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Socioeconomic Perspectives on Infant Mortality in Alabama*

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ABSTRACT Socioeconomic and demographic variables are examined in a maximum likelihood spatial lag framework to determine conditions influencing infant survival in Alabama using county-level data. The analysis is motivated by the basic premise that economic development and unidimensional health interventions such as immunization programs are not enough to ensure constant mortality decline in low-income regions. The results suggest that differences in socioeconomic factors can explain a large portion of the variation in child mortality rates among counties and across races in Alabama. The results also concur with prior conclusions that maternal and infant health remains an important reflection of the social and economic well-being of any population and societal equity.

During the past three decades, infant and neonatal mortality rates have decreased dramatically in the U.S. with improvements in sanitation, nutrition, infant feeding and maternal and child health care (U.S. Department of Health and Human Services 2002). Particularly, the combined impact of advanced technology and the evolution of neonatology have resulted in improved neonatal outcomes (Mason et al. 2003; Currie and Gruber 1997). Disparities continue to exist, however, between black and Native American infants, who die at a rate two and a half times the rate of white babies (U.S. Bureau of the Census 2000; Hummer 1993; Waxman 1999), with most occurring in the post neonatal period. Differences also exist between

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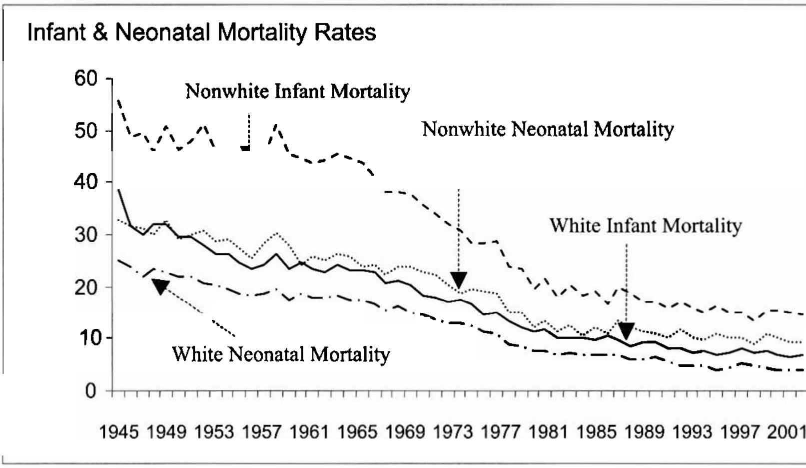
urban and rural communities, and among the various regions of the United States of America (Waxman 1999).

In Alabama, the causes of infant mortality are the traditional causes that derive from the situation of poverty on one hand, and the still insufficient sanitation system in the most depressed areas on the other hand. Infant mortality continues to be caused by illnesses related to diarrhea, acute respiratory infections, and neonatal afflictions, the principal sources that lead to the early death of the youngest Alabamians, especially in the rural counties where the average infant mortality rate (10.1 deaths per 1,000 live births) continues to be higher than the state and national rates of 9.8 and 6.9 deaths per 1,000 live births, respectively (Alabama Vital Statistics and Health Profile 2002).

Given the continued public interest and concern about infant health and economic development, this paper examines the possible contributing factors to the observed high infant mortality rates in Alabama. The research is motivated by the basic premise that economic development and unidimensional health interventions such as immunization programs are not enough to ensure constant mortality decline in low-income regions such as the Black Belt region; widespread social development is necessary to sustain a consistent mortality decline (Palloni 1985; Zerai 1996). The paper explores county-level data in an empirical framework that sheds light on the overall trend on infant and neonatal mortality rates, and the pragmatic racial gaps in these variables. The framework suggests strong links between socioeconomic characteristics, technological progress, access to healthcare and infant and neonatal mortality. Because observed socioeconomic characteristics may be correlated with unobserved health-related behaviors, the analytical framework is not intended to identify true treatment effects, but rather linking fundamental socioeconomic characteristics, such as income, education, and area of residence, to infant health outcomes.

To explore these links, the paper starts off by providing background. Next literature on infant health care is reviewed and then a panel of cross-section data for whites and nonwhites is constructed. This is followed by an outline of the econometric approach, the findings, and the conclusions and recommendations.

Figure 1: Pattern of Infant and Neonatal Mortality Rates in Alabama.



Source: The Figure is constructed by the author using data from Alabama Vital Statistics and Health Profile, 2002.

