth outcomes-child health status relationship was less than expected. Perhaps the benefits of healthy practices during infancy are realized at an older age.

Demonstration of the significant direct effect of maternal characteristics on both sets of health practices suggests that there is greater potential for mediation of social influence on health outcomes than was specifically hypothesized. Testing the mediation of the maternal characteristics-child health status relationship, however, would require the variance in child
health status due to birth outcomes to be controlled. It would be possible to remodel these data in future model tests in this way.

Measuring the construct, child health status, was also problematic. Validity was quite low as a result of the poor performance of the developmental health indicator, the Denver Developmental Screening Test score. The long form of this test, designed to be used by trained assessors, is accepted as a reliable and valid standardized tool for assessing developmental appropriateness of young children, across all racial/ethnic and SES groupings (Frankenburg, Dick, & Carland, 1975; Frankenburg & Dobbs, 1967). The shorter form, designed to be an easy rapid prescreen for detecting delays, has also been shown to be a reasonably valid tool (Frankenburg, Fandal, & Thornton, 1987; Burgess, Asher, Doucet, Reardon, & Daste, 1984), especially for use by parents of all SES groups (Rosenbaum, Chau-Lim, Wilhite, & Mankad, 1983). Possible explanations for its poor performance in this study are that, if it was administered correctly, (a) developmental health is not a valid indicator of overall child health; (b) it did not perform up to its own high standard for accuracy, although false positive results were a problem with earlier versions of the tool (Frankenburg et al., 1987); or (c) it actually does not measure what it purports to measure, in spite of the evidence. Another plausible reason is that it was administered incorrectly, possibly a result of the impersonal nature of large surveys that require the briefest of instructions. Developmental progress is very rapid in early childhood and, as
the index children’s ages ranged more than a year, it would be difficult to measure appropriate developmental health in a survey format. Perhaps this is a symptom of Starfield’s (1987) general concern about the difficulties in measuring child health status.

The other indicators of health status performed well. Apart from its reasonable representation of the latent construct, the measure of physical health status appears to be valid based on its widespread use (e.g., Zambrana, Ell, Dorrington, Wachsman, & Hodge, 1994; McGauhey & Starfield, 1993; McGauhey et al., 1991; and Angel & Worobey, 1988). The functional health status composite, while justifiable in theory (Stein & Jessop, 1983), has not been previously used. Based on its good performance in this study, it could become a reasonable index for assessing functional health status in other preschool-age children with further methodological work.

Major Issues

Based on the abundance of cited research that supports aspects of this model, relationships between factors within the model were shown to be theoretically sound prior to its original specification. However, there is much philosophical debate regarding the concept and the term, causality. Cliff (1983) warns that causality cannot be established through SEM. At best, what an investigator may say about significant paths between factors is only that one factor influences another, even when variables follow each other in time. Alternatively, Mulaik (1987), in his lengthy discussion on this subject,
concludes that factors in a structural model are shown to be functionally related, regardless of whether or not that is called causality. Furthermore, cause-and-effect relationships are nevertheless tenuous as are all hypotheses that are confirmed empirically, subject to revision and reconfirmation as the environmental context changes. Bearing in mind the disagreements over the nature of a structural model’s relationships, a discussion of the main issues extracted from this investigation follows.

**Multiple dimensions of child health status.** In this study, it was presumed that broadening the definition of child health status to include functional and developmental, as well as physical, health would be more sensitive to influencing factors. As a result, significant relationships were revealed that probably would not have been fully appreciated with a narrower definition of health. A regression analysis of the comparative ability of each health measure to reflect its antecedents would inform future research of this nature. Although Keltner (1992) was able to determine a positive link between physical health in young children and features of the home environment, she alluded to the lack of precision in measuring general child health status using only data from routine physical screening. One would expect an even stronger association with the addition of developmental and functional health measures. The study by McGauhey et al. (1991) compared seven child health status measures, including behavioral, physical, and functional dimensions, for relative risk from high-risk social environments.
A high-risk social environment, largely described by parental socioeconomic measures, was found to heighten the risk for poor health in children when health status was broadly defined. Interestingly, their findings showed that a mother’s perception of her child’s health (their physical health measure), appeared as or more sensitive to risk compared to the other health measures. At least for social environment antecedents, measures of physical health status alone may suffice. Without use of the additional measures, though, one may never know what relationships were missed. Possibly then, physical health by itself is reflective of a wider array of factors in a child’s milieu than was presumed in this study. Notwithstanding, common sense would suggest that using a broader definition of health, including measures of a more positive nature than the conventional morbidity and mortality indicators, would be more sensitive to antecedent influence.

**Health practices as mediators.** The ability of health status at birth to determine health status at 3 years of age was only moderately modified by the intervention of health practices in infancy. This implies that either the developing fetus is more sensitive than the older infant to the salubrious effects of positive health practices or that the relationship between maternal characteristics and birth outcomes is more amenable to modification by an intervening variable. Moreover, the addition of a direct causal influence on infant health practices from maternal characteristics hinders a clear explanation of the mechanism of mediation, as stated previously. Despite the
confusion, the bottom line is unchanged: Nurses should understand that interventions are important modifiers of resistant relationships of health outcomes with their antecedents.

**Measuring social disadvantage.** The significant direct effect of maternal characteristics on both types of health practices measured in the present study stresses the limitations that social inequality place on preventive health behavior. Krieger (1991) went so far as to suggest that social class labeling on individual health records may assist health care providers in prevention and early detection of known reproductive problems in certain groups of women, based on her investigations using block-tract census data. Although Williams (1990) argued that more work was needed to identify the critical social characteristics that are most essential in detecting social stratification of health overall.

