The Effect of Prenatal Support on Birth Outcomes in an Urban Midwestern County

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ABSTRACT

Objectives: In Dane County, Wisconsin, the black-white infant mortality gap started decreasing from 2000 and was eliminated from 2004 to 2007. Unfortunately, it has reappeared since 2008. This paper examines risk factors and levels of prenatal care to identify key contributors to the dramatic decline and recent increase in black infant mortality and extremely premature birth rates.

Methods: This retrospective cohort study analyzed approximately 100,000 Dane County birth, fetal, and infant death records from 1990 to 2007. Levels of prenatal care received were categorized as "less-than-standard," "standard routine" or "intensive." US Census data analysis identified demographic and socioeconomic changes. Infant mortality rates and extremely premature (≤ 28 weeks gestation) birth rates were main outcome measures. Contributions to improved outcomes were measured by calculating relative risk, risk difference and population attributable fraction (PAF). Mean income and food stamp use by race were analyzed as indicators of general socioeconomic changes suspected to be responsible for worsening outcomes since 2008.

Results: Risk of extremely premature delivery for black women receiving standard routine care and intensive care decreased from 1990-2000 to 2001-2007 by 77.8% (95% CI = 49.9-90.1%) and 57.3% (95% CI = 27.6-74.8%) respectively. Women receiving less-than-standard care showed no significant improvement over time. Racial gaps in mean income and food stamp use narrowed 2002-2007 and widened since 2008.

Conclusions: Prenatal support played an important role in improving black birth outcomes and eliminating the Dane County black-white infant mortality gap. Increasing socioeconomic disparities with worsening US economy since 2008 likely contributed to the gap's reappearance.

INTRODUCTION

The Dane County, Wisconsin black infant mortality rate dropped from 3 times that of whites prior to 2002 to approximately the same as whites from 2004-2007.[1] During the years 2002-2007, 34 babies that otherwise would have died, survived, and 45 babies that would have been born at or before 28 weeks gestation were born later.[1] In contrast, black infant mortality rates remained high in the rest of Wisconsin and nationally during this time period.[2] Unfortunately, the black-white infant mortality gap has reappeared in Dane County. This paper analyzes primarily the disappearance of the black-white infant mortality gap from 2000-2007 and also offers preliminary observations on the resurgence of excess black infant mortality since 2008 with suggestions for further research.

There is a long history in the United States of racial disparities in infant mortality, which makes it all the more notable that Madison and Dane County managed to close the infant mortality gap. High levels of infant mortality were attributed to overcrowding in urban housing and unsanitary environments, which included lack of access to clean water and ventilation. Other factors included contaminated milk supplies, generally insufficient diets and high rates of contagious diseases. Since the Civil War, US urban and state public health officials have developed programs designated as "child-saving" to deal with increasingly high rates of infant mortality, which grew as industrial cities expanded. One such program, notable in its success and in its very brief life, occurred in Milwaukee, Wisconsin's south side immigrant neighborhood, where health officers, partnering with local midwives and the local parish priest, were able—within 1 year,

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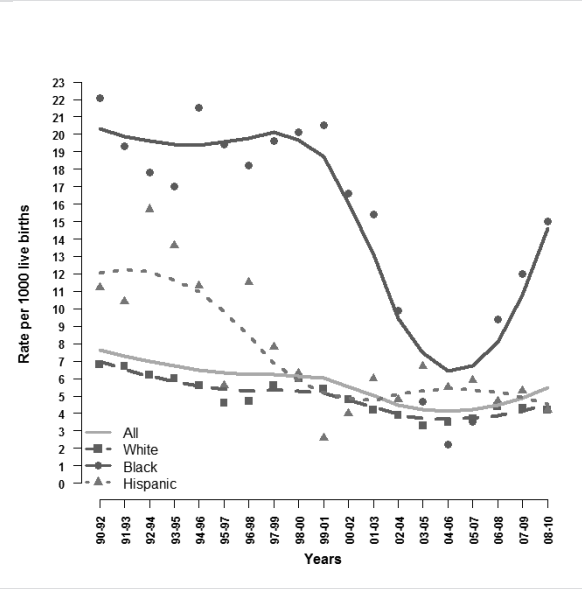
Table 1. Modified Kotelchuck Index of Prenatal Care

Intensive
Care initiated by the 4th month and at least 110% of the expected visits
Standard routine
Care initiated by 4th month and 50% - 109% of the expected visits
Less-than-standard
Care initiated after the 4th month or less than 50% of the expected visits

Figure 1. Infant Mortality Rates by Race, Dane County 1990-2010



Three-year moving average infant mortality rates fitted with a locally weighted regression (loess).

1911—to decrease infant mortality rates from 125/1000 live births to 44/1000.[3] Mortality rates for black children throughout the United States were always higher, sometimes as much as double the rates of white children.[4] By 1920, black infants died at a rate 60% higher than white children.[4] Efforts to close this gap included the Sheppard Towner Act—which provided federal dollars to establish educational programs focusing on maternal and infant health—in the 1920s and ongoing efforts throughout the 20th century after those funds were no longer available. Despite these efforts, enormous racial disparities continued, and black children continued to face almost twice the risk of mortality and morbidity of white children.[5] The longstanding history of racial disparities underscores just how impressive the closing of the racial gap in Dane County infant mortality was. This study was designed to test the hypothesis that prenatal care (in a broad sense) played a significant role in lowering the Dane County black prematurity and infant mortality rates from 2002-2007.

METHODS

Birth and Infant Death Records

Investigators analyzed over 100,000 Dane County, Wisconsin linked birth and death records provided by the Bureau of Health Information and Policy of the Wisconsin Department of Health Services (DHS) for the period 1990-2007. We present infant mortality rates with 3-year rolling averages to minimize the effect of year-to-year variability and a locally weighted regression (LOESS) to smooth the trend curve.

US Census

US Census data were obtained for the period 1990-2010, including data from the American Community Survey (ACS) for the years 2007-2010. Despite a change in sampling rate from a 1 in 6 sample used in the Long Form Census of 1990 and 2000 to a 1 in 11 sample in the ACS, the currency and refresh of these data, along with the lack of Long Form Census tabulations, make the ACS data the logical comparative in a time series of this nature. The ACS data informed yearly estimated trends over this later period of our study (2007-2010).

US Census data obtained for Dane County, Wisconsin were analyzed visually for relevant contextual factors relating to the observed changes in the birth outcome data. Data tables were produced through the American Factfinder website (www.factfinder.census.gov). Data were converted to percentage of the population values.

Vital record data for the majority of data in this paper defines black and white as non-Hispanic black and non-Hispanic white. However, US Census data used in median income calculations do not have a separate category for Hispanic and includes those of Hispanic ethnicity in black and white statistics. Race and ethnicity are now appreciated as social, rather than biological, constructs.[6] In light of that, some epidemiologists are suggesting that studies omit data about race and replace it with relevant socioeconomic data. However, as Nancy Kreiger suggests, to omit "race" and rely solely on "class" ignores the persistence of racism and also evidence that interpersonal and structural discrimination can harm health.[7] Thus, we have decided to continue to use data collected about race and add to it wherever possible information about various social and economic factors that impact health.

Outcome and Selected Determinants

The main outcome of interest was extremely preterm birth, defined as birth through 28 weeks of gestation, and how it related to prenatal support provided.[8]

Prenatal care utilization was quantified using a modified Kotelchuck Index[9] and its components (Table 1). With the Kotelchuck Index, the level of prenatal care category is based on the expected number of visits given the month prenatal care

was initiated and the length of the pregnancy. Therefore, the level of prenatal care is not affected by a shorter pregnancy.

The Kotelchuck Index was modified slightly for this paper. In the original index, the expected number of visits is reduced when care is initiated late. In the modified index, the expected number of visits is only adjusted for gestational age at delivery. Therefore, in the original index, a woman would be expected to have fewer visits if she started prenatal care late and her level of care could be misclassified as adequate. With our modification, a woman starting prenatal care late is more likely to have fewer than expected visits and a lower category of care.

One other adjustment we made to the original Kotelchuck Index was to expand the category of standard routine care to include the Kotelchuck category of "intermediate care." The purpose of the modifications is to minimize misclassification into the intensive care category by assuming high risk or complicated pregnancy for women with generally routine pregnancies.

Although our prenatal care metric is based only on number of physician/nurse practitioner/midwife visits and time of initiation, the concept of prenatal support, as discussed in this study, extends beyond quantifying clinical care and includes both quality of care and other kinds of support derived from nursing case management and home visiting, Special Supplemental Nutrition Program for Women, Infants and Children (WIC), mom- and baby-oriented community services and other systems.

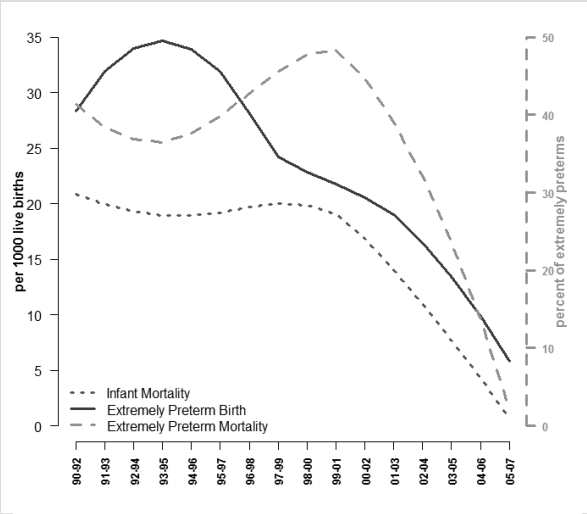
Statistical Analysis

The study design was retrospective cohort. We assessed the association between various risk factors (medical condition, previous preterm delivery, age, marital status, tobacco use, previous pregnancy termination, and previous child death) and outcomes using crude and adjusted relative risks (RR). Crude RR confidence intervals (CIs) were calculated by Wald normal approximation. For adjustment of relative risk regression we used family quasipoisson and the link log from R general linear modeling.

Selection of risk factors to be included in regression analysis was made according to their relative association in our study population with extremely premature birth rates with some allowance for those factors frequently mentioned in the literature. Exact Wilcoxon Mann-Whitney Rank Sum Test was used to assess differences in mean gestational age.

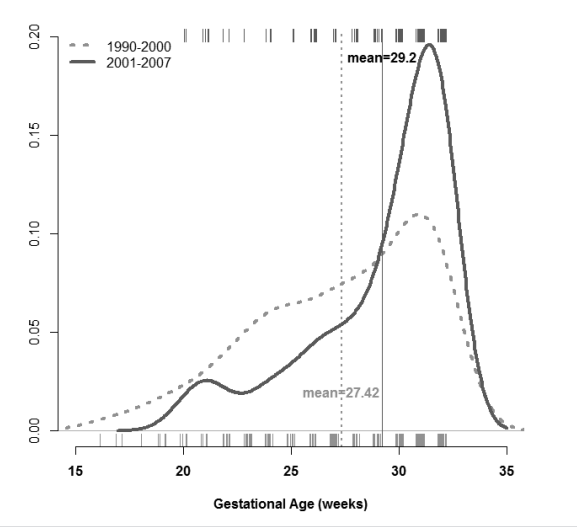
The 95% CI for the prevalence and risk measures were calculated using Wilson confidence's limit for binomial. The impact of selected risk factors was assessed with population attributable fraction (PAF) using the Levin's formula expressed in percents with appropriate modification for the polytomous variables. The statistical analysis was conducted using R, a Language and Environment for Statistical Computing (R Foundation for Statistical Computing, Vienna, Austria). The missing or implausible birth weights were imputed using the R package Amelia.

Figure 2. Comparison of Trends in Infant Mortality, Extremely Preterm Birth (≤ 28 weeks of Gestational Age) and Mortality Among Extremely Preterms, Dane County Black Infants 1990 to 2007



Only extremely preterm mortality (dashed line) is expressed in percents on the right vertical axis. The other 2 rates are per 1000 on the left axis. All the lines are smoothed with a locally weighted regression (loess).

Figure 3. Distribution of Gestational Ages of Preterm Births. Dane County Black Infants 1990-2000 and 2001-2007

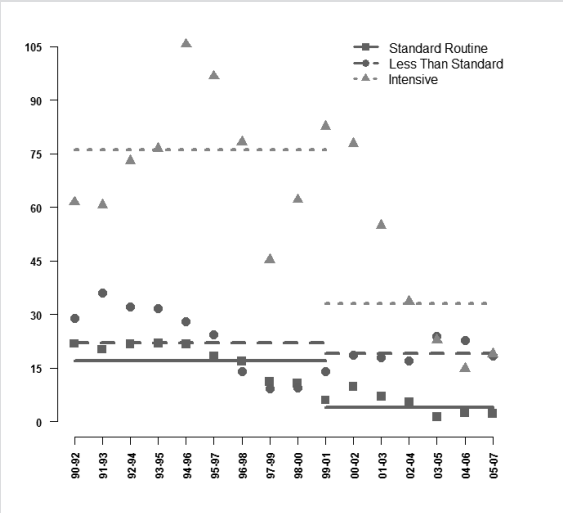


In addition to the density curves, the small bar plots at the bottom and at the top of the figure represent the individual very preterm births for the respective periods of bottom (1990-2000) and top (2001-2007). The small bar plots are jittered to minimize overlapping.

RESULTS

Infant mortality rates for whites, blacks, and Hispanics in Dane County improved from 1990 to 2007 (Figure 1). The 57.4% (95% CI = 32.6-73.1) decline in black infant mortality rates from 1990-2001 to 2002-2007 corresponded with a 53.9%

Figure 4. Birth ≤ 28 Weeks Gestation Rates and Averages by Category of Prenatal Care, Dane County Black Infants 1990-2007



The horizontal segments represent the average risk of extremely preterm for the 2 periods of 1990-2000 and 2001-2007 by prenatal care category.

(95% CI = 33.5-68) decline in the black extremely premature birth (Figure 2). The mean gestational age of black babies born at very preterm (≤ 32 weeks of gestation) showed a statistically significant increase from 27.4 to 29 weeks of gestation, contributing to their increased survival (Figure 3). Based on Wisconsin Department of Health Services estimates of average Medicaid billings for children in the first 4 years of life by birth weight category, the reduction in extremely preterm would amount to $6.75 million in hospital charges averted.[10]

Black women who received "less-than-standard" care (Table 1), showed no significant improvement in rates of extremely premature birth over time: 2.2% (95% CI 1.4-3.5) in 1990-2000 compared with 1.9% (95% CI 1.1-3.3) in 2001-2007. Those who received "standard routine" care declined from 1.7% (95% CI 1.2-2.4) to 0.4% (95% CI 0.2-0.8) while "intensive" care declined from 7.6% (95% CI 5.7-10.1) to 3.3% (95% CI 2.1 to 5.0). Both were large and significant decreases (Table 2): risk of extremely premature delivery for black women receiving "standard routine" care and "intensive" care decreased from 1990-2000 to 2001-2007 by 77.8% (95% CI 49.9-90.1) and 57.3% (95% CI 27.6-74.8) respectively. "Standard routine" and "intensive" care also had improved risk ratios compared to "less-than-standard" care: from 0.8 (95% CI 0.4-1.4) to 0.2 (95% CI 0.1-0.5) for standard routine care and from 3.4(95% CI 2-5.9) to 1.7 (95% CI 0.8-3.6) for intensive care (Figure 4, Table 2).

The prevalence of most pregnancy risk factors (fewer previous preterm births, teenagers, smokers, and women with a previous child death) among black women decreased over time, while those diagnosed with medical conditions and delivering over age 35 increased. For all risk categories, except age, the risk ratio tended to decrease from 1990-2000 to 2001-2007, though not significantly based on the 95% confidence intervals. The PAF for black unmarried women and smokers was high because of the prevalence of these risk factors in the population (Table 3).

Regression analysis shows that after adjustment, risk of extremely preterm delivery is less likely for "standard routine" care and 2001-2007 time period, while it is more likely for intensive care, comorbid medical conditions, black and other race, maternal age less than 20, and previous preterm birth. Age over 35 was not significantly associated with the decrease in extreme premature birth rate (Table 4).

The Dane County black infant mortality rate increased to 12 (95% CI 7.6-18.8) for 2007-2009 and 15 (95% CI 10-22.4) for 2008-2010.

Analysis of Dane County economic data shows that black per capita income rose during the period of improved birth outcomes (2000-2007) and decreased over the time that the gap between black and white infant mortality returned (2008-2010) (Figure 5). This worsening of black economic conditions from 2008 also is demonstrated in a dramatic increase in the percentage of blacks in Dane County using food stamps (Figure 6).

DISCUSSION

The authors previously have reported that, for 4 years during the past decade, the black/white infant mortality gap in Dane County, Wisconsin disappeared. They further demonstrated that the 67% decline in black infant mortality rates (from 19.4 infant deaths per 1000 live births during 1990-2001 to 6.4 during 2002-2007) was largely attributable to the concomitant 61% decline in extremely premature births.[1] This report offers the additional findings that increased gestational age among premature babies was also a key factor in the reduction of black infant mortality and that prenatal support has a protective effect on extremely preterm birth.

Other studies have shown the link between premature birth and infant death and have offered evidence that various interventions can, despite social and economic deprivation, improve outcomes. These include increasing the number of primary care physicians, especially family physicians[11], WIC[12], breastfeeding[13], improved interconception care[14], greater access to contraception,[15] and more continuous, culturally specific and equitable care.[16-19] The "three delays" (seeking care, getting to a health facility, and receiving quality care once in a health facility) associated with maternal mortality in developing countries also may be relevant to decreasing infant mortality in the United States.[20]

Our findings suggest that prenatal support systems can

have great impact on black infant mortality and premature birth and that the effectiveness of such systems can significantly improve over a relatively short time period. In Dane County, prenatal support systems associated with "intensive" care for women with complicated pregnancies (a minority of women that contribute the majority of extremely premature births), dramatically increased their effectiveness over the past decade. Similarly, systems associated with "standard routine" care (the majority of women at lesser risk but who still contribute substantial numbers of extremely premature births), increased their effectiveness. Those who received "less-than-standard" care had no significant reduction in extremely premature birth over time, although the number of women receiving "less-than-standard" care declined significantly.

How and why prenatal support systems became so much more effective appears to be multifactorial (Table 4). Individual contributors can be explored further in future studies. We postulate that change came about through increased cooperation and collaboration among various system components, triggered by immigration (mostly from elsewhere in the United States) of racial and ethnic minorities beginning in the 1990s. Reports from the late 1990s suggest that forces were brought to bear on hospitals, primary care systems, public health, and community organizations to rethink care for a changing population of pregnant women and babies.[21] For example, the Harambee Center was established in 1995 to provide coordinated delivery of social services; original partners included Access Community Health Center, Madison and Dane County Health Departments, Planned Parenthood, the Early Childhood Family Enhancement Center and the Madison Public Library. BadgerCare (a state insurance program) began in 1999 to expand prenatal care coverage to those who earned too much

Table 2. Risk of Extremely Preterm Birth (≤ 28 Weeks Gestation) Among Blacks by Level of Prenatal Care

Dane County 1990-2000 and 2001-2007

Category of Care	Years	Prevalence (N)	Rate%(95%CI)	RR(95%CI)
Less-than-standard care	1990-2000	24.1 (810)	2.2 (1.4,3.5)	1
	2001-2007	19.5 (586)	1.9 (1.1,3.3)	1
Standard routine care	1990-2000	59.2 (1990)	1.7 (1.2,2.4)	0.8 (0.4,1.4)
	2001-2007	61.2 (1842)	0.4 (0.2,0.8)	0.2 (0.1,0.5)
Intensive Care	1990-2000	16.8 (564)	7.6 (5.7,10.1)	3.4 (2,5.9)
	2001-2007	19.4 (583)	3.3 (2.1,5)	1.7 (0.8,3.6)

Abbreviations: CI, confidence interval; RR, relative risk.
Rate is the percent of extremely preterm births in the category of care

Table 3. Determinants of Extremely Preterm Birth for Dane County Black Mothers 1990-2000 and 2001-2007

Factors	Years	Prevalence (N)	Rate% (95%CI)	RR (95%CI)	PAF
Unmarried	1990-2000	75% (2524)	3.2 (2.6,3.9)	1.8 (1,3.1)	36.9
	2001-2007	76.9% (2338)	1.4 (1,2)	1.7 (0.7,3.9)	33.5
Smoking	1990-2000	29.8% (1002)	4.6 (3.5,6.1)	2.2 (1.5,3.3)	26.6
	2001-2007	22.6% (678)	2.1 (1.2,3.4)	1.9 (1,3.7)	17.2
Previous termination	1990-2000	2.5% (84)	9.5 (4.9,17.7)	3.6 (1.8,7.2)	6.1
	2001-2007	2.8% (86)	3.5 (1.2,9.8)	2.9 (0.9,9.1)	5
Previous death	1990-2000	2.6% (86)	11.6 (6.4,20.1)	4.5 (2.4,8.3)	8.2
	2001-2007	1.8% (56)	5.4 (1.8,14.6)	4.4 (1.4,14)	6
Medical condition	1990-2000	49% (1649)	3.9 (3.1,4.9)	2.1 (1.4,3.3)	36
	2001-2007	57.9% (1761)	1.3 (0.9,2)	1.1 (0.6,2)	2.6
Previous premature	1990-2000	5.9% (198)	8.6 (5.4,13.3)	3.5 (2.1,5.8)	12.8
	2001-2007	4.8% (146)	2.1 (0.7,5.9)	1.6 (0.5,5.3)	3
Mother's age <20	1990-2000	25.9% (872)	3.4 (2.4,4.9)	1.3 (0.8,2)	7.1
	2001-2007	20.4% (622)	1.9 (1.1,3.3)	1.7 (0.9,3.4)	12.6
Mother's age >35	1990-2000	5% (169)	2.4 (0.9,5.9)	0.9 (0.3,2.4)	-0.5
	2001-2007	6.1% (185)	1.6 (0.6,4.7)	1.4 (0.4,4.8)	2.3

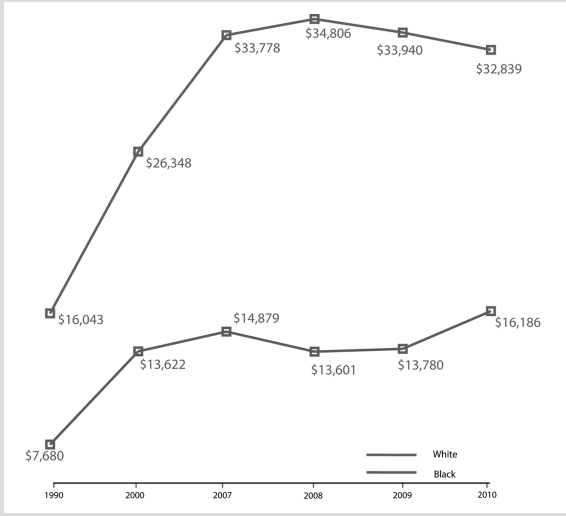
Abbreviations: CI, confidence interval; PAF, population attributable fraction; RR, relative risk.
"Rate is the percent of extremely preterm births in the risk factor

Table 4. Unadjusted and Adjusted Risk Ratios (RR), Prevalence, and *P*-value of Selected Determinants of Extremely Preterm Birth (≤ 28 weeks) in Dane County, 1990 to 2007

Predictors	Prevalence	Crude RR (95%CI)	Adjusted RR (95%CI)	*P*-value
Standard routine[1]	75.6	0.3 (0.2,0.3)	0.3 (0.2,0.3)	<0.001
Intensive[1]	17	2.4 (2.2,2.6)	2.1 (1.7,2.6)	<0.001
Medical[2]	37.1	2.1 (1.8,2.4)	1.4 (1.2,1.6)	<0.001
Previous preterm birth[3]	2.1	4.7 (3.6,6)	2.5 (1.9,3.2)	<0.001
Black race[4]	6.6	3.5 (2.8,4.2)	2.3 (1.9,2.8)	<0.001
Other race[4]	12	1.3 (1,1.6)	1.3 (1,1.6)	0.023
2001-2007[5]	42.1	0.8 (0.7,0.9)	0.6 (0.6,0.8)	<0.001
Mother's age < 20yrs[6]	5.9	2.4 (1.9,3)	1.7 (1.4,2.2)	<0.001
Mother's age > 35yrs[6]	12.3	1.1 (0.9,1.4)	1 (0.8,1.2)	0.936

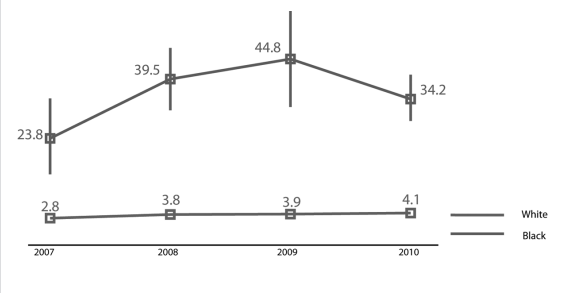
Adjustment for race and time period and the following predictors: level of prenatal care,medical history, previous preterm birth and mother's age. All the risk factors were still associated with extremely preterm birth after adjustment except age over 35 years, and the effect of time period was still significant.
Reference groups: 1 = less than standard; 2 = non-medical; 3= no previous preterm birth; 4 = white race; 5 = 1990-2000; 6 = Mother's age 20-35

Figure 5. Dane County Median Income by Race, 1990-2010



Top line = white. Bottom line = black.

Figure 6. Percent Food Stamp Participation by Race, Dane County 2007-2010



Top line = black. Bottom line = white.

to qualify for Medicaid. Both of these programs were affected by the economic downturn of recent years.

The return of excessive black infant mortality to Dane County is very disheartening. The great recession of 2008 that halted the rising economic tides of previous years appears to have broadly affected birth outcomes, most drastically for blacks. Local prenatal support systems and women's health programs may be key in confronting new challenges.

Wisconsin's birth cost recovery policies may be exacerbating racial disparities in birth outcomes, especially in hard economic times.[22] Birth cost recovery involves recouping Medicaid medical expenses related to pregnancy and delivery from unmarried fathers. Wisconsin is 1 of 9 states collecting birth cost recovery from Medicaid patients and one of the two most aggressive. Because unmarried women seeking Medicaid prenatal care coverage are forced to report the father of the baby, they may be less inclined to seek prenatal care. If they do report the father and are living with him out of marriage, money recouped from him is money upon which she may depend. Since, of 2007 Wisconsin births, 84% of white women compared with 27% of black women were married when they gave birth, this policy has a greater impact on black women and their families.[23]More research is needed on the impact of Wisconsin's birth cost recovery policies.

As key factors leading to the elimination and reappearance of the Dane County black-white infant mortality gap are identified, they may be exported elsewhere in Wisconsin and nationally. Ninety-one percent of Wisconsin black infant deaths occur in the cities of Beloit, Kenosha, Milwaukee and Racine.[24] An initiative funded by the Wisconsin Partnership Program, Lifecourse Initiative for Healthy Families (LIHF), is researching ways to impact the high black infant mortality rate in these 4 counties.[24,25] The life course perspective explains racial disparities in birth outcomes by the cumulative effect of lifetime exposure to more risk factors and fewer protective factors, especially at critical times.[26] The life course approach, "which has increasingly been advocated by researchers and health officials across the country, focuses on breaking the cycle of infant mortality by attacking poverty, racism and segregation, health care, chronic diseases, stress, low birth weight and a range of behaviors such as smoking."[27] The elimination of the Dane County black-white infant mortality gap demonstrates that change can be achieved and intensified research and support for prenatal care in a broad sense are essential. The association between worsening socioeconomic conditions and reappearance of the Dane County black-white infant mortality gap supports the LIHF approach.

CONCLUSIONS

In Dane County, Wisconsin, during 2000-2007, dramatic declines in black premature birth and increases in black infant survival were strongly associated with the growing effectiveness of local prenatal care systems. The reappearance of a large black/white infant mortality gap during 2008-2010, the years of a great recession that disproportionately affected blacks, suggests that socioeconomic factors predominate.

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