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ABSTRACT

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Empirical evidence has consistently documented the direct relationship between infant mortality and socioeconomic inequality in the United States and numerous other countries. While the majority of these studies reveal an inverse relationship between socioeconomic level and infant mortality not even this finding is free from disagreement. Furthermore, the specific nature and magnitude of this relationship has varied over time.

This study will examine the relationship between socioeconomic status and infant mortality in metropolitan Ohio by using birth and infant death data centered on the 2000 Census. The analyses presented herein will describe and analyze the relationship between infant mortality and socioeconomic status in metropolitan Ohio in the year 2000. The key finding is that in spite of remarkable declines in infant mortality during the past several decades, most notably in neonatal mortality, there continues to be a pronounced inverse association between the infant death rate and the economic status of a population.

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INTRODUCTION

Despite remarkable progress in reducing infant mortality during the 20th century, all available evidence indicates that the fruits of this progress have not been shared equally by every segment of the population. Rather, an extensive literature review up to 1990 revealed that the lowest socioeconomic groups in all societies were characterized by an extremely pronounced disadvantage when it came to the probability that a newborn infant would survive its first year of life (Stockwell and Goza, 1994: 10-27). More recent studies document the continued existence of a marked inverse association between infant mortality and various indicators of socioeconomic status, not only in the United States (Pappas et al., 1993; Gortmaker and Wise, 1997; Mansfield et al., 1999; Sohler et al., 2003), but also in many other countries (Quine and Quine, 1993; Lynch et al., 1994; Bennett, 1999; Stainstreet et al., 1999; Villaneuva and Garcia, 2000; Szwarcwald et al., 2002).

It has long been recognized that income is an important risk factor contributing to infant mortality (Cramer, 1995) and health in general (Williams and Collins, 1995). Simply put, poverty places a population at risk of many factors related to worsening health and increased infant mortality. These include, but are not limited to, the environmental, social and behavioral correlates of poverty (Hogue and Hargraves, 1993), as well as the economic and psychosocial factors related to place of residence (Polednak, 1996); a factor also determined by income. Many of the conditions that prevailed in the early years of the twentieth century when the inverse relationship between infant mortality and socioeconomic was first measured (Woodbury, 1925; Altenderfer, 1949) have changed. Some of the changes have benefited all (e.g., advances in public health sanitation, medical care technology and the general overall level of living of the American population); while others have not (e.g., the increased crowding of economically deprived racial and ethnic minorities in urban ghettos and the widening economic gap between such urban concentrations and the more affluent surrounding suburbs). Similarly, fluctuations in the amount of attention and financial resources directed at reducing socioeconomic health differentials are also capable of exerting an influence on the nature and magnitude of the relationship between economic status and infant mortality. Furthermore, research has shown that the nature and strength of this relationship can vary over time (Antonovsky and Bernstein, 1977; Stockwell et al., 1988), and place (Rodwin and Neuberg, 2005). Hence there is an obvious need to examine recent data to monitor any transitions that may be taking place in this fundamental relationship.

Reflecting this need, a long-standing research program within the Department of Sociology at Bowling Green State University has focused on examining mortality differentials in the metropolitan centers of the state of Ohio. To date this research has focused on the relationship between socioeconomic status, more specifically family income status, and levels of mortality during the first year of life. Thus far this relationship has been examined at four points in time centered on the decennial censuses of 1960, 1970, 1980 and 1990 (Adamchak and Stockwell, 1979; Stockwell et al., 1987a; Stockwell and Goza, 1996a). Those studies consistently revealed the presence of a strong and persistent inverse relationship between infant mortality and family economic status in metropolitan Ohio. This relationship became blurred and less pronounced in 1970, but by 1980 and again in 1990 there was a pronounced and consistent inverse association between these two variables. The one major exception to this general conclusion is that from 1960 to 1990 nonwhites never experienced this inverse relationship. As such, nonwhites who resided in high-income areas were unable to transform their socioeconomic position into good health in the same way as whites (Williams, 1996; 1997).

This study will update previous analyses by examining data centered on the 2000 census to present a description and analysis of the relationship between socioeconomic status and infant mortality for the total population, and for separate age, sex, race and cause of death groups. Because the nature and magnitude of the relationship between infant mortality and socioeconomic status reflects a variety of societal conditions, not the least of which is changing social policy, we will attempt to answer two key questions. First, how pronounced are differentials across income areas in 2000? Because of the recent de-emphasis of basic social programs directed at the poor (Hummer et al., 1999), other recent policy shifts that have benefited the wealthy more than the impoverished (Williams and Collins, 1995), and because the first to benefit from medical advances are usually those in the highest income areas (Stockwell et al., 1988), we hypothesize that a pronounced infant mortality differential will remain across income areas. Secondly, we will also monitor the relationship between income area and infant mortality for nonwhites to determine if the prior, almost random pattern continues. We expect that the independent influence of race on infant mortality levels will continue as few significant health improvements occurred to nonwhites during the 1990s.