While measurement of social advantage is common throughout all health and behavioral science literature, what constitutes appropriate components is not consensual. Morgan and Chinn (1983) compared two British measures of social inequality for ability to differentiate childhood morbidity. A comprehensive measure using housing, age, employment, family structure, social status, and car ownership was found to be no better than the conventional one that only measured occupational class. Gould and LeRoy (1988) used only median family income as their proxy for socioeconomic status (SES) because of the lack of other pertinent information.
on Californian birth certificates, their data source. However, they were able to show that higher rates of teenage pregnancy and low birthweight occurred in lower income residential areas. Paneth, Wallenstein, Kiely, and Susser (1982) were more fortunate in investigating infant mortality and SES using the additional information available on birth and death certificates in New York. By using mother's age, marital status, level of education, and several indications of health care subsidy, they were able to show a marginal association between SES and mortality for degrees of LBW. In a more recent investigation, living in public housing and feelings of helplessness were found to be the most significant predictors of LBW when poverty was controlled (Shiono, Rauh, Park, Lederman, & Zuskar, 1997). Results from these studies suggest that any number of indicators of social advantage are sensitive to variations in levels of poor health and death. Abramson, Gofin, Habib, Pridan, and Gofin (1982) reached a similar conclusion although the low correlations between social indicators that they found prompted them to recommend using more than a single measure to increase the likelihood of detecting links between social class and health. From a methodological perspective, the time lag frequently seen in epidemiologic studies between measurement of SES and health outcome does not detect changes in SES, especially in income, which would impair the whole scenario of exposure and effect if SES is not measured more often (Kaplan & Lynch, 1997).
In any case, the measures of maternal age, education, marital status, and household income that were used in this study seemed to have fully captured the construct within this particular context, supported by the reliability and validity estimates. Based on more current wisdom, however, different and/or additional measures should be used in future work.

The significant direct effect that maternal characteristics had on all but one of the model's variables suggests that levels of social advantage initiates a chain of effects leading to downstream health through interactions with other, more immediate variables. Rutter and Quine (1990) proposed an interesting mechanism of material deprivation to explain the relationship between social class and pregnancy outcomes which implies that the role of social disadvantage is axiomatic for health. The full implication of this argument is that all other variables act as a filter, possibly to the extent that any effect of social advantage or disadvantage on subsequent health is transmitted entirely to other variables that happen to be associated with both this fundamental cause and its ultimate effect. While this provocative notion remains somewhat difficult to investigate, what is most apparent from this study's findings is that a mother's level of social advantage, defined within the context of culture, is a potent influence on her child's health, even if in an oblique manner.

Race and health. It was important to separate out the effects of race from other indicators of social advantage. Angel and Worobey (1988) argue
that combining social class and culture (i.e., race/ethnicity) confuses the two effects because certain groups have greater or lesser access to resources. Rather, as these authors explain, culture "...provides the context in which other variables operate" (p. 40). Problems in separating the two effects may be from using the traditional measures of income and education to operationalize SES. Guralnik and Leveille (1997) contend that the higher rates of mortality and morbidity seen in minority racial/ethnic groups that remain after the effects of SES are controlled, may be explained by expanded measures of wealth.

Many investigators have attempted to investigate the exclusive effect of race and its effect on health and health access. For example, Hummer (1993) tested four logistic regression models also using items from the 1988 NMIHS data set to demonstrate that maternal age, education, adequacy of prenatal care, pregnancy weight gain, prematurity, and birthweight would mediate the effect of race on infant mortality. He was unable to completely explain racial differences in infant mortality, between 52% and 75% of the variance depending on the model, without the contributions of prematurity and birthweight. Based on the more-than-doubled infant mortality rate observed for African-Americans compared to Anglos, he concluded that his findings clearly emphasize that a unique, yet still poorly defined, set of determinants for infant mortality exists for African-Americans. While infant mortality is still a relatively rare outcome, low birthweight and prematurity
are not. Gould and LeRoy (1988) found a consistent 5 percent gap in birthweights between white and black infants across all income brackets in 127,558 births although Starfield et al. (1991), who surveyed a group of over 3800 women annually from 1979 to 1988, found similar birthweight discrepancies for both black and poor white infants. Lieberman et al. (1987), however, found that being very young, single, poor, and uneducated were the biggest risk factors for premature delivery, regardless of race. Clearly, the singular influence of minority race, on poor birth outcomes at least, is not easy to separate from markers of social disadvantage because of the disproportionate representation in the lower socioeconomic strata. Clarifying the actual mechanism that race exerts is probably less important than how it is manifesting itself. Kempe and a large body of associates from institutions in three states (1992) reported not only an increased risk for low birthweight in black versus white infants but also a higher proportion of all major conditions in the mothers that precipitate premature delivery. Granted that low birthweight occurs for some reason, these findings emphasize where preventive efforts should be focused: promoting positive prenatal health practices especially in the minority racial and ethnic groups.

In summary, the findings from this study do not necessarily expand knowledge as much as they explicate an understanding of the theoretical relationships that were tested by confirming relationships established in previous investigations, albeit in a piecemeal fashion. Addressing Stein’s and
Jessop’s (1983) view of the fundamental controversies concerning measurement of health status, these results suggest that a satisfactory definition of health must tap multiple domains and measure the positive end of the spectrum. Following Schorr et al. (1984) who argued that mortality and morbidity measures were important indicators for health policy, measures including positive aspects of health such as those used in this study, should also become sentinel events in channeling health care expenditures as child health status improves in this country.

Limitations

Cliff (1983) warns the overzealous modeler that data are only able to disconfirm models, not confirm them. Further, when models are not disconfirmed, there may be other models that are not disconfirmed either. As a result, a common error in SEM occurs when one assumes that the final model is the only explanation for the changes observed in the dependent variables. In actuality, if a model is found to have a good fit, many other explanatory models may do just as well (Loehlin, 1992). It is likely that this model of preschool-age child health status antecedents does not include important influential factors that impact downstream health in young children. Possible variables that are also known to have influence on some of the factors in the model that could be included in future tests are urban or rural residence, parity, and other mediators such as intervening illnesses, stress and social support (Williams, 1990), to name a few.
The use of secondary data sets for a purpose other than its primary one, also has well-known deficiencies. For example, the inability to control what information was collected and how it was measured can be troublesome for the secondary data analyst. Both Kiecolt and Nathan (1985) and McCall and Appelbaum (1991) discuss a number of concerns in using secondary data sets that, in essence, amounts to a potential methodological mismatch between an original study's purpose and that of a subsequent one. A related concern, addressed by Hyman (1972), is the 'slippage' problem (pp. 30-31) which involves overly liberal interpretations of intended original meanings. The direct and nonabstract nature of the NMIHS questions leaves little room for slippage although the possibility exists. Hyman describes a converse problem that occurs when the secondary analyst must select from an overabundance of appropriate items, which was a more realistic concern in the present study, due to the wealth of information in the NMIHS data base. It is possible that more valid indicators of the model's latent factors were available in the data sets, especially for child health status.

