PREDICTORS OF INFANT MORTALITY AMONG COLLEGE-EDUCATED BLACK AND WHITE WOMEN, DAVIDSON COUNTY, TENNESSEE, 1990-1994

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Strategies to reduce US infant mortality rates often focus on the black-white disparity in rates. Linked Infant Birth and Death Files for Davidson County, Tennessee, from 1990 through 1994 were used to determine infant outcomes for infants born to college-educated white and black women. Risks for adverse outcomes were identified by comparing infant deaths to live births using logistic regression analyses. The following variables entered the logistic model process: maternal and paternal age; race and education; nativity status; maternal risk factors; interpregnancy interval; parity; infant gender; tobacco or alcohol use; number of prenatal visits; trimester in which prenatal care began; marital status; gestational age; and birthweight. After adjustment for the effects of the other variables, a gestational age <28 completed weeks of gestation was the most significant independent predictor of infant death. Black race was not identified as a significant predictor of infant mortality. Regardless of race, a decrease in infant mortality rates among college-educated women in this country depends on the prevention of preterm births. Strategies to diagnose early preterm labor must proceed from a comprehensive maternal care program for all women. Open channels of communication between patient and provider will form the cornerstone for preterm prevention-intervention programs. Analysis of state and local infant mortality data may identify regional differences in infant mortality rates and differences in risk factors associated with adverse infant outcomes. (*J Natl Med Assoc.* 1998;90:477-483.)

Key words: infant mortality ◆ college-educated mothers ◆ race

Infant mortality is a standardized indicator of a nation's health. In 1991, the infant mortality rate in the United States ranked a dismal 24th among countries or geographic areas with a population of ≥1 million.[1] Marked differences in infant mortality exist by race, which contributes to the poor US ranking.[2-4] A large proportion of the racial disparity in infant mortality rates has been shown to be due to a high rate of very low birthweight (VLBW) infants among blacks. Since 1960, rates for infant mortality and low birthweight (LBW) for blacks were twice those of whites.[5] The Surgeon General's national health objectives for the year 2000 include reducing the overall infant mortality rate to no more than 7 per

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1000 live births and reducing the infant mortality rate for blacks to no more 11 per 1000.[6]

Several studies have confirmed the influence of sociodemographic factors on reproductive outcomes.[7,8] Social determinants of infant mortality may include poverty, problems of limited access to health-care services, poor preconceptual care, racism, psychosocial stresses, and poor nutrition.[9-11] Studies of infant outcomes among college-educated women show lower infant mortality rates than rates among less educated women, but the black-white disparity in infant mortality rates actually widens among college-educated women.[12-14]

Few studies have examined the relationship of county of residence to pregnancy outcomes. The analysis of state and local infant mortality data may provide a database useful for developing and monitoring regional infant mortality prevention/intervention strategies. This study analyzed Linked Birth and Death Files for the largest county in the Nashville, Tennessee, metropolitan area to assess the factors that may uniquely contribute to infant mortality among college-educated women in this county. Regional allocation of public health funds should be guided by information gathered at the prevention level.

MATERIALS AND METHODS

Linked Infant Birth and Death Files for Davidson County, Tennessee, were used to determine outcomes for infants born to college-educated black or white women. Data on singleton births for 5 years from 1990 through 1994 were combined in this analysis. All information about the infant was drawn from the birth/death certificates. Included in the study were infants whose mothers were ≥20 years of age, completed at least 16 years of education, resided in Davidson County, Tennessee, and had a recorded race of white or black. Infants <20 weeks of gestation, of twin or multiple births, or with lethal congenital abnormalities were excluded.

Infant mortality was calculated as the number of deaths of children <1 year per 1000 live births. The neonatal mortality rate was defined as the number of deaths of children <28 days per 1000 live births. The postneonatal mortality rate was defined as the number of deaths of children between 28 days and 1 year of age.

Independent predictors of infant death were identified by using stepwise logistic regression analyses. Logistic regression was conducted using SAS software (SAS Inc, Cary, North Carolina).[15] In logistic regression analyses, records were excluded if data were missing on any variable in the specific model under consideration. Ninety-five percent confidence intervals were computed and statistical significance was assessed by two-sided *P* values.