DATA AND METHODS

This research is based on three distinct data sources. The first consists of the 1999-2001 death records for the state of Ohio. These vital statistics are completed at the local level and coverage is universal as state law requires death certificates for the disposition of all bodies and because these certificates are sometimes needed for legal purposes. Although the quality of mortality data from the national vital statistics system has been called into question (e.g., Glasser,

1981), this data is the best available for the study of infant mortality in the state of Ohio. The second data source consists all birth records for the year 2000 and the third is the census tract summary tape file (STF) 3A for Ohio.

In order to analyze these data we first aggregated all birth records for the six cities by sex and race within their respective census tracts. Next, death records for the three years 1999-2001 were likewise aggregated. Following the aggregation of individual records to the level of the census tract, 2000 census tract data were merged with these records and the basis demographic information needed to compute independent variables was extracted. These raw data were then used to calculate the independent and dependent measures described in the following sections for each census tract in each of the six cities, and for the broader groupings of tracts having similar income characteristics.

These research procedures are used in this update as they were also utilized in the initial study of 1960 and 1970 census data (Stockwell and Wicks, 1981). More specifically, the basic relationship between the major components of infant mortality and socioeconomic status is examined within an ecological framework in which the primary analytical unit is the census tract of mother's usual residence. The **independent variable**, which was selected based on a factor analysis of a variety of socioeconomic indicators, is defined as the *percentage of low-income families in each census tract at the time of the decennial census*. For the 2000 data, the low-income cut-off point, defined as roughly 50 percent of the median family income in metropolitan Ohio, was $25,000. The **dependent variable** data consist of counts of the number of live births in each census tract during the census year, and counts of the number of infant deaths occurring during the three years centering on the 2000 census date, thus providing the data needed to calculate conventional three-year average infant mortality rates. For the present analysis we were able to extract these data for six metropolitan areas: Akron, Cincinnati, Cleveland, Columbus, Dayton and Youngstown.

Despite the fact that our data were compiled from individual census tracts, it was not feasible to carry out our analysis on the basis of such units. This was because of frequent problems of rate instability at the individual tract level due primarily to an absence of any infant deaths, even over a three-year period, yielding an infant mortality rate of zero. This is a problem that became especially serious when we sought to examine more specific patterns of mortality based on age, race and/or cause of death. Accordingly, in order to increase the reliability of the dependent variable, it was necessary to base the analysis on broader combinations of tracts. To do this all census tracts in the six metropolitan areas were first ranked in terms of the percentage of families with an annual income of less than $25,000. Next, each tract was assigned an income area score from “1” (High SES) to “5” (Low SES) in such a manner that approximately 20

percent of the tracts were allocated to each of the five income areas. Census tracts then were combined to form income areas and the various infant mortality rates were calculated for the five income areas. Because our earlier studies utilized the same methodology, this procedure also permits maximum comparability. The percent ranges and the number of tracts in each area can be found in **Table 1**.

(Insert Table 1 about here)

RESULTS

Table 2 contains the 1999-2001 infant mortality rates in the five income areas of the Ohio metropolitan aggregate. These rates, which express the average number of deaths under one year of age in a year per 1,000 live births, are presented as the total infant mortality (deaths before 365 days) rate and for the conventional neonatal (deaths under 28 days) and postneonatal (deaths at ages 1 to 11 months) components of infant mortality. Inspection of these rates first reveals that the neonatal mortality rate is over twice as high as the postneonatal one. This result is consistent for all income areas. Second, these rates clearly document that there is an obvious and extremely pronounced inverse association between infant mortality and family economic status in metropolitan Ohio. The basic infant mortality rate increased steadily and consistently from the highest to the lowest income area, such that the Area V rate is nearly three times as high as that of Area I (i.e., the ratio of the infant mortality rate in Area V to that in Area I was 2.8). Furthermore, it is readily apparent that this economic differential is quite marked for both neonatal and postneonatal components of infant mortality. However, the Area V/Area I ratio is much stronger for the postneonatal period (i.e., 4.6) where the environmentally-related exogenous causes of death (defined below) continue to play an important role, especially for the lowest income areas.