Certain methodological issues that were either unavoidable or obvious only on hindsight may have had an untoward impact on the veracity of these results. The use of parcels, single-indicator factors, and fixed error variances are debatable practices, as recognized and addressed in Appendix D. Given the rapidly evolving nature of SEM and the frequent affronts to its current wisdom that quickly end up as common practice, there currently is at least
divided support for all of these methods.

Perhaps the biggest concern was the presence of the large remaining residuals that could not be treated by further modification. It is possible that the model was fundamentally misspecified, although the bulk of previous evidence combined with common sense would tend to quell that argument. The use of ADF theory to model ordinal and other non-normally distributed variables, a relatively new tool in SEM analysis, should have adequately solved the problem of non-normality. Furthermore, ADF estimates are only stable with large samples (Hu, Bentler, & Kano, 1992; Anderson & Gerbing, 1988). In consideration of the support for using ADF cited in Chapter 3 and Appendix D, the estimates from this study are thought to be stable and reasonable approximations of the true model because of the large sample used. While NCHS data is generally considered to be of the highest standard due to the degree of rigor imposed on the survey process, another explanation for the large residuals is that the data quality was poor for any of a number of reasons. Various low zero-order correlations, skewed and peaked frequencies of some raw variables, and truncated distributions of the infant height and weight variables are possibly diagnostic features of substandard data. Nevertheless, the fit indices used as criteria to determine the adequacy of fit of the overall model to the NMIHS data, even those that incorporate the residuals (e.g., RMR), give credence to the generality of the model as tested.
One further limitation should be addressed. The disproportionate oversampling of blacks in the original NMIHS sampling frame, alter the ability to generalize the results of this model test to the larger population. However, results from the model test with each subgroup cross-validates the test and demonstrates the lack of bias based on race since the model fit held for both groups.

Implications for Providers of Child Health Care

The public health model utilizes a health promotion approach to initiate change in the health behaviors of large groups. Because health practices are more modifiable than other determinants of health, such as pre-existing health conditions or socioeconomic status, public health campaigns first persuade members of population groups to intend to change their behaviors and then teaches them how (Stroebe & Stroebe, 1995). The findings from this study add to the growing body of evidence that permits health professionals to operate within that public health framework. Results from this study also provide a rudimentary but much improved understanding of structural influences on young children’s health status, while opening research opportunities for further additions to the model. The bulk of the research cited in this report mostly focused on fragments of this complex picture. These findings provide a beginning insight into how these pieces fit into the bigger context.
Jamrozik and Sweeney (1996) maintained that, because a child's first encounter with health care occurs before birth, health care professionals have the potential to exert an appreciable amount of control over a growing child's level of health. This emphasizes not only the importance of timely health care interventions, but also how essential it is to use a longitudinal investigation for simplifying the interdependent contributions of interventions and other factors, retrospective all the way to the prenatal period. Without a longitudinal design, understanding the scope of antecedent influence is severely restricted. For example, in their cross-sectional analysis, the findings of numerous longstanding health problems in foster care children obtained by Halfon and associates (1995) emphatically begged the question concerning precedent.

Studies of even a longitudinal nature are sometimes so narrowly focused that factors exogenous to the relationship under study are ignored. To illustrate, Overpeck, Moss, Hoffman, and Hendershot (1989) reported differences in health status based only on weight at birth in nearly 58,000 children ranging in age between under 2 to 17 years. While findings such as these are important in and of themselves, the health care provider is not necessarily enlightened as to what can or should be done to prevent such a dismal outcome. McGauhey et al. (1991), arguing for a multivariate approach, reanalyzed the same data used by Overpeck's group, with the inclusion of socio-environmental factors to detect an increased risk for poor health. Their
results revealed the conspicuous presence of protection from risk with some socio-environmental factors, producing a much clearer contextual picture. The lessons for health care providers gleaned from this type of analysis are much more instructive therefore, the longitudinal aspect of this study strengthens its usefulness.

Findings from this study have important ramifications for nursing care providers in maternal-child and/or public health settings. Considering their potential to impact a child’s evolving health through periodic contact starting in fetal life, a nurse’s knowledge of the interdependence of social characteristics, pregnancy outcomes, health practices, and preschool-age health would be crucial to their understanding of the mechanisms of cause. Further, broadening health assessments to include other dimensions, at least in young children, would permit better detection of health outcomes that result from antecedent events.

Recommendations for Further Study

Loehlin (1992) warns that structural equation models are “inherently hypothetical” (p.226) and need further testing and support through cross-validation with other samples. Therefore, it is necessary for this model to be tested again under different sampling conditions; considering the size requirements of the ADF mode, perhaps with another large, existing data set. Operationalizing the model’s factors with more and/or different indicators may improve the measurement properties of the model which would lend
stronger support to the structural components. The unanticipated low correlations between some intra-factor items should be investigated in future research in order to determine if they are a spurious result of this sampling frame or a real phenomenon. Reasons for truly low correlations may be of interest and should be pursued. While a wealth of empirical evidence exists for the influence of prenatal maternal characteristics on more proximate behaviors and events, its influence on infant health practices does not enjoy the same support. Future study of this relationship should update the elements for currency of effect of social advantage on health care access at each stage of development.

Factors not included in this model that may be worthy of further study are variables that are temporally concurrent within the child’s milieu. Keltner’s (1992) finding of significant correlations between high levels of family routines and stimulation in the home and a preschooler’s physical health status, suggests that the child’s social environment, which may or may not be related to the mother’s level of social advantage, would be a reasonable factor to add to future tests of this model. Additionally, trials with different interventions would promote an understanding of the relative efficacy of various health practices in determining health which would tend to focus public health efforts on only the most effective practices.
Conclusions

This research endeavor sought to test a model of young child health status and a select set of its precursors. Specifically, this secondary analysis of the NMIHS data:

(a) demonstrated predictive value of modeled antecedents;
(b) demonstrated the extent of effects of maternal social disadvantage;
(c) used a large nationally representative sample, promoting generalizability;
(d) used longitudinal data, giving credence to the relational findings;
(e) demonstrated the extent that health promotion interventions can make a difference in health outcomes, highlighting where nurses should focus their endeavors.