Variables expected to influence infant mortality were identified from previous studies.[16-23] The following risk factors entered the modeling process as dichotomous variables:

- infant gender,
- maternal race,
- tobacco use during pregnancy,
- alcohol use during pregnancy,
- marital status,
- United States born,
- first delivery,
- short interpregnancy interval (for women with parity of one or greater, the interpregnancy interval was defined as length of time from the last delivery to the next conception calculated as the interval between consecutive deliveries minus the gestational age of the next child at birth[20] (<9 months or >9 months), and
- maternal risk factors for the pregnancy, ie, anemia, cardiac, lung, or renal disease; active genital herpes; hydramnios or oligohydramnios; hemoglobinopathy; hypertension (chronic or pregnancy-induced); eclampsia; previous preterm, large, or small for gestational age infant; renal disease; Rh sensitization; or uterine bleeding (any factor present or all factors absent).

To allow for a nonlinear relationship to infant outcomes, the following risk factors entered the modeling process both as continuous variables and as stratified dichotomous variables:

- maternal and paternal age, and years of education,
- trimester in which prenatal care began,
- parity,
- gestational age, and
- birthweight.

To identify interaction between continuous variables, new variables were created from product combinations of variables as appropriate. The effects, if any, of these new terms on the modeling process were determined. Noninteractive terms would have a negligible effect.[24]

Previous studies have identified the impact of birthweight and gestational age on infant mortality rates.[25-32] Many stratifications of gestational age and birthweight entered the modeling process to identify the best fitting model. Very low gestational age infants were defined as infants whose clinical estimate of gestational age was <28 weeks. Low gestational age infants were defined as infants whose gestational age was ≥28 weeks and <37 completed weeks. Normal gestational age infants were infants of gestational age ≥37 weeks. Very low birthweight infants were defined as infants weighing <1500 g at birth. Low birthweight infants were defined as weighing ≥1500 g and <2500 g. Normal birthweight infants were defined as those weighing ≥2500 g at birth.

The dataset also was categorized into nine mutually exclusive subsets according to gestational age and birthweight which entered the modeling process:

- very low gestational age and (intersect) VLBW infants,
- low gestational age and (intersect) VLBW infants,
- normal gestational age and (intersect) VLBW infants,
- very low gestational age and (intersect) LBW infants,
- low gestational age and (intersect) LBW infants,
- normal gestational age and (intersect) LBW infants,
- very low gestational age and (intersect) normal birthweight infants,
- low gestational age and (intersect) normal birthweight infants, and
- normal gestational age and (intersect) normal birthweight infants.

Poorly ascertained factors (eg, weight gain during pregnancy and drug abuse) were not included in the analyses. Other factors thought to be in the causal pathway of infant deaths (complications of labor and delivery, and abnormal conditions of the newborn) were not included in these analyses.

RESULTS

Following exclusions for lethal congenital anomalies (<2.7% of records excluded), there were 9411 single births to black or white women who completed at least 16 years of education and resided in Davidson County, Tennessee. The overall 5-year mean infant mortality rate for all of Davidson County from 1990 to 1994 was 9.25 infant deaths per 1000 live births. The overall mean 5-year infant mortality rate for college-educated mothers was 2.56 infant deaths per 1000 live births or 24 deaths per 9387 live births. In our population, the mean 5-year neonatal and postneonatal infant mortality rates were 2.13 and 0.43 per 1000, respectively. For college-educated mothers, the infant mortality rate decreased by 33% over the 5-year study period. This population of college-educated mothers accounted for 23% of the total single births for the county during the study period.

Selected characteristics of the sample by outcome of pregnancy based on Davidson County, Tennessee, Linked Birth and Death Files from 1990 to 1994 are shown in Table 1. The infant mortality rate was almost six times higher for blacks than for whites. Infant mortality rates were highest for 30- to 34-year-old mothers and lowest among 20- to 24-year-old mothers. Unmarried women had almost twice the infant mortality rate of married women. Women born outside the United States had higher infant mortality rates. Tobacco and alcohol use was negligible among women in the study group. Infant death rates were highest among first-time mothers. Ninety-seven percent of live births and 100% of infant deaths were to mothers with parity ≤3. Infant mortality rates were inversely related to parity. Virtually all mothers began prenatal care in the first trimester. Women with any of the reported medical risk factors previously described had infant mortality rates more than three times those of other mothers. Of women with previous deliveries, those with short interpregnancy intervals had infant mortality rates more than four times higher than others.