How does the socioeconomic gradient affect infant mortality levels? To monitor growing interest in the stepwise progression of risk (e.g., Williams and Collins, 1995) and to document the effects of the single-level improvements that families might realistically experience, this and the other tables that follow will present mortality ratios to indicate how much could be gained or lost by moving to the next income level. Not surprisingly, moving up the income area ladder always resulted in fewer infant deaths. However, the largest reduction in total, neonatal, and postneonatal mortality occurred when moving from income area IV to III. Even so, the reduction in postneonatal mortality when moving from income area II to I was just as pronounced.

(Insert Table 2 about here)

Table 3 reveals that both males and females exhibited the same general patterns just described for the total population. Not unexpectedly, male death rates are everywhere higher than corresponding female rates, and consequently, male total and neonatal differentials are slightly more pronounced. The only noteworthy sex difference was that male postneonatal rates are typically much higher than among females, as was the male Area V/Area I ratio (i.e., 4.9 vs. 4.1). The cause for this is not entirely clear, but it clearly warrants additional investigation.

As witnessed in **Table 2**, the largest reductions in total, neonatal, and postneonatal mortality generally occurred when moving from income area IV to III. Among males, the highest reduction in postneonatal mortality occurred when moving from income area II to I, while for females this occurred when moving from income area III to II.

(Insert Table 3 about here)

Table 4 contrasts infant mortality among white and nonwhite population segments. In 1960, the initial starting point for this research, almost all nonwhites in Ohio were Black (99%). From 1990 to 2000, the Black share of Ohio's nonwhite population decreased from 87% to 76%. Although in 2000 there were sizeable Hispanic (13%) and Asian (8%) populations, the vast majority of nonwhites were still Black (76%). For this reason and for purposes of comparison and consistency, we will continue to maintain the categories used in prior analyses.

Table 4 indicates that in 2000 the general inverse relationship was characteristic of both white and nonwhite subgroups, but that it was somewhat more pronounced for the former. Although the patterns for the white population reveal several minor reversals that negate a consistent inverse gradient, it is clear that the strength of the relationship, as measured by the ratios of mortality rates in Area V to those in Area I, is greater for whites. **Table 4** also indicates that on average nonwhite infant mortality levels were twice those of whites, a finding in keeping with past state and national results.

Perhaps the most significant point to make with respect to nonwhite mortality rates pertains to the existence of a clear and consistent inverse association between the infant mortality rates -- total, neonatal, and postneonatal – and area income status. This is noteworthy because it is the first time since 1960 that an inverse socioeconomic differential has characterized the nonwhite population. As recently as 1990 there was very little difference in nonwhite infant mortality rates from one income area to another. Furthermore, from 1980 to 1990 the infant mortality rate of the highest non-white income area increased from 14.2 to 17.8, a result that lead to significant blurring of the relationship between infant mortality and family economic status (Stockwell et al., 2005). At that time the absence of an inverse relationship with income status for nonwhites, a result also observed in other studies (Carlson, 1984; Schoendorf et al., 1992; Hummer, 1993),

was taken as an indication that race had an independent effect on infant mortality levels (Stockwell and Goza, 1996b). However, as observed in **Table 4**, a significant reversal occurred during the 1990s such that by 2000 non-whites in the highest income area experienced a significant reduction in their infant mortality rate, as it declined from 17.8 to 8.5. Consequently, for the first time since at least 1960 there was a clear and pronounced nonwhite inverse relationship between non-white economic status and infant mortality.

Table 4 also reveals the strong influence of economic status on infant mortality levels for both whites and nonwhites. These results suggest that socioeconomic resources are beginning to benefit whites and nonwhites in similar ways, something that did not occur in the past. They also suggest that unlike earlier decades, when nonwhites and whites differed in their ability to transform socioeconomic resources into good health (Stockwell and Goza, 1994; Williams, 1996; 1997), societal conditions are now such that this may no longer be the case (Hayward et al., 2000).

Another possible explanation for the emergent inverse socioeconomic differential among the nonwhite population is that the growing non-Black component among nonwhites may have helped smooth out this inverse relationship. However, as recently as 1990 the Hispanic and Asian nonwhite percentages were 10 and 7 percent, respectively, versus 13 and 8 percent in 2000. Because these numbers are not extremely different than in 1990 when an inverse relationship did not exist, we suggest that although a possible explanation, a more likely one is that nonwhites residing in high-income areas are finally able to tap into some of the health benefits associated with residence in such areas.