With the dramatic changes taking place in health care, pressure is building for the development of new measures that monitor health and health-related activities. These measures will have much value in shaping future investments in health care services (Schorr et al., 1983). Starfield (1987) addressed the question of why child health status measurement from a policy perspective is important. She argued that large scale investigations demonstrate the impacts of both social phenomena and health policy on health, in the general as well as in special populations, while small area investigations elucidate the impact of biology on individual health and distinguish differences in health care service delivery. None of this will be
possible without more and better methodological tools. This investigation has made a minor contribution toward that goal.
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### Appendix A

**Other Studies Using NMIHS Data**

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<th>Author</th>
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<th>Sample Description</th>
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<th>Dependent Variable</th>
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<td>-</td>
<td>prevalence and pattern of exercise in pregnancy</td>
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<td>risk assessment</td>
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<td>predictive</td>
<td>race, prenatal care advice, biomedical information</td>
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Appendix B

Codebook of Measured Variables

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**Birth Outcomes**

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<td>4 - fair</td>
<td></td>
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<td>5 - poor</td>
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<tr>
<td>Developmental assessment (DDST score)</td>
<td>A5-7 RS</td>
<td>60</td>
<td>dds1, dds12-3</td>
<td>45</td>
<td>0</td>
<td>7361</td>
<td>dds1</td>
<td>0.00 to 16.00</td>
<td></td>
<td>unchanged</td>
<td>continuous</td>
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<td>Indicator</td>
<td>Item Source</td>
<td>Tape Location</td>
<td>Base Variables</td>
<td>Missing Value Codes</td>
<td>Missing Cases</td>
<td>Imputed Values</td>
<td>Valid Cases</td>
<td>New Variable</td>
<td>Original Codes</td>
<td>Recodes</td>
<td>Level of Measurement</td>
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<tr>
<td>Activity level</td>
<td>A10^48 67</td>
<td>play</td>
<td>8,9</td>
<td>43</td>
<td>0</td>
<td>7363</td>
<td>play</td>
<td>1 - very inactive 2 - not very active 3 - mod. active 4 - very active 5 - too active</td>
<td>0 - very inactive, not very active, too active 1 - mod. to very active</td>
<td>ordinal</td>
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<tr>
<td>Cheerfulness</td>
<td>A12^48 69</td>
<td>happy</td>
<td>8,9</td>
<td>48</td>
<td>0</td>
<td>7358</td>
<td>happy</td>
<td>1 - usually happy 2 - occ. irritable 3 - irritable mostly</td>
<td>0 - occ. irritable to irritable mostly 1 - usually happy</td>
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<tr>
<td>Fearfulness</td>
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<td>fear</td>
<td>9</td>
<td>46</td>
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<td>7360</td>
<td>fear</td>
<td>1 - no or mild fear 2 - few strong fears 3 - lots strong fears</td>
<td>0 - none to mild fear 1 - few to lots of strong fears</td>
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<tr>
<td>Ability to get along</td>
<td>A14^48 71</td>
<td>getalong</td>
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<td>56</td>
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<td>7350</td>
<td>getalong</td>
<td>1 - gets along mostly 2 - some difficulty 3 - great difficulty</td>
<td>0 - with great difficulty 1 - with some difficulty to gets along mostly</td>
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<td>Tantrums</td>
<td>A15^48 72</td>
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<td>7356</td>
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<td>0 - frequent 1 - occ. to never</td>
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<td>getalong</td>
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<td>tantr</td>
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</table>

121
Note. (1) MQ=1988 NMIHS - Mother's Questionnaire, LBS=1991 LF - Live Birth Survey, MPS=1991 LF - Medical Provider Survey; (2) missing value codes are as follows:

<table>
<thead>
<tr>
<th>MQ</th>
<th>LBS</th>
<th>MPS</th>
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<tbody>
<tr>
<td>refused</td>
<td>4, 91</td>
<td>7, 97, 997</td>
</tr>
<tr>
<td>don’t know</td>
<td>5, 92</td>
<td>8, 98, 998</td>
</tr>
<tr>
<td>not applicable, not appropriate, vague, missing</td>
<td>6, 93, 98</td>
<td>9, 99, 999</td>
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<tr>
<td>legitimate skip</td>
<td>9, 99, 999, 9999</td>
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</tbody>
</table>
Appendix C
SPSS Command Files: Calculation of the Adequacy of Prenatal Care Utilization index^*

The SPSS commands below were adapted from the original calculations written in SAS command language, with the author's permission^*.

*expected number of visits for length of gestation
do if (gestat ge 35)
compute uexp=(gestat - 35) + 9
else if (gestat ge 34)
compute uexp=9
else if (gestat ge 32)
compute uexp=8
else if (gestat ge 30)
compute uexp=7
else if (gestat ge 26)
compute uexp=6
else if (gestat ge 22)
compute uexp=5
else if (gestat ge 18)
compute uexp=4
else if (gestat ge 14)
compute uexp=3
else if (gestat ge 10)
compute uexp=2
else if (gestat ge 6)
compute uexp=1
end if

*expected number of visits adjusted for month of initiation
do if (pncbeg eq 10)
compute expvis=uexp - 17
else if (pncbeg eq 9)
compute expvis=uexp - 13
else if (pncbeg eq 8)
compute expvis=uexp - 9
else if (pncbeg eq 7)
compute expvis=uexp - 7
else if (pncbeg eq 6)
compute expvis=uexp - 6
else if (pncbeg eq 5)
compute expvis=uexp - 5
else if (pncbeg eq 4)
compute expvis=uexp - 3
else if (pncbeg eq 3)
compute expvis=uexp - 2
else if (pncbeg eq 2)
compute expvis=uexp - 1

Variable labels
gestat = gestational age in weeks
pncbeg = month of pregnancy that prenatal care was initiated
pnvis = total number of visits during pregnancy

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else if (pncbeg eq 1 or pncbeg eq 0)
end if
if (expvis le 0) expvis=1

*observed/expected visit ratio
compute evratio=(pnvis / expvis) * 100

*expected visits index (rating of adequacy of received service)
do if (evratio ge 110)
compute evindex=4
do if (evratio ge 80)
compute evindex=3
do if (evratio ge 50)
compute evindex=2
do if (evratio ge 0)
compute evindex=1
end if

*month prenatal care began (rating of adequacy of initiation of care)
do if (pncbeg eq 1 or pncbeg eq 2)
compute init=4
else if (pncbeg eq 3 or pncbeg eq 4)
compute init=3
else if (pncbeg eq 5 or pncbeg eq 6)
compute init=2
else
compute init=1
end if
if (pncbeg eq 0) init=0