Background

There exist very pronounced gaps in infant mortality between white and nonwhite populations in Alabama (Figure 1). For instance, for every 1,000 black babies born in 2000, 9.3 babies died before they were one month old, compared to 4.2 babies that died for every 1,000 white babies born (Alabama Statistics and Health Profile 2002). Regrettably, disparities in health outcomes are high in the state as shown by the differences in access to adequate prenatal care between black and white populations. In 2002 only 64.3 percent of pregnant black women in Alabama receive adequate care compared to 84.0 percent of pregnant white women (United Health Foundation 2003).

Specifically, the high levels of late prenatal care among rural residents suggest an ongoing problem of access to basic care for rural women and their infants, and this delay in care is associated with increased levels of post neonatal mortality (Larson, Hart and Rosenblatt 1997). Previous research has shown that conditions present during pregnancy and birth can affect the mental and physical

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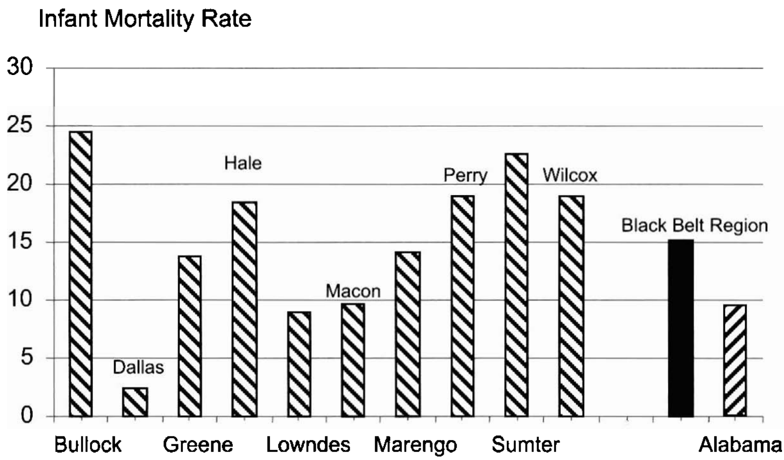
capabilities for an individual's lifetime—poor health adversely affects educational attainment, labor force participation, and earning ability (Miller, Coutler and Schorr et al. 1985; Meara 2001). When women without adequate prenatal health care give birth to unhealthy infants, a cycle of poverty and poor health is perpetuated (Miller et al. 1985; Spurlock et al. 1987; Hughes and Simpson 1995; Costa and Steckel 1997; Meara 2001; Almond, Chay and Greenstone 2001).

Another disturbing aspect is that Alabamians have a higher incidence of characteristics associated with infant mortality and morbidity (Alabama Vital Statistics and Health Profile 2002). Such characteristics include births to teens, low birth weight infants, child poverty, and multiple births, which are usually associated with smaller babies who have additional health complications at birth and early in life. Compounding the concern is the fact that in 2002 Alabama's infant mortality rate was ranked the third highest in the United States (United Health Foundation 2003). Because infant mortality is considered one of the most sensitive demographic indicators of health status and an important indicator of economic and social development (Spurlock et al. 1987), these data lead to questions about the source of the problem and how to deal with it.

A possible explanation for Alabama's high infant mortality rate is the socioeconomic structure of its population. Indeed, in most of the predominantly black and rural counties—e.g., the Black Belt counties—where poverty levels are especially high, infant mortality rates are seen to be greater than the state's rate (Figure 2). In 2002 infant mortality rate among the Black Belt counties ranged from a low of 2.5 deaths per thousand live births in Dallas County to a high of 24.4 deaths per thousand live births in Bullock County. Other counties with particularly high infant mortality rates were Sumter and Wilcox Counties with 22.6 and 19 deaths per thousand live births, respectively. The rate of 6.5 per 1,000 births in 2000 was the lowest ever attained for white infants, and the rate of 15.4 for black infants was the third lowest rate ever achieved. Thus, legislation and public policies should be scrutinized for their impact on this group of Alabamians.

Figure 2: Pattern of Infant Mortality Rates among Alabama's Black Belt Counties*—2000.



* Counties whose residents are more than 50 percent African-American (Census 2000)

Source: The Figure is constructed by the author using data from Alabama Vital Statistics and Health Profile, 2002.