Data on paternal age, race, and years of education were available on 97%, 96.2%, and 97% of records, respectively. Mean paternal age was 32.6±5.4 years; 99.2% of men were married to women of the same race. Mean paternal years of schooling completed was 15.62±1.65. Paternal age and years of education completed were not significantly different between the two groups of live births and infant deaths.

Mean birthweight was 3422.04±542.65 g; mean birthweight for live births was 3427.83±528.79 versus 1063.39±902.60 for infant deaths. Overall 5-year mean clinical gestational age for the study group was 38.91±1.85 weeks (38.92±1.72 for live births and 26.00±4.54 for infant deaths).

Table 2 shows percent distribution of stratified infant birthweights and gestational age by infant outcome. Very low birthweight infant mortality rates were more than 1000 times those of normal birthweight infants. Very low gestational age infant mor-

Table 1. Selected Characteristics of Davidson County College-Educated Mothers, 1990-1994: Percent Distribution by Infant Outcome and Corresponding Infant Mortality Rate (IMR)*

Characteristic	% Live Births	% Infant Deaths	IMR†
Maternal race	n=9387	n=24	
White	85.0	50.0	1.50
Black	15.0	50.0	8.59
Maternal age (years)	n=9381	n=24	
20-24	6.7	4.2	1.61
25-29	35.5	33.3	2.40
30-34	39.3	45.8	2.98
≥35	18.5	16.7	2.31
Marital status	n=9381	n=24	
Married	93.0	87.5	2.40
Unmarried	7.0	12.5	4.60
United States born?	n=9383	n=24	
Yes	94.8	91.7	2.47
No	5.2	8.3	4.12
Any tobacco use?	n=9378	n=24	
Yes	3.0	0.0	0.00
No	97.0	100.0	2.64
Any alcohol use?	n=9368	n=23	
Yes	0.7	0.0	0.00
No	99.3	100.0	2.47
Parity	n=9381	n=24	
0	45.8	54.2	3.03
1	32.2	37.5	2.98
2	14.6	8.3	1.46
3	4.4	0.0	0.00
>3	3.0	0.0	0.00
Short interpregnancy interval?‡	n=4960	n=10	
Yes (<9 months)	0.2	10.0	8.33
No (≥9 months)	99.8	90.0	1.82
Trimester prenatal care began	n=9366	n=23	
First	96.8	100.0	2.54
Second	2.9	0.0	0.00
Third	0.3	0.0	0.00
Any maternal medical risks?	n=9387	n=24	
Yes	15.2	37.5	6.32
No	84.8	62.5	1.88

*Total births=9411, live births=9387, and infant deaths=24).
†Per 1000 live births.
‡Applies to 4970 mothers with at least one previous delivery.

tality rates were more than 4000 times higher than normal gestational age infants.

Adjusted odds ratios (ORs) and 95% confidence intervals (CI) for infant death for variables in the best-fitting models were calculated. Two independent predictors of infant mortality were identified, very low gestational age and low gestational age infants of birthweight <2500 g. For gestational age <28 weeks, the OR was 13,355.72 (95% CI 1649.12-108,163.08). For gestational age ≥28 and <37 weeks and birthweight <2500 g, the OR was 112.71 (95% CI 11.68-1087.57). Odds ratios were calculated by exponentiating the derived coefficient or parameter estimate. For the variable very low gestational age, the parameter estimate was 9.4997 (SE 1.0672). For the independent predictor low gestational age with birthweight <2500 g (this variable is the union of the two subsets low gestational age intersect VLBW union low gestational age intersect LBW), the parameter estimate was 4.7248 (SE 1.1566).

DISCUSSION

Infant mortality rates for both black and white women in this population were reduced from the overall rates for Davidson County. However, the disparity in rates was wider among college-educated women. In our study population, infant mortality rates for black infants were almost four times the rates for white infants. In the overall Davidson County population, infant mortality rates for blacks were about 2.6 those for whites. The Healthy People 2000 goals to decrease overall infant mortality rates to 7 per 1000 live births and to decrease infant mortality rates for blacks to <11 deaths per 1000 live births were met for women in our study population.