*adequacy of prenatal care utilization index
do if (evindex=0 or init=0)
compute apncu=0
else if (evindex eq 0 or init ge 1 and init le 2)
compute apncu=1
else if (evindex eq 3 or init ge 3 and init le 4)
compute apncu=3
else if (evindex eq 4 or init ge 3 and init le 4)
compute apncu=4
else
compute apncu=2
end if

*Kotelchuck, 1995
^personal communication with the author, 1997
Appendix D
Detailed Methods

Sample Size Requirements

A major drawback of SEM is the need for very large samples to satisfy the requirements for matrix inversion and parameter estimation. One rule-of-thumb instructs that ten subjects per latent variable plus 50 are required (Ferketich & Verran, 1990), while another calls for ten times the number of paths to be estimated (McLaughlin & Marascuilo, 1990). Youngblut (1994) warns that if the number of subjects divided by the number of paths is less than five, the results are likely to be unstable. However, mixing ordinal and interval level variables, as in this study, even demands much larger samples. Appendix A, which includes codebook documentation of the model’s variables, shows valid numbers of cases for all indicators (some items from the 1988 survey included a small percentage of imputed values derived from subjects with similar characteristics.

Mixing levels of measurement requires a correlation matrix that combines polyserial, polychoric, and Pearson product-moment correlation coefficients, depending on the measurement levels of the pairs of variables that are being correlated (Anderson & Gerbing, 1988; Huba & Harlow, 1988). The type of correlation calculated for each pair of indicators is shown in Table D.1. Because normality could not be assumed for such data, an asymptotic covariance matrix (ACM) was estimated by PRELIS for input into LISREL. The minimum sample size required for estimating an ACM from this type of correlation matrix is

\[
k(k - 1) \over 2
\]

where \( k \) represents the number of indicators to be used in the model, although stable parameter estimates are not guaranteed at these bare minimums (Jöreskog & Sörbom, 1996a).

For the model tested in this study where \( k \) equaled 12, the minimum required sample size was 66. However, weighted least squares (WLS), the estimation procedure required for use with ACMs, demands extraordinarily large samples to estimate parameters with reasonable precision (Hu, Bentler, & Kano, 1992; Anderson & Gerbing, 1988).

The stringent assumption of a normal distribution that was once called for in early SEM has since been relaxed with development of ADF estimators, a necessity when both ordinal and non-normal continuous variables are used (Browne, 1984; Huba & Harlow, 1987; Anderson & Gerbing, 1988; Jöreskog & Sörbom, 1988). In his seminal work, Browne (1984) pointed out that the primary distribution concern in SEM is actually kurtosis, rather than skewness as in other analytic methods used in the social sciences (Huba & Harlow, 1987), because this term is part of the mathematical expression used in calculation of the covariance structures. Therefore, it was more important
Table D.1

Types of Correlations Computed For Each Pair of Indicators

<table>
<thead>
<tr>
<th></th>
<th>$x_1$</th>
<th>$x_2$</th>
<th>$x_3$</th>
<th>$x_4$</th>
<th>$y_1$</th>
<th>$y_2$</th>
<th>$y_3$</th>
<th>$y_4$</th>
<th>$y_5$</th>
<th>$y_6$</th>
<th>$y_7$</th>
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<tbody>
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<tr>
<td>$x_2$</td>
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<tr>
<td>$x_3$</td>
<td>PS</td>
<td>PS</td>
<td>PS</td>
<td>PS</td>
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<tr>
<td>$y_1$</td>
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<td>PS</td>
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<td>PS</td>
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<td>PS</td>
<td>PC</td>
<td>PC</td>
<td>PC</td>
<td>PS</td>
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</table>

Note:  $x_1$ = maternal age;  $x_2$ = maternal education;  $x_3$ = household income;  $x_4$ = marital status;  $y_1$ = prenatal health practices;  $y_2$ = gestational age;  $y_3$ = birthweight;  $y_4$ = Apgar score (5 minutes);  $y_5$ = infant health practices;  $y_6$ = level of health;  $y_7$ = developmental assessment;  $y_8$ = functional health status.  PE=Pearson product-moment correlation (when both variables are continuous), PS=polyserial correlation (when one variable is continuous and the other is ordinal), PC=polychoric correlation (when both variables are ordinal).
to assess normality of the continuous variables based on degree of kurtosis rather than skewness. A coefficient of multivariate kurtosis is calculated in PRELIS, permitting an accurate assessment. In addition to normality assessment, other screening included scrutiny of all item coding to ensure consistent low-to-high or negative-to-positive direction.

**Treatment of Missing Values**

Because estimation of the ACM requires exclusion of all cases with any missing values, Jöreskog & Sörbom (1996a) warn that it is not unusual to lose a substantial fraction of one’s sample when modeling in the ADF mode. For the larger sample (N=7406), PRELIS output revealed the following number of cases per number of missing values: 875 subjects had 1 item missing, 717 had 2 items missing, 723 had 3 items missing, 129 had 4 items missing, 14 had 5 items missing, and 7 had 6 items missing. No pattern of missing values could be detected, therefore, it was assumed that all values were missing at random.

Because 33% of the sample was lost as a result of listwise deletion, coefficients from pairwise-deleted correlations were compared in order to further detect the presence of bias. Table D.2 reveals only small to no difference for all pairs of variables except for maternal age and household income (r=.35 vs. r=.46), prenatal health practices and infant health practices (r=.20 vs. r=.13), birthweight and developmental assessment (r=.18 vs. r=.13), and Apgar score (5 minutes) and infant health practices (r=.07 vs. r=.13). No pattern could be ascertained from these differences and, as a result, were assumed to be simple random fluctuations. Means and standard deviations of the continuous variables were also compared without consequence.

During the original specification of the model, a number of items were proposed as operationalizations of the latent constructs but were deleted prior to starting the actual analysis. Table D.3 lists the 11 variables that were removed from the model. The most common reason for removal was a low response rate on one or more of the base variables used in constructing the indicator. The requirement for listwise deletion necessitated these removals to retain an adequate sample size for modeling in the ADF mode. Most removed indicators were theoretically appropriate for use in the model, however, several were excluded because they were deemed to be theoretically inconsistent, on hindsight, with other indicators in a particular factor. Measures of height and weight during infancy appeared to have truncated distributions, possibly due to data entry problems, promoting a lack of confidence in the quality of those variables. In addition, the indicators representing functional health status were dichotomized and collapsed into one composite variable for the sake of identification and parsimony.