Literature Review

In the literature, one of the most influential and controversial theories regarding infant mortality was posited by Thomas McKeown, an eminent British historical demographer, in his book 'The Modern Rise of Population' (McKeown 1976). Central to his text was the thesis that advances in material conditions, especially nutrition due to greater food supplies and possibly housing standards best explained (infant) mortality changes over the last three centuries, since infants with a healthy nutritional level acquired a greater resistance to disease (McKeown 1976). In other words, his theory stressed economic factors at the expense of all others. Parallel to McKeown's theory, researchers have incorporated indicators of socioeconomic development, health care systems, and public health characteristics as determinants of infant and neonatal mortality (Korenbrot et al. 1993; Andes 1989; Hughes and Simpson 1995; Paneth 1995; Miller et al. 1985; Spurlock et al. 1987). Yet the relationships of these indicators to infant mortality have not been consistent. For instance, higher average income per capita is generally related to lower infant mortality rates, but this relationship has not been consistent and tends to be less pronounced in industrialized countries (OECD 2001).

In studying the problem of child mortality in the U.S., epidemiologists have described a disturbing and as-yet unexplained phenomenon. Namely, African American babies are twice as likely as white infants to be born low birth weight, to be born pre-term, and to die at birth (CDC 2002). Statistically, only 17 percent of all births in the U.S. are to African American families, yet 33 percent of all low birth weight births and 38 percent of all very low birth weight births are to African American families (Shiono and Behrman 1995). Little is known about why African American infants are at such high risk of adverse birth outcomes. Many believe that scientists must take a fresh look at this problem and approach it from a different vantage point. This problem could be associated with the low socioeconomic status of African Americans.

Hughes and Simpson (1995) discuss how the strong association between socioeconomic status and health problems in children (for example, low birth weight, infectious diseases, asthma, failure to thrive, teen pregnancy, and child abuse) has resulted in the development of social programs aimed at reducing poverty and its devastating effects. While it is not clear how the mother's socioeconomic status translates into the birth of a low birth weight infant, it is thought that poverty with its associated reduced access to health care, poor nutrition, lower educational levels, inadequate housing, greater physical and psychological stress, and fewer life satisfactions may be responsible for some of the increased risk for low birth weight births.

Federal programs aimed at reducing the effects of poverty have been implemented in the past decade. The Special Supplemental Food Program for Women, Infants and Children (WIC) provides pregnant women with food vouchers, nutritional education, and referrals to other health and social services. The effects of the WIC program on reducing low birth weight births have been extensively evaluated, and the results are mixed (Kotelchuck et al. 1984; Buescher, Larson, Nelson 1993; Nancy and Karen 1998). Also, income supports for impoverished pregnant women became available with the start of the Aid to Families with Dependent Children (AFDC) program in 1935. The AFDC program, more commonly called welfare, is not nearly as well studied as the WIC program. There is some indication that the receipt of welfare is helpful in improving maternal weight gain during pregnancy, but there is little direct evidence to show any relationship between income supports obtained as part of welfare and reductions in low birth weight or pre-term births (Shiono and Behrman 1995; Costa and Steckel 1997; U.S. Department of Health and Human Services 1991).

Previous studies have also noted that women who are surrounded by poverty and violence and go without adequate housing, food, or employment may turn to unhealthful lifestyle choices as a means of coping (Chomitz, Cheung, and Lieberman 1995). Chomitz et al. (1995) emphasize that expecting women to simply change their behavior without support and attention from the health care system, society, and influential people in their lives is unrealistic and fosters the belief that women are solely to blame for their undesirable behaviors. They add that while women do make their own choices with regard to individual behaviors and overall lifestyles, they also face systemic, psychosocial, biological, and attitudinal barriers to lifestyle changes. They concluded that having a healthful lifestyle may not be a high priority for many women who are more concerned with day-to-day survival.

Data

The data set assembled for this exercise include (by race and county) factors traditionally known to affect infant mortality rate. These factors are defined to include: maternal age at birth, maternal education, income, low birth weight, proportion of mothers receiving inadequate prenatal care, out of wedlock births, rural-urban place of residence, advancement in medical technology, and physicians per 10,000 populations (Table 1). Starting with maternal age at birth (teen births), there is an age band in the fertility span of a woman during which reproductive risks are at a minimum. In general, children born to teen mothers are associated with high mortality risk because of the physiological immaturity combined with the social and psychological stress that comes with it. Turning to maternal education, its key role in reducing infant mortality has been well recognized (Chen, Wilkins and Cyr 1998; Din-Dzietham and Hertz-Picciotto 1998; Huddleston and Brady 2001); and a number of theoretical links have been identified.