This article identifies very low gestational age infants and low gestational age infants of LBW as significant independent predictors of infant mortality in this population of college-educated black and white women. All very low gestational age infants were of VLBW, and the set of all low gestational age infants <2500 g also were of either VLBW or LBW. The sets of VLBW normal gestational age infants or LBW normal gestational age infants were not identified as predictors of infant death from our study. Very low birthweight and possibly also LBW when studied alone may behave as surrogates for gestational age. The extensive use of early ultrasonography in this country and the collection of clinical estimates of gestational age on linked birth/death data has aided the study of the impact of gestational age on infant mortality.

Regional epidemiologic studies of preterm delivery based on linked birth/death data may not have the statistical power to consider causes of preterm delivery. Etiologies of preterm delivery include idiopathic preterm labor, preterm and premature rupture of membranes, and maternal illness severe enough to warrant induced preterm delivery. This study did not have sufficient sample size for analysis of these group causes of preterm delivery.

Studies are needed to elucidate causes of preterm delivery and to assess the preventability of preterm delivery. The development of classifications of preterm delivery by etiology would facilitate study. There is an urgent need to develop and test interventions to prevent preterm delivery. Some proposed interventions, ie, home uterine activity monitoring, nutritional intervention, bed rest, tocolytic therapy, and surgical procedures for incompetent cervix have not been sufficiently evaluated for the clinically important endpoint of preterm delivery prevention.

Although black-white disparities in infant mortality rates exist in our study population, race was not found to be a significant independent predictor of infant mortality. This does not mean that race is unimportant, but suggests that its effect may be mediated by very low gestational or low gestational age-LBW. Most black women and white women have pregnancies that result in the birth of a full-term, normal-weight infant. In our study population, the prevention of preterm labor and delivery is much more likely to lead to direct improvement of infant mortality regardless of race. The thrust of strategies to prevent preterm delivery hinge on identifying women with symptoms of preterm labor and intervening with prophylactic measures. The importance of educating patients about symptoms of preterm labor cannot be overstressed.

Improving the health of women and children will require establishing a system of maternity care that is comprehensive, case-managed, culturally appropriate, and available to all women regardless of cost. In our population, approaches to maternal care need not be targeted by race. Race did not sufficiently identify women at risk for preterm delivery

Table 2. Infants Born to Davidson County College-Educated Mothers, 1990-1994: Distribution of Infant Birthweights and Clinical Gestational Age by Infant Mortality Rate (IMR)*

	IMR†
Birthweight	
Very low birthweight (<1500 g)	263.16
Low birthweight (1500-2499 g)	3.10
Normal birthweight (≥2500 g)	0.22
Gestational Age	
Very low gestational age (<28 weeks)‡	580.65
Low gestational age (≥28 and <37 weeks)	6.78
Normal gestational age (≥37 weeks)	0.12

*Total births=9411, live births=9387, and infant deaths=24.
†Per 1000 live births.

in this study. A community-based, cross-disciplinary approach to patient education is necessary to maximize collaboration between patients and providers. Primary care research is needed to evaluate these population-based patient education approaches to preterm delivery prevention.

There are limitations to the generalizability of this study. This study is retrospective, and the findings are preliminary in nature. Results among college-educated women in Davidson County may differ from findings among similar women in other counties statewide or nationwide. Regional differences, eg, demographic differences, differences in specialized health-care facilities (neonatal intensive care units), differences in insurance coverage of maternal care services, and patient cultural differences, may all contribute to variations in infant mortality rates. On the other hand, effective community-based interventions to decrease infant mortality would best be shaped by regional data analyses.

CONCLUSION

This study examined linked infant birth/death files for college-educated women in Davidson County, Tennessee, to determine risk factors for adverse infant outcomes. After adjustment of the effects of other variables, very low gestational age was found to be a significant independent predictor of infant death. Gestational age ≥28 weeks and <37 weeks with birthweight <2500 g also was an independent predictor of infant mortality. Further studies are needed to categorize and evaluate etiologies of preterm delivery.

Strategies to diagnose early preterm labor must proceed from a comprehensive maternal care program for all women. Open channels of communication between patient and provider will form the cornerstone for all preterm prevention-intervention programs. Primary care outcomes research should be used to determine successful interventions. Finally, analysis of state and local infant mortality data may identify regional differences in infant mortality rates and differences in risk factors associated with adverse infant outcome.

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