**Modeling Sequence**

PRELIS was used to define the sample by listwise deletion of cases, assess multivariate kurtosis, and generate the mixed-type correlation and asymptotic covariance matrices used in the modeling procedure. A two-phased approach, recommended and used by several authors (e.g., Anderson & Gerbing, 1988; Netemeyer, Johnston, & Burton, 1990; and Schumaker &
Table D.2

Correlations With Pairwise and Listwise Deletions

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<tr>
<th></th>
<th>x₁</th>
<th>x₂</th>
<th>x₃</th>
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<th>y₂</th>
<th>y₃</th>
<th>y₄</th>
<th>y₅</th>
<th>y₆</th>
<th>y₇</th>
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</tbody>
</table>

| M     | 25.71| 8.49 | 11.80| .00  | .00  | 38.12| .00  | 3027.85| .00 | .00 | 3055.00| .00 | 12.09| .00 |
|       | 25.57| 8.37 | 11.76| .00  | .00  | 38.17| .00  | 3055.00| .00 | .00 | 12.18  | .00 |

| S     | 5.76 | 2.10 | 5.52 | 1.00 | 1.00 | 4.10 | 1.00 | 852.57  | 1.00| 1.00| 2.85   | 1.00|
|       | 5.74 | 2.08 | 5.47 | 4.05 | 830.00| 2.75|

**Note:** x₁ = maternal age; x₂ = maternal education; x₃ = household income; x₄ = marital status; y₁ = prenatal health practices; y₂ = gestational age; y₃ = birthweight; y₄ = Apgar score (5 minutes); y₅ = infant health practices; y₆ = level of health; y₇ = developmental assessment; y₈ = functional health status. Lefthand figures represent correlations for pairwise-deleted sample (N=7406) and righthand figures represent correlations for listwise-deleted sample (N=4940).
<table>
<thead>
<tr>
<th>Deleted variable</th>
<th>Factor</th>
<th>Reason for deletion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban/rural residence</td>
<td>MC</td>
<td>Low correlation with other indicators in factor; very uneven dichotomy</td>
</tr>
<tr>
<td>Illegal substance use</td>
<td>PHP</td>
<td>Low response rate on one or more base variable(s)</td>
</tr>
<tr>
<td>Apgar score (1 minute)</td>
<td>BO</td>
<td>High colinearity with Apgar score at 5 minutes</td>
</tr>
<tr>
<td>Growth - weight</td>
<td>IHP</td>
<td>Possible data entry error; low response rate on one or more base variable(s); theoretically inconsistent with other variables in parcel</td>
</tr>
<tr>
<td>Growth - height</td>
<td>IHP</td>
<td>Possible data entry error; low response rate on one or more base variable(s); theoretically inconsistent with other variables in parcel</td>
</tr>
<tr>
<td>Hospitalizations</td>
<td>IHP</td>
<td>Low response rate on one or more base variable(s); theoretically inconsistent with other variables in parcel</td>
</tr>
<tr>
<td>Doctor visits</td>
<td>IHP</td>
<td>Theoretically inconsistent with other variables in parcel</td>
</tr>
<tr>
<td>Accidental injuries</td>
<td>CHS</td>
<td>Too few injuries reported</td>
</tr>
<tr>
<td>Growth - weight</td>
<td>CHS</td>
<td>Low response rate on one or more base variable(s)</td>
</tr>
<tr>
<td>Growth - height</td>
<td>CHS</td>
<td>Low response rate on one or more of base variable(s)</td>
</tr>
<tr>
<td>Attention span</td>
<td>CHS</td>
<td>Low correlation with other indicators in functional health status parcel</td>
</tr>
</tbody>
</table>

**Note.** MC=maternal characteristics, PHP=prenatal health practices, BO=birth outcomes, IHP=infant health practices, and CHS=child health status.
Lomax, 1996) was followed whereby the measurement model was assessed separately from the structural model.

The measurement model, using LISREL notation, is characterized by

\[ x = \Lambda \xi + \delta \]

where \( x \) represents the observed variables, \( \Lambda \), the path between the latent factors and the observed variables, \( \xi \), the latent factors, and \( \delta \), the error variances. The measurement model was estimated without restrictions on the factor covariance matrices, according to recommended procedure (Jöreskog & Sörbom, 1996c).

The full structural model, depicted in Figure 3.3, is expressed by the following equation:

\[ \eta = B\eta + \Gamma \xi + \zeta \]

where \( \eta \) represents the endogenous factors, \( B \) is the influence of the endogenous factors upon each other, \( \Gamma \) represents the paths between exogenous and endogenous factors, \( \xi \) represents the exogenous factors, and \( \zeta \) indicates factor error (Anderson & Gerbing, 1988; Jöreskog & Sörbom, 1996c).

Identification of a model is a matter of determining whether enough information exists in the model matrix to calculate a unique vector of its parameters. Although model identification is difficult to ascertain with total confidence, variances of the latent factors were standardized towards that end (Jöreskog & Sörbom, 1996b). Additionally, to satisfy the necessary although not sufficient, 'order condition' of identification,

\[ t \leq 1/2 (p + q)(p + q + 1) \]

must be verified, where \( t \) equals the total number of free parameters in the model and \( 1/2 (p + q)(p + q + 1) \) equals the number of equations where \( p \) and \( q \) equal the numbers of \( x \) and \( y \) variables. For the hypothesized model in this study, \( t \) equaled 32 and the other term equaled 78, thus the condition was satisfied. LISREL also checks identification by assessing positive definiteness of the model matrix determined by a procedure that produces a converged solution of estimates following a preset number of minimizing iterations.

Modification, or respecification, followed detailed recommendations by Jöreskog & Sörbom (1996b, pp. 128-129). If fit indices were below recommendations for good fit, the modification indices were examined for changes that were consistent with theory. A quantile plot, or Q-Q plot, displays ordered standardized residuals plotted against their normalized deviates at corresponding percentage points along a 45-degree diagonal line. Extreme departures from this pattern require respecification. These plots were assessed for alignment with the diagonal. Parameters with the largest modification indices were freed or restricted, capitalizing on the most substantial chi-square improvement possible, and then re-estimated. All modifications were made within the strict confines of theoretical reason.