First, education may affect infant mortality rates both indirectly, through its effect on earnings, and directly, through its effects on health-related knowledge and responsiveness to that knowledge. Therefore, even though education and income tend to be strongly correlated, both measures are included in the regressions. The risk of death is expected to be lower among children whose mothers have better than high school education.

As for income, it might be that the environmental conditions of poverty are to some degree responsible for increasing risk for the illnesses found to be more common as a cause of death among poor infants. This is mostly true for infections, because poor families are less likely to have clean water supplies, adequate sewage disposal, or knowledge of effective hygiene (Spurlock et al. 1987; Lynch et al 2000; Meara 1999). Further, the stress of living in poverty may make it difficult for parents to address the needs of their ill children as closely as might be desirable (Spurlock et al. 1987; Deaton and Paxson 1999; Fiscella and Franks 1997; Kaplan et al. 1996; Lynch et al. 2000; Meara 1999). There is also a close relationship between poverty, poor nutrition, and poor infant health. Parents with low income are unable to afford a balanced diet/required nutrition for the expectant mother and the infant, which leads to poor health for both. Thus, the risk of death is expected to be lower among children whose mothers/families have adequate income.

The increasing numbers of teen and single mothers have also been cited as possible reasons for the observed high levels of low birth weight births and late prenatal care (DuPlessis, Bell and Richards 1997). First, teen mothers are often slow in announcing their pregnancy and seeking medical care due to expectations of disapproval from their parents and society. Likewise, single mothers often delay telling others about their pregnancy and, therefore, may not get early prenatal care (Larson, Hart and Rosenblatt 1997). Thus, in agreement with previous research, the risk of infant death is expected to be high among children born to teen mothers, single mothers, and mothers receiving inadequate prenatal care.

Table 1: Summary of Variables and Expected Signs.

Variables	Description	Expected Sign: Infant Mortality White	Infant Mortality Non-White	Neonatal Mortality White	Neonatal Mortality Non-White
Teen births	Birth to teenagers as a percent of all births by county of residence and race of mother.	+	+	+	+
Inadequate prenatal care	Percent of births by mothers receiving inadequate prenatal care by county of residence and race of mother.	+	+	+	+
Low birth weight	Low birth weight infant (<1500 grams) as a percent of all births by county of residence and race of mother.	+	+	+	+
Illegitimacy	Percent of teenage births to unmarried women by county of residence and race of mother.	+	+	+	+
Income	County per capita income in dollars.	-	-	-	-
Education	County high school dropout rate.	-	-	-	-
Physicians	Number of licensed practical nurses per 10,000 populations per county.				
Rural area	Rural area: 1 if county is rural based on 2000 Census; 0 otherwise.	+	+	+	+
Technology	Technology advancement: 1 if there is a hospital in the county with neonatal intensive care unit (NICU); 0 otherwise.	-	-	-	-
Spatial effect	Squared distance inverse spatial weights matrix between counties.	+	+	+	+

Studies in diverse regions of the world have also found higher mortality rates in rural than urban areas. The general presumption is that rural-urban residence distinguishes clearly between poor and good sanitation, housing structure and availability of health resources. Not only are rural populations in Alabama disadvantaged socioeconomically, but they are historically under-served in health infrastructure and health personnel (U.S. Department of

Health and Human Services 1991; US Congress 1992). In this paper the rural-urban phenomenon is measured by a dummy variable representing the proportion of the population residing in rural areas, and the risk of infant death is expected to be higher among rural populations.

Looking at the relationship between infant mortality and advancement in medical technology, it is undeniable that the twentieth-century transformation of medicine put technology and physicians at the center of maternal and infant healthcare. As a result, the care provided in hospitals has influenced the process of birth itself and the care specific to neonates (less than one month old), which in turn has influenced post-neonatal mortality (Collins and Thomasson 2002). Beyond doubt, improvements in medical technology have clear implications for the overall level of infant mortality, and one would expect, therefore, the risk of infant death to dwindle with advancement in technology. In this paper the technology advancement phenomenon is measured by a dummy variable representing easy access to hospitals with a neonatal intensive care unit.

Lastly, a higher proportion of physicians in the population are expected to increase the general awareness of public health issues (and remedies). To the extent that physicians are attracted to areas with plentiful and state-of-the-art medical facilities (Collins and Thomasson 2002), the physician variable could reflect the supply of medical facilities (Lave and Lave 1974:2; Collins and Thomasson 2002). *Ceteris paribus*, one would expect a larger number of physicians per 10,000 population to lower the effective cost of medical care, and therefore to lower the risk of infant death.

The data on the independent variables are for the year 2000 and are compiled from different sources. Particularly, low birth weight, births to single mothers, and mothers receiving inadequate prenatal care are drawn from the Alabama Department of Public Health, Vital Statistics (2002). High school dropout rates are calculated using data from the U.S. Department of Commerce, Bureau of the Census (2000). Per capita income data are drawn from the Bureau of Economic Analysis (BEA 2002), while physician data are from the Center for Economic and Business Research (2003) at the University of Alabama. Finally, the dependent variables for the analysis are three-year averages (1999-2001) of infant and neonatal mortality rates by race. These data are also drawn from the Alabama Department of Public Health, Vital Statistics (2002).

Outliers

The small sample size also makes the analysis vulnerable to bias from outliers. To minimize the influence of outliers the following adjustment procedure were undertaken: (1) Outliers were defined and identified as those observations which deviated by more than 5 standard deviations from the mean. (2) Outlier identification and adjustment were performed only over the non-zero observations for each variable. Outliers were replaced with a mean which was calculated only over the positive observations and not all observations; by replacing an outlier with a mean calculated over *all* observations we would be implicitly assuming that the true value of the variable could have been zero, while in fact we know that it was positive. (3) Outlier adjustment was conducted on unweighted-data for two reasons. First, given that zero valued observations are excluded from the calculation of means, and it is to be expected that these will not be distributed randomly, the weights are unlikely to work as intended (i.e. the weights were designed to be used on the entire sample and not a subset of positive observations). Second, the weights *per se* do not add any more information as to whether a particular observation is an outlier or not and therefore they need not be applied at this stage.

Econometric Approach

Theoretically, this research is motivated by the basic premise that economic development and unidimensional health interventions such as immunization programs are not enough to ensure constant mortality decline in low-income areas; widespread social development is necessary to sustain a consistent mortality decline (Palloni 1985; Zerai 1996). The main analytical difficulty has been in specifying the mechanisms of multilevel models that delineate the pathways by which community and location characteristics influence individual behavior (Tienda 1991; Zerai 1996) and specifying the mechanisms through which socioeconomic and geographical dimensions affects child survival (Cleland and van Ginneken 1988; Zerai 1996). Unfortunately, this research does not solve any of those dilemmas. But it contributes to the state of knowledge on the mechanism through which geographical dimensions influence child survival by specifying and testing for spatial dependence in mortality data.

The variables postulated to have significant influences in predicting child mortality are regressed against the rates of infant and neonatal mortality. To allow the coefficients to differ between race categories the regression is estimated separately for white and nonwhites. In all, four equations of the form specified in equation 1 are estimated.

$$Y_i = X_i\beta + e_i \qquad (1)$$

where Y represent infant/neonatal mortality rates[1], i indexes county, X is a set of race-county characteristics identified in Table 1, β is a vector of coefficients to be estimated, and e is the random error term. To control for geographical dimensions (spatial dependence[2]) between observations, equation (1) is modified to a maximum likelihood spatial lag model (SAR-ML), which is employed with the assumption that the expansion and contraction of health and socioeconomic factors affecting child survival in Alabama is impervious of politically constructed geographical boarders. The spatial lag model is defined as (Anselin 1988; Land and Deane 1992):

$$Y_i = \rho W_1 Y + X_i\beta + \varepsilon_i \qquad (2)$$

In equation 2, Y_i is a random variable with a spatial autoregressive structure; ρ is the spatial autoregressive parameter; W is a predefined row standardized squared distance inverse spatial weights matrix between counties—computed using county central place latitude and longitude coordinates, based on Euclidean straight line

[1] Infant mortality rate is defined as infant deaths per 1,000 live births coded by race of mother and county of residence whereas neonatal mortality rate is defined as an infant death that occurs less than 28 days after birth coded by race of mother and county of residence.

[2] Spatial dependence exists if either the dependent variables or the error terms are correlated with each other. If the dependent variables in the analysis are spatially dependent, then spatial lag is present. If the model does not correct for the lag, regression estimates will be biased. If spatial error is present, the regression estimator will be inefficient. The presence of either spatial lag or spatial error (or both) could therefore substantially change the conclusions of the analysis (Anselin 1988).

distance (see Anselin 1998 for more detail on how spatial weights and spatial lag variables are created), and *WY* represents the spatial lag of the dependent variable *Y*. The analysis is performed in S-PLUS software package. The assumption of no spatial error dependence is tested via a Lagrange Multiplier test[3].

To allow the coefficients to differ between race categories the regressions are estimated separately for whites and nonwhites. In a non-race-specific regression, one would enter the proportion of nonwhite births to control for race differences. But this variable would be highly correlated with the percentage of other independent variables such as high school dropout. By fitting race-specific regressions, multicollinearity is reduced and the coefficients of the independent variables are allowed to vary between races. The problem of random movements or "noise" in the determination of regression coefficients are also attenuated by employing a three-year average[4] of the race-specific mortality and neonatal mortality rates for the period 1999-2001 as the dependent variables and by estimating weighted regressions, where the set of weights is the square root of the race-specific number of births in 2000 (Grossman and Jacobowitz 1981).

Results and Discussion

Table 2 reports regression results for the spatial lag infant mortality equation. Column 1 and 2 correspond to the white infant mortality equation, whereas column 3 and 4 correspond to the nonwhite equation. In general, the coefficients reported in table 1 have the expected signs: *ceteris paribus*, higher levels of income, women's education, technological advancement, physicians, and teen births tend to lower infant mortality rates, whereas inadequate prenatal

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[3] The LM test for spatial autoregressive or moving average errors is asymptotically distributed as $\chi^2(1)$, and reads as: $LM_\lambda = \frac{\left(\hat{\varepsilon}'W\hat{\varepsilon}/\hat{\sigma}^2\right)^2}{T_1}$ where T_1 is the matrix trace expression $tr(W'W + W^2)$ (Anselin and Kelejian 1997).

[4] Using a three-year average to compute mortality rates dampens the variation shown among the Black Belt counties (Figure 2) and the observation that infant deaths are relatively rare events in rural counties with small populations.

care, low birth weight, higher percentage of out of wedlock births (illegitimacy), rural residence, and spatial effect are correlated with higher infant mortality rates.

Looking at the individual variables, the estimated results on the teen births variable are contrary to what is expected. Generally, a U-shaped relationship is expected between maternal age and the risk of child birth. One would expect children born to teenage women to be associated with higher mortality risks. There is no clear explanation for the observed ambiguity on this variable, but probably the teenage data used are skewed more to the upper end of the age bracket, such that capturing the expected age effect becomes difficult. Data on individual women would allow further investigation into this possibility.

In both race equations, the positive effects of inadequate prenatal care and low birth weight births on infant mortality are statistically significant. These results are not new, because medical research has long established that the lack of adequate prenatal care among expecting mothers often leads to low birth weight births, especially among women with unhealthy lifestyles. Adequate prenatal care has been associated with improved birth weights and seems to result in both the lengthening of gestation and improved intrauterine growth (Harris 1982). As for the out of wedlock births, the coefficient is significant only in the nonwhite equation. This is not surprising given that there are more than twice unmarried mothers in the nonwhite population compared to the white population in Alabama.

Looking at the education variable, the coefficient is positive and statistically significant. This result supports prior conclusions that a mother's education influences her choices and skills in health care practices (Bailey 1988; Das Gupta 1990; Caldwell 1989). Caldwell noted for instance, that both educated and illiterate mothers recognize when their child is sick but the educated mother more frequently will take action "without waiting for (her) husband to notice the child's condition too" (Caldwell 1989:106). Caldwell added that "This is partly because illiterate women do feel a lack of capability when dealing with the modern world" (Caldwell 1989:106). In his analysis he also found that the educated mother is "more likely to report back to the health center if the treatment does not seem to be affecting a cure" (Caldwell 1989:106). This led him

Table 2: Infant Mortality Regression Coefficients.

Variables	Dep. Var. = White Mortality Rates Coefficient	Stand. Error	Dep. Var. = Nonwhite Mortality Rates Coefficient	Stand. Error
Constant	0.301*	0.147	-0.182**	0.060
Teen births	-0.026	0.170	-0.123	0.108
Inadequate prenatal care	0.734*	0.428	1.334*	0.550
Low birth weight	0.623*	0.308	0.353*	0.163
Illegitimacy	0.003	0.002	0.154*	0.078
Income	-3.498*	1.534	-2.696*	1.811
Education	-0.420*	0.187	-0.217*	0.131
Physicians	-0.013	0.013	-0.705*	0.389
Rural dummy	-0.099	0.087	0.063	0.080
Technology dummy	-0.147*	0.091	-0.207	0.147
Spatial effect	0.047	0.071	0.037	0.064
Pseudo R-square	0.439		0.417	
LM test	0.021		0.026	
(χ^2 with 1 d.f.)	(Pr = 0.057)		(Pr = 0.138)	
Sample size	67		67	
Gradient norm	7.181e-7		3.46e-4	

** p<.01, * p<.05
Pseudo R-square values are squared correlations.

to conclude that "educated women see the (health process) as experimental... (And do not feel it is an attack on the health care practitioner to give this important feedback)." As posited by Joshi (1994:24), it is through the acquisition of skills and identity that education impacts the health behavior of women.

Turning to per capita income and physician variables, the effects are statistically significant in both equations for per capita income, but significant only in the nonwhite equation for the physician variable. These results imply, for instance that increase in per capita income would reduce the risk of infant death—specifically, nonwhites' per capita income and wealth in Alabama lag behind whites' implying tighter budget constraints and less demand for all normal goods, including infant-related healthcare (ranging from maternal nutrition to physician services for infants). In other words, increases in any or all of these variables would create a mechanism through which the risk of child death could be reduced.

The analysis also included a technology dummy variable to provide a sense of how advancement in medical technology relates to the risk of infant death. For whites, there is a strong positive relationship with technology. For nonwhites, however, the observed relationship is insignificant. In general, the results concur with previous studies (Horbar and Lucey 1995) that improvements in neonatal intensive care and drug therapies to help very pre-term babies breath outside the womb may be responsible for much of the observed declines in infant deaths across the nation. However, the nonwhite results raise questions on whether the nonwhite population in Alabama has benefited from this technology.

As for the spatial effect variable, the coefficients show a positive but statistically insignificant effect. Previous studies (Land and Deane 1992; Mencken 1998) have offered an explanation of this coefficient. In relation to the current analysis, it is the association between the value of infant mortality in county *i* to values of infant mortality at other counties. Though not statistically significant, the positive coefficients imply that counties with high mortality rates are also likely to be spatially near other counties with high mortality rates. Similarly, the Lagrange Multiplier tests pertaining to the key assumption of no spatial error dependence are statistically insignificant in all equations ($P<0.05$). Under this condition the spatial lag model without spatial error adjustments is sufficient. The lack of significance for the spatial effect coefficients suggests that infant mortality patterns in Alabama may be more socioeconomically driven than spatial. The estimation of a spatial lag model, however, has allowed the study to address the potential problem of model misspecification, which might occur when investigations with geographical units of analysis are not adjusted for spatial effects (Anselin 1988).

Table 3: Neonatal Mortality Regression Coefficients.

Variables	Dep. Var. = White Neonatal Rates Coefficient	Stand. Error	Dep. Var.= Nonwhite Neonatal Rates Coefficient	Stand. Error
Constant	0.658*	0.325	2.099**	0.586
Teen births	-0.124	0.111	0.124	0.091
Inadequate Prenatal care	-1.644*	0.764	1.349*	0.701
Low birth weight	0.619*	0.349	0.181**	0.034
Illegitimacy	-0.026	0.174	0.307	0.229
Income	-2.167*	1.316	-0.508*	0.268
Education	-0.587*	0.336	-0.322*	0.189
Physicians	-0.566*	0.359	0.0169*	0.009
Rural dummy	0.062	0.052	0.058	0.043
Technology dummy	-0.124*	0.082	-0.587	0.413
Spatial effect	0.033	0.054	0.083	0.091
Pseudo R-square	0.434		0.411	
LM test	0.163		0.331	
(χ^2 with 1 d.f.)	(Pr = 0.136)		(Pr = 0.139)	
Sample size	67		67	
Gradient norm	1.186e-6		7.195e-7	

** p<.01, * p<.05

Pseudo R-square values are squared correlations.

Comparing the coefficients across racial groups (columns 1 and 3), it appears that rural residence was more detrimental for nonwhites than for whites, and that advancement in medical technological was less beneficial for nonwhites than for whites. Furthermore, the comparatively low returns (in terms of mortality) to both income and education variables for nonwhites might reflect endemic poverty and the relatively low quality of education received by nonwhites (see Margo 1986, 1990; Din-Dzeitham and Hertz-Picciotto 1998).

Turning to the neonatal equation (Table 3), column 1 and 2 correspond to the white neonatal mortality, whereas column 3 and 4 correspond to the nonwhite neonatal mortality equation. The estimated results are parallel to the infant mortality results. By and large, higher levels of income, maternal education, advancement in medical technology, and the physician per 1,000 population variables tend to lower neonatal mortality rate, whereas inadequate prenatal care, low birth weight, and rural residence are correlated with higher neonatal mortality rate.

Surprisingly, however is the ambiguity on the physician variable. Though statistically significant, the observed relationship between neonatal mortality and the physician variables in the nonwhite equation is contrary to the hypothesized negative effect. As for the teen birth variable, the coefficient has the hypothesized sign only in the nonwhite neonatal equation, but not significant ($p<.05$). In this context, the determination of statistical significance can never eliminate entirely the contention that an observed increase in neonatal mortality was due to chance; it merely suggests that a chance occurrence was highly unlikely. Confidence in statistical findings can only be enhanced through collaboration of other findings that relate logically to the hypothesis being studied. Similarly, the estimated results for the out of wedlock births (illegitimacy) and inadequate prenatal care variables are contrary to the hypothesized positive effect. The results for the spatial effect variables are also not statistically significant in both neonatal equations. Nevertheless, the observed positive effect imply that there are some disadvantages associated with being closer to other counties with high rates of neonatal mortality.

Conclusions

The findings in this paper are not new. Many other studies have reported similar findings; however, the difference in this exercise lies in the effort to control for spatial dependence. In general, the results suggest that the differences in socioeconomic factors can explain a large portion of the differences in child mortality rates among counties and across races in Alabama. Low socioeconomic status might not only constrain expenditures on healthcare, but might also influence fundamental attitudes regarding health, sickness, death, and treatment (Beardsley 1987: 33). The findings concur with prior conclusions (Beardsley 1987: 33; McCloskey and Wise 1999) that maternal and infant health remains an important reflection of the social and economic well-being of any population and societal equity.

Recommendations

Based on the results in this paper, attention should begin with education for both patients (pregnant women) and providers. The method most likely to bear short term positive results in this regard is to increase community awareness and involvement. This would require participation in patient education programs as well as optimizing use of both medical and social service resources to educate teens on the dangers of teen and out of wedlock pregnancy. Health care provider education requires community effort to identify those at risk and to integrate them into an easily accessible, quality health care system. Albeit the social and economic circumstances of patients' lives are not within the capability of physicians to solve, they are the context in which clinical outcomes occur. It is also possible that disparities in infant and neonatal mortality may not be completely eliminated until the average level of maternal health and education is equivalent amongst different populations.

Any discussion of strategies is also incomplete without acknowledging that the causes of infant morality are rooted not only in individual behaviors, but also in poverty. For Alabama, legislation and public policies should be scrutinized for their impact on the poorest Alabamians. Without a strenuous effort to decrease poverty in the state, infant mortality rate may remain among the highest in the nation. Another public policy issue, though basic, impacts not only the definition of the problem, but the scope of the solutions. Should we seek just to narrow the gap or should we seek true health equivalence for white and nonwhite infants in Alabama? If the latter is true, then additional initiatives may be necessary to accelerate Alabama's progress in reaching this goal.

Limitations

Data limitations are the most obvious drawbacks in this study. Thus, the findings may be biased due to missing variables or the manner in which some key variables are measured. For example, no information concerning the personal habits of pregnant mothers such as smoking, alcohol consumption, stress, and diet were included in the analysis, but these could affect the results significantly. Improvements in the data set could be made by having data on individual women, obtained from birth certificates. Data on individual women allow for further insight into the socioeconomic factors that are associated with infant mortality and morbidity. In addition, the data used to measure the physician variable (number of licensed practical nurses per county) might include physicians who are not relevant to preventing infant mortality. Specific data on physicians who are relevant to preventing infant mortality such as primary care physicians, Obstetrician/Gynecologists and pediatricians would allow further insight into the role of health care delivery in lowering infant mortality. More complete information could also lead to better cost and benefit estimates for policy makers to use when making judgments concerning prenatal health care delivery. Finally, the small sample size also makes the analysis vulnerable to bias from outliers, but adjustments are made to minimize the influence of outliers.

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