As earlier witnessed in **Tables 2** and **3**, the largest reductions in total, neonatal, and postneonatal mortality most often occurred when moving from income area IV to III, however, there were important exceptions. Among whites the largest reduction in neonatal mortality occurred when moving from income area V to IV, while for postneonatal mortality a move from area II to I resulted in a reduction of the same size that occurred when moving from income area IV to III. Among nonwhites, the highest reduction in total and neonatal mortality occurred when moving from income area II to I, an additional indication that high status nonwhites are now systematically receiving health benefits associated with their place of residence.

(Insert Table 4 about here)

Table 5 presents infant mortality rates that have been calculated separately for two broad cause of death categories -- **endogenous causes**, or those most directly associated with the physiological processes of gestation and birth (e.g., congenital anomalies, low birth weight), and **exogenous causes**, or those whose origin is located in the external environment (e.g., pneumonia,

infectious and parasitic diseases, accidents). This latter category also includes Sudden Infant Death Syndrome (SIDS). Although we do not yet have a fully adequate understanding of the causes of this condition, research suggests that it is more appropriate to classify it as an exogenous cause of death (Nam et al., 1989).

(Insert Table 5 about here)

Table 5 suggests that the inverse association between infant mortality and economic status is characteristic of both broad cause groups; however, it is notably stronger for the exogenous death rate. This is not unexpected, given the close association between exogenous causes and the living conditions of the external environment. Furthermore, it is very likely related to the previously noted differences with respect to neonatal and postneonatal mortality. That is, when contrasting **Table 5** data with those of **Table 2** it can be seen that the neonatal death rates closely resemble the endogenous cause rates, whereas the postneonatal death rates are generally similar to the exogenous cause rates. Thus, despite growing evidence of a weakening of the traditional age/cause proxy relationship (Frisbie et al., 1992; Kirby, 1993; Poston and Rogers, 1985; Stockwell et al., 1987b), our results suggest that there continues to be a close fit between age and cause of death in infancy. The last column of **Table 5** presents the ratio of endogenous to exogenous deaths for each income area. Results indicate that this ratio is the highest for income area I (i.e., 2.3), systematically decreasing to 1.3 for area V. These results serve to reinforce the importance of quality of life factors, especially those related to the external environment, in predicting who will survive their first year. Because infants in the lowest income area were over four times as likely to die of exogenous causes, the relative contribution of this broad cause group was much greater. As earlier witnessed in **Tables 2**, **3** and **4**, the largest reductions in endogenous and exogenous mortality occurred when moving from income area IV to III.

CONCLUSION

Perhaps the most important conclusion to be drawn from this research is that there continues to be a pronounced inverse association between the infant death rate and the economic status of a population. Recent overall declines in infant mortality clearly reflect the success of continuing efforts to enhance the quality of perinatal care as well as general improvements in the overall level of living of the American population. It is equally clear, however, that the major progress that has been made in both improving the nature and delivery of maternal and child health care and raising the overall level of living has not resulted in an elimination of the long-standing mortality gap between the higher and lower income groups in our society.

The explanation of this marked economic differential, and especially explaining our failure to achieve greater equality in levels of infant mortality, continues to be a challenge for social scientists as well as health professionals (Eberstein et al., 1990; Eberstein, 1989). As we noted a decade ago (Stockwell et al., 1994), part of the problem here is that there are two main components to the explanation, one medical and one social: both have an underlying economic cause, and it is difficult, to say the least, to try and disentangle the relative influences of each. On the one hand, persons in lower income groups still do not have access to the same quality of health care that is available to the more affluent members of our society. How much of this is due to a lack of adequate health care facilities and services for members of lower economic groups? How much is due to a failure to take full advantage of those maternal and child health care services that are available? What accounts for the failure to take full advantage of existing health care facilities? These are questions for which satisfactory answers continue to elude us.

On the other hand, the general standard of living of persons in lower income groups, as well as some of their behaviors, are often detrimental to infant survival. How much of the socioeconomic differential can be attributed to an inadequate diet, for example, either because of lack of adequate financial resources or because of ignorance? How much is due to having to live under substandard housing conditions? How much is due to a greater incidence of high-risk behavior such as smoking and/or drinking during pregnancy? How much is due to variations in educational attainment? Age at childbearing? Marital status? Again, these are questions for which answers are not readily available

In an era when a major topic of national debate concerns the adequacy and accessibility of our health care facilities and when access to good health care is seen as a basic human right for all citizens, not just a privilege for those who can afford it, the persistence of a strong and pervasive inverse association between family economic status and the risk of dying in infancy must be considered a serious problem for the society. Finding ways to deliver the best care to all persons and alleviate this problem should be a major national priority.