Several authors discuss the bind that SEM investigators are in between the requirement for large samples and the penalty of misinterpretation of model fit as a result of overly sensitive chi-square significance with large
samples. The chi-square statistic is sensitive to sample size where samples roughly above 200 tend to distort accurate interpretation by indicating a significant probability level even for very minute differences, thereby leading to inappropriate model rejection (Hayduk, 1987; Tanaka, 1987; Pedhazur & Schmelkin, 1991). To test the null chi-square hypothesis (i.e., that the observed model did not differ significantly from the theoretical one), significant changes in chi-square values with the test of constrained models nested within the original one were used as a criterion instead (Jöreskog & Sörbom, 1996c). Stand-alone, incremental, and parsimony indices were also used to determine goodness of fit, as described in Chapter 3. The above approach was followed for the structural model test until a meaningful and interpretable solution with the best fit was reached.

The aim of testing the measurement model without the structural parameters was not only to determine the psychometric properties of the operationalized latent factors, but also to determine that a converged and proper solution could be reached (Anderson & Gerbing, 1988). Attempts to run the measurement portion of the theoretical model, as originally proposed, did not yield an admissible solution. In the context of matrix algebra, a ‘converged’ solution is one where the matrices have full column ranks, no rows of only zeroes, and are positive definite where all possible weighted sums in a covariance matrix have a variance greater than zero (Jöreskog & Sörbom, 1996c; Wothke, 1993). A ‘proper’ solution is obtained when all error variances are positive (Dillon, Kumar, & Mulani, 1987).

Rindskopf (1984) describes inadmissible solutions as a common problem that frequently produces estimates that include at least one non-positive error variance, or what is known as a Heywood case. A point emphatically articulated by Rindskopf is that the weak indicator is nearly impossible to detect because the negative variance is rarely produced by it. The detection process is somewhat analogous to squeezing a balloon full of water. No matter where one squeezes, the balloon always expands somewhere else.

Among the many conditions that have the potential to yield an inadmissible solution, the likely reason in this investigation was one of, what Rindskopf calls, “overfactoring” or the inclusion of unnecessary factors (p.115). He describes this as occurring when a factor has none or only one large loading among its indicators. Of the five indicators originally included in PHP, factor loadings were -0.230, -0.031, 0.008, 0.012, and 0.028. Of the four indicators included in IHP, factor loadings were 0.110, 0.014, 0.030, and 0.240. Theoretical misspecification was not as likely the cause of the low values as was non-normality and the use of ordinal variables. While the ADF mode of estimation should have been robust to these violations, the low intercorrelations within each factor proved to be too problematic. Cohen, Cohen, Teresi, Marchi, and Velez (1990) offer an interesting explanation for this circumstance. In discussing measurement problems encountered in modeling with latent variables, they describe two types of latent constructs (also described in Pedhazur & Schmelkin, 1991 and Hayduk, 1987). The first is the classic case in SEM where an underlying latent entity is thought to ‘cause’
the shared variance in a group of observed variables, called "empirical stand-
ins" (p.184). The second case works in the opposite fashion where the
observed variables are thought to produce a common latent variable that
emerges from them. In this scenario, the observed variables do not
necessarily intercorrelate as, for example, may be the case with components of
the gross national product or with specific illnesses that contribute to general
health status. This offers a plausible explanation for the disappointing
intercorrelations and factor loadings that were obtained for PHP and IHP
when all the proposed indicators were used.

Parels

The solution to overfactoring offered by Rindskopf is to eliminate the
offending factor or, if it correlates highly with another factor, to combine
them. As this was not possible within the theoretical constraints of this
study's model, an alternate solution was sought. A practice in factor analysis,
attributed to Cattell as early as 1956, is parceling (Kishton & Widaman, 1994).
A parcel is a simple unweighted summation or average of several measured
variables which are conceptually similar (Catanzaro, 1997; Gregorich, 1997;
Russell, 1997). The known benefits of parceling are (a) greater reliability of
parcel scores, (b) less influence of idiosyncracies of individual items, (c) fewer
problems from normality violations of individual items (Marsh, Antill, &
Cunningham, 1989) especially with polychoric correlations when the
bivariate normality test is failed (Gregorich, 1997), (d) improved factor
intercorrelations (Rigdon, 1997), and (e) an improvement in fit of the overall
model (Russell, 1997). However, this seemingly made-to-order solution is
nevertheless, a much debated practice (Hayduk, 1987). The loudest objection
comes when one ignores the basics of item-level analysis that establishes
adequacy of the psychometric properties (Mulaik, 1997; Schaffer, 1997;
Gregorich, 1997). In light of the hypothetical existence of the two types of
latent constructs (Cohen et al., 1990; Hayduk, 1987; Pedhazur & Schmelkin,
1991), establishing sound measurement properties for a factor may be
inappropriate, and futile, in the second case. For this reason, as well as the
named benefits, parceling was found to be a reasonable alternative towards
obtaining a converged and proper solution.

Error Variances

In spite of obtaining an admissable solution with the parcelled factors,
one Heywood case still emerged, for apg5. Dillon, Kumar, and Mulani (1987)
tested three different strategies that are frequently used in coping with
Heywood cases and found that simply setting the error variance to zero when
it is due to sampling fluctuations (e.g., when the model provides a reasonable
fit, the confidence interval around the offending estimate covers zero, and
the magnitude of its standard error is roughly equivalent to the others as in
this case), and not misspecification or underidentification, produced favorable
results in simulations. However, other authors suggest fixing the variance to
some arbitrary small number because, realistically, measurement is not likely
to be perfect (Anderson & Gerbing, 1988). Jöreskog & Sörbom (1989)
recommend fixing the value to .15 times the indicator's variance, which was
done. The error variance for \textit{apg5} was set to .15, after adjusting for variance, to be consistent with an arbitrarily chosen 85 percent level of reliability.

Parcelling all the indicators in each of two factors resulted in single indicators for those factors, which is not a preferrable practice (Schumacker & Lomax, 1996; Anderson & Gerbing, 1988). Where the use of single-indicator constructs is unavoidable, as in this case, error variance cannot be estimated and should be set to an appropriate value (Schumacker & Lomax, 1996; Jöreskog & Sörbom, 1989). Therefore, the error variances for both PHP and IHP were also fixed to .15.

**SPSS Command Files: Definition of the Study Sample**

The following files include only variables that were used in the final model test, therefore the 1991 Provider Survey is not represented here although it is also linked by mother's 1988 identification number (NCHS, 1991; NCHS, 1993a; NCHS, 1993b). The data files that were accessed for the study sample were public use data tapes from NCHS.

```spss
TITLE \textquote{\textit{nmihs8a}}
DATA LIST file='\textquote{dtkbo:icpsr.maternel\_infant\_health\_1988\}partone.' /
/ID 2-9 pnbcg 29-29 pgezer 1213-1214 pgalcob 1241-1243 pgsrnsk 1258-1260 bmult
/prebwt delwgt race hisp hhinc blive nowlive bdfur wcc1m wcc2m wcc3m
/wcc4m wcc5m wcc6m vac1dt vac2dt vac2pol vac3pol vac3dt
matage bwgm gestat mateduc wednow apg5 pnvis
SELECT IF (blive=1 and nowlive=01)
save outfile=nmihs8a.sys
finish

TITLE \textquote{\textit{nmihs8b}}
data list file='\textquote{dtkbo:icpsr.maternel\_infant\_health\_1988\}parttwo.' /
/ID 2-9 pnbcg 29-29 pgezer 1213-1214 pgalcob 1241-1243 pgsrnsk 1258-1260 bmult
/prebwt delwgt race hisp hhinc blive nowlive bdfur wcc1m wcc2m wcc3m
/wcc4m wcc5m wcc6m vac1dt vac2dt vac2pol vac3pol vac3dt
matage bwgm gestat mateduc wednow apg5 pnvis
SELECT IF (blive=1 and nowlive=01)
save outfile=nmihs8b.sys
finish

TITLE \textquote{\textit{combines 88 a & b}}
ADD FILES FILE=nmihs8a.sys/F=\textquote{nmihs8b.sys}
sort cases by id
save outfile=nmihs8.sys
finish

TITLE \textquote{\textit{nmihs9}}
data list file='\textquote{dtkbo:icpsr.infant\_maternal\_health\}nodot_da6401.1b'
/id 7-14 yselive 22 ddst 60-61 ddst2 63 ddst3 64 play 67
/happy 69 fear 70 getalong 71 tantr 72 lohmat 76
compute newddst=(ddst + ddst2/10 + ddst3/100)
sort cases by id
save outfile=nmihs9.sys
finish

```

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title 'merges 88 and 91'
get file=nmihs8.sys
get file=nmihs9.sys
match file=file=nmihs8.sys/file=nmihs9.sys/by=id/map
select if (bmult=2 and yeslive=1)
save outfile=merge.sys
finish

**LISREL Command Files: The Model Test**

The first command file was used to screen the data and prepare the asymptotic covariance matrix using PRELIS. The files following used SIMPLIS command language in LISREL to test the model (a) using the full sample, (b) a subsample using only black respondents, and (c) a subsample using only white respondents.

prelis screen
da ni=12 mi=-999 tr=li
la
matage mateduc hhinc wednow gestat bwgm apg5 loh ddst fhs pnhlth infrac
ra=dat.dat
co matage mateduc hhinc bwgm gestat ddst
or wednow apg5 loh pnhlth infrac fhs
ou ma=pm sm=corr.mat sa=acov.mat

**full sample**

observed variables: matage mateduc hhinc wednow gestat bwgm apg5 loh ddst fhs pnhlth infrac
correlation matrix from file=corr.mat
asymptotic covariance matrix from file=acov.mat
sample size: 4940
latent variables: mc php bo ihp chs
relationships:
    matage mateduc hhinc wednow=mc
    pnhlth=php
gestat bwgm apg5=bo
    infrac=ihp
ddst fhs loh=chs

    chs=ihp bo
    ihp=bo mc
    bo=php mc
    php=mc

set the error variance of pnhlth to .15
set the error variance of infrac to .15
set the error variance of apg5 to .15
let the errors of mateduc and wednow correlate
let the errors of mateduc and hhinc correlate
let the errors of php and ihp correlate
options: rs mi ss ef se me=wls ad=off it=100
end of problem
white model
observed variables: matage mateduc hhinc wednow gestat bwgm apg5 loh ddst fhs pnhlth
infrac

correlation matrix from file=wcorr.mat
asymptotic covariance matrix from file=wacov.mat
sample size: 2179
latent variables: mc php bo ihp chs
relationships:
    matage mateduc hhinc wednow=mc
    pnhlth=php
    gestat bwgm apg5=bo
    infrac=ihp
    ddst fhs loh=chs

    chs=ihp bo
    ihp=bo mc
    bo=php mc
    php=mc

set the error variance of pnhlth to .15
set the error variance of infrac to .15
set the error variance of apg5 to .15
let the errors of mateduc and infrac correlate
let the errors of matage and ddst correlate
let the errors of wednow and ddst correlate
let the errors of mateduc and pnhlth correlate
options: rs mi ss ef se me=wls ad=off it=100
end of problem

black model
observed variables: matage mateduc hhinc wednow gestat bwgm apg5 loh ddst fhs pnhlth
infrac

correlation matrix from file=bcorr.mat
asymptotic covariance matrix from file=bacov.mat
sample size: 2431
latent variables: mc php bo ihp chs
relationships:
    matage mateduc hhinc wednow=mc
    pnhlth=php
    gestat bwgm apg5=bo
    infrac=ihp
    ddst fhs loh=chs

    chs=ihp bo
    ihp=bo mc
    bo=php mc
    php=mc

set the error variance of pnhlth to .15
set the error variance of infrac to .15
let the errors of mateduc and wednow correlate
let the errors of matage and pnhlth correlate
options: rs mi ss ef se me=wls ad=off it=100
end of problem
Candice Cook Bowman was born on October 5, in [redacted]. She holds bachelor's degrees from San Diego State University (1972) and Creighton University (1979) and a master's degree from the University of Colorado Health Sciences Center (1982). She has been a registered nurse since 1979. The first 8 years of her nursing career were spent in neonatal intensive care units in Colorado and Australia, both on staff and as a clinical specialist. From 1987 to 1993, she lectured in the School of Nursing at the University of Canberra, Canberra, Australia as a tenured faculty member. She has been a research assistant and adjunct faculty member during her full-time study at George Mason University.
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