Low Birth Weight and School Readiness

Nancy E. Reichman

Summary

In the United States black women have for decades been twice as likely as white women to give birth to babies of low birth weight who are at elevated risk for developmental disabilities. Does the black-white disparity in low birth weight contribute to the racial disparity in readiness?

The author summarizes the cognitive and behavioral problems that beset many low birth weight children and notes that not only are the problems greatest for the smallest babies, but black babies are two to three times as likely as whites to be very small. Nevertheless, the racial disparities in low birth weight cannot explain much of the *aggregate* gap in readiness because the most serious birth weight–related disabilities affect a very small share of children. The author estimates that low birth weight explains at most 3–4 percent of the racial gap in IQ scores.

The author applauds the post-1980 expansions of Medicaid for increasing rates of prenatal care use among poor pregnant women but stresses that standard prenatal medical care cannot improve aggregate birth outcomes substantially. Smoking cessation and nutrition are two prenatal interventions that show promise. Several early intervention programs have been shown to improve cognitive skills of low birth weight children. But even the most promising programs can narrow the readiness gap only a little because their benefits are greatest for heavier low birth weight children and because low birth weight explains only a small share of the gap.

The author stresses the importance of reducing rates of low birth weight generally and of extending to all children who need them the interventions that have improved cognitive outcomes among low birth weight children. But because black infants are more likely to be born at the lowest birth weights, *preventing* low birth weight—when researchers learn how to—is likely to be more effective than early intervention in narrowing birth weight–related racial gaps in school readiness.

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In the United States, black women have for decades been twice as likely as white women to give birth to babies of low birth weight—those weighing less than 2,500 grams, or about 5.5 pounds. Not only is low birth weight a leading cause of infant mortality, but infants who survive are at elevated risk for many long-term health conditions and developmental disabilities that can impair school readiness. The black-white disparity in low birth weight is so large and so persistent that it raises the question of whether it contributes to racial disparities in children's cognitive abilities and in readiness.

This article, which focuses on the effect of low birth weight on the racial gap in test scores, consists of six sections. The first provides a brief overview of low birth weight in the United States—definition, trends, and associated rates of survival and child disability. The second discusses disparities in low birth weight by race, ethnicity, and nativity, as well as survival rates by race. The third section, the heart of the paper, examines the link between low birth weight and school readiness. It reviews the cognitive and behavioral problems that beset many low birth weight children, noting that the problems are greatest for the smallest babies and that black babies are much more likely than white babies to be very small. It also explores the effect of birth weight on the black-white gap in readiness and confirms earlier findings that the racial disparity in birth weight explains only a few percentage points of the aggregate gap. The fourth section looks at the determinants of low birth weight, focusing on those that vary by race. The fifth considers past efforts to tackle the problem of low birth weight through prevention or through amelioration of its adverse consequences. It highlights early intervention programs that have been shown to improve cognitive outcomes among low birth weight children and thus close at least a small portion of the readiness gap. The final section summarizes the article's key findings, highlights important implications, and offers recommendations.

Low Birth Weight in the United States

Low birth weight is a widely used and much studied marker of infant health.[1] It is well measured, reliably recorded, and readily available from vital statistics files and many other data sets. Birth weight is often categorized as very low (less than 1,500 grams, or about 3.3 pounds), low (less than 2,500 grams), or normal (2,500 grams or more). Further distinctions include extremely low (less than 1,000 grams) and moderately low (1,500–2,499 grams) birth weight. Births can also be characterized by gestational age: very preterm (less than 32 weeks), preterm (less than 37 weeks), and term (37 weeks or more). These terms and their definitions are summarized in table 1, along with the corresponding rates of births in the United States in 2000. Babies considered small for gestational age (SGA) or growth retarded are typically below the 10th percentile in sex-specific birth weight for gestational age. All low birth weight babies are preterm or growth retarded (they can be both), and virtually all very low birth weight babies are preterm.

Trends

Babies born in the United States are more likely to be low birth weight than those born in almost every other developed country.[2] Low birth weight is the second leading cause of infant mortality in the United States after birth defects, and surviving infants are at elevated risk for debilitating medical conditions and learning disorders.[3] Figure 1 shows rates of low birth weight, very low birth weight,