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Table 1
Family income quintiles for Ohio metropolitan aggregate: 2000

Income Areas	Percent of families with annual income less than $25,000	Number of Census Tracts
I (High income)	0.0 – 10.6	171
II	10.7 – 18.5	171
III	18.6 – 31.1	172
IV	31.2 – 49.3	172
V (Low income)	49.4 & over	171
All areas	. . .	857

Source: Ohio Department of Vital Statistics 1999, 2000, and 2001.

Table 2

Infant mortality rates* and areas ratios for income areas in a metropolitan aggregate: Ohio, 1999-2001

Income Areas	Mortality Rates		
	Total	Neonatal	Post neonatal
All Areas	10.0	7.0	3.0
I (High income)	6.0	4.8	1.2
II	7.4	5.4	2.0
III	9.5	6.6	2.9
IV	14.1	9.2	4.9
V (Low income)	17.0	11.5	5.5
Ratio			
II/I	1.2	1.1	1.7
III/II	1.3	1.2	1.4
IV/III	1.5	1.4	1.7
V/IV	1.2	1.2	1.1
V/I	2.8	2.4	4.6

Source: Ohio Department of Vital Statistics 1999,2000,2001.

*Number of deaths under one year of age per 1,000 live births.

Table 3
Infant mortality rates and area ratios for income areas in a metropolitan aggregate by Sex: Ohio, 1999-2001

	Males			Female		
	Mortality Rates			Mortality Rates		
Income Areas	Total	Neonatal	Post neonatal	Total	Neonatal	Post neonatal
All Areas	11.1	7.8	3.3	8.8	6.2	2.6
I (High income)	6.5	5.2	1.3	5.5	4.4	1.1
II	8.0	5.5	2.5	6.8	5.3	1.5
III	11.0	7.9	3.1	8.1	5.4	2.7
IV	16.1	10.7	5.4	12.2	7.7	4.5
V (Low income)	19.0	12.7	6.4	14.8	10.3	4.5
Ratio						
II/I	1.2	1.1	1.9	1.2	1.2	1.4
III/II	1.4	1.4	1.2	1.2	1.0	1.8
IV/III	1.5	1.4	1.7	1.5	1.4	1.7
V/IV	1.2	1.2	1.2	1.2	1.3	1.0
Ratio: V/I	2.9	2.4	4.9	2.7	2.3	4.1

Source: Ohio Department of Vital Statistics 1999, 2000, and 2001.

Table 4
Infant mortality rates and area ratios for income areas in a metropolitan aggregate by race: Ohio,1999-2001

	Whites			Non White		
	Mortality Rates			Mortality Rates		
Income Areas	Total	Neonatal	Post neonatal	Total	Neonatal	Post neonatal
All Areas	7.1	5.1	2.0	15.6	10.8	4.8
I (High income)	5.8	4.7	1.1	8.5	6.3	2.2
II	6.5	4.7	1.8	11.9	8.9	3.0
III	6.8	4.3	2.5	14.8	11.1	3.7
IV	10.1	6.1	4.0	16.8	11.3	5.5
V (Low income)	14.4	10.9	3.5	17.9	11.7	6.2
Ratio						
II/I	1.1	1.0	1.6	1.4	1.4	1.4
III/II	1.0	.9	1.4	1.2	1.2	1.2
IV/III	1.5	1.4	1.6	1.1	1.0	1.5
V/IV	1.4	1.8	.9	1.1	1.0	1.1
Ratio: V/I	2.5	2.4	3.2	2.1	1.9	2.8

Source: Ohio Department of Vital Statistics 1999, 2000, and 2001.

Table 5
Infant mortality rates and area ratios for income areas in a metropolitan aggregate by major cause of death category: Ohio,1999-2001

Income Areas	All Causes	Endogenous causes	Exogenous causes	Ratio Endo/Exog causes
All Areas	10.0	6.3	3.7	1.7
I (High income)	6.0	4.2	1.8	2.3
II	7.4	5.0	2.4	2.1
III	9.5	6.2	3.4	1.8
IV	14.1	8.8	5.4	1.6
V (Low income)	17.0	9.5	7.5	1.3
Ratio				
II/I	1.2	1.2	1.3	.9
III/II	1.3	1.2	1.4	.9
IV/III	1.5	1.4	1.6	.9
V/IV	1.2	1.1	1.4	.8
Ratio: V/I	2.8	2.3	4.2	.5

Source: Ohio Department of Vital Statistics 1999, 2000, and 2001.