Table 1. Definitions of Low Birth Weight and Related Outcomes, United States

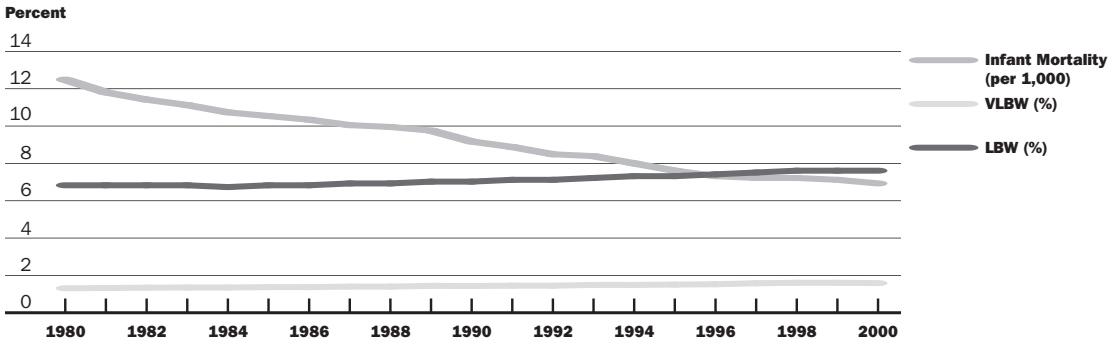
Term	Definition	Percent of live births, 2000
Normal birth weight	At least 2,500 grams	92.4
Low birth weight (LBW)	Less than 2,500 grams	7.6
Moderately low birth weight	1,500–2,499 grams	6.2
Very low birth weight (VLBW)	Less than 1,500 grams	1.4
Extremely low birth weight (ELBW)	Less than 1,000 grams	0.7
Preterm	Less than 37 weeks' gestation	11.6
Very preterm	Less than 32 weeks' gestation	1.9

Source: Joyce A. Martin and others, "Births: Final Data for 2000," *National Vital Statistics Reports* 52, no. 10 (Hyattsville, Md.: National Center for Health Statistics, February 12, 2002).

and infant mortality (death before age one) in the United States from 1980 to 2000. Thanks to increased specialization in delivering maternal and newborn health care and to advances in neonatal intensive care technology, the United States made substantial progress in reducing the infant mortality rate over this period, although its gains have lagged behind those of other developed countries.[4] Rates of low and very low birth weight, meanwhile, increased slightly, owing partly to the increasing prevalence of multiple births; the rate of low birth weight among singleton births has remained steady, at about 6 percent.[5]

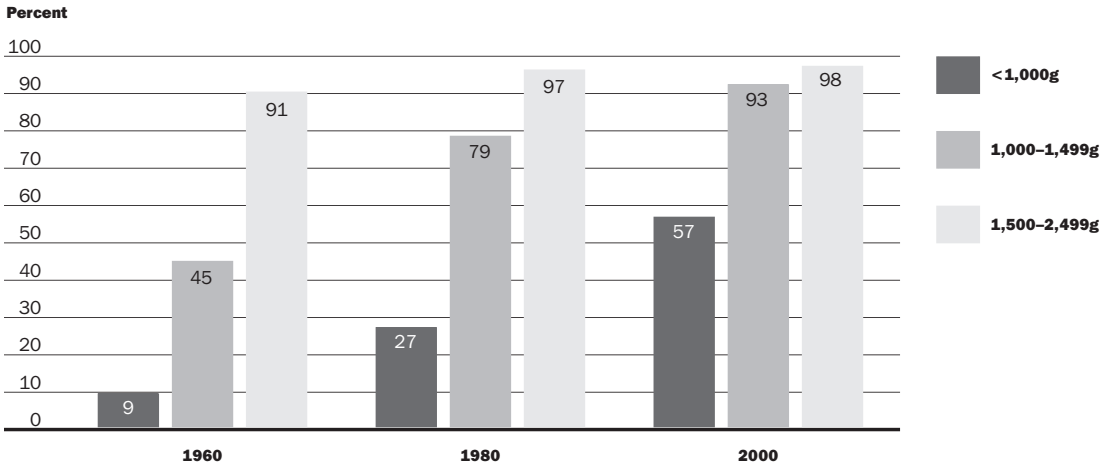
Low birth weight babies are much more likely to survive today than they once were. Since 1960, survival rates have increased dramatically for very low and extremely low birth weight babies born in the United States (figure 2). Although less than 10 percent of extremely low birth weight singleton infants born in 1960 lived to their first birthday, that figure increased to 27 percent for those born in 1980 and to 57 percent for those born in 2000.[6] And while fewer than half of very low birth weight (defined here as 1,000–1,499 grams) singleton babies born in 1960 survived, by 2000 the share surviving had increased to

Figure 1. Low Birth Weight, Very Low Birth Weight, and Infant Mortality Rates, United States, 1980-2000



Source: Centers for Disease Control and Prevention, *Morbidity and Mortality Weekly Report,* vol. 51(27): 589–92 (www.cdc.gov/ mmwr/ preview/mmwrhtml/mm5127a1.htm).

Figure 2. One-Year Survival Rates of Singleton Low Birth Weight Infants, by Birth Weight, United States, 1960, 1980, and 2000



Sources: Data for 1960 are from U.S. Department of Health, Education, and Welfare, Public Health Service, Office of Health Research, Statistics, and Technology, "A Study of Infant Mortality from Linked Records, by Birth Weight, Period of Gestation, and Other Variables, United States, 1960 Live-Birth Cohort," (PHS) 79-1055 (Hyattsville, Md.: National Center for Health Statistics, May 1972). Data for 1980 are from U.S. Department of Health and Human Services, Public Health Service, "National Infant Mortality Surveillance (NIMS) 1980," (Atlanta: Centers for Disease Control, Center for Chronic Disease Prevention and Health Promotion, Division of Reproductive Health, December 1989). Data for 2000 are from National Center for Health Statistics, "Live Births, Infant Deaths, and Infant Mortality Rates by Plurality, Birthweight, Race of Mother, and Gestational Age: United States, 2000 Period Data," table LFWK 46 (www.cdc.gov/nchs/datawh/statab/unpubd/ mortabs.htm#Linked).

Notes: This figure was adapted from a slide provided by Nigel Paneth, M.D., M.P.H., Michigan State University. Only single births are used. The figures for 1960 were calculated using cutoffs of <1,001 grams and 1,001–1,500 grams.

more than 90 percent. Likewise, the survival rates of moderately low birth weight singleton infants increased from 91 percent in 1980 to 98 percent in 2000.[7] The new survivors, however, are at high risk for health and developmental problems, as discussed below.

Survival and Disability

The majority of moderately low birth weight infants thrive, suffering few or no problems. It is the lightest babies who are most at risk of disabilities, both cognitive and physical, that can impair school readiness. Of the many child health conditions associated with low birth weight, perhaps the most potentially disabling is cerebral palsy, a group of disorders characterized by the inability to control movement and often accompanied by cognitive impairments.[8] Preterm very low birth weight infants are up to 30 percent more likely to develop cerebral palsy than are babies born at term.[9] Other serious conditions associated with low birth weight or preterm birth include mental retardation, respiratory distress syndrome (RDS), bronchopulmonary dysplasia (BPD), retinopathy of prematurity (ROP), and deafness. RDS and BPD can lead to feeding difficulty, recurrent respiratory infections, asthma, and growth delay.[10] ROP, a disorder caused by abnormal growth of blood vessels in the eye, can lead to blindness.[11] All these disabilities can impair learning and inhibit a child's school readiness. Almost without exception, the prevalence of these disabling conditions increases as birth weight decreases.

A recent review of forty-two studies of infants born after 1970 found no change between 1976 and 1990 in the prevalence of major neurodevelopmental disabilities among ex-

tremely immature (26 weeks or less) and extremely small (800 grams or less) survivors. Throughout that period, cerebral palsy affected 12 percent of extremely immature and 8 percent of extremely small survivors; mental retardation affected 14 percent of each group; 8 percent of each group was blind; and 3 percent of each group was deaf. Overall, 22 percent of extremely immature survivors and 24 percent of extremely small survivors had at least one major disability.[12]

Disparities in Low Birth Weight by Race, Ethnicity, and Nativity

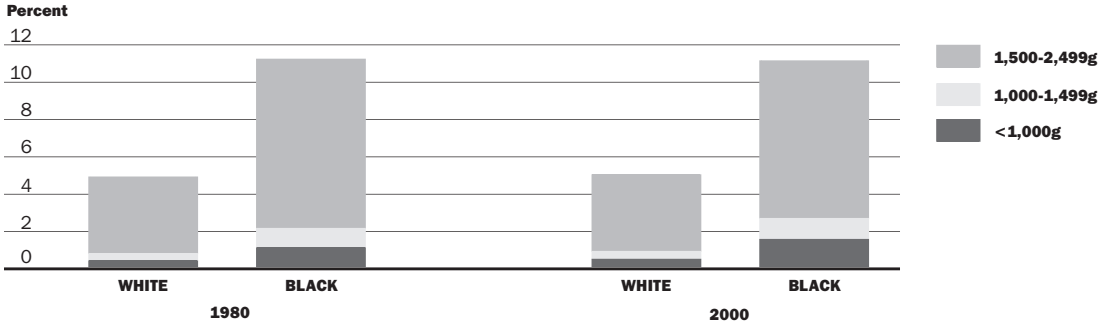
The black-white disparity in low birth weight in the United States is glaring and persistent. In 2000, 13 percent of babies born to black mothers were low birth weight, compared to 6.5 percent of those born to white mothers.[13] (By contrast, rates of low birth weight for the other racial groups reported by the National Center for Health Statistics were close to that of whites: 6.8 percent among American Indians and 7.3 percent among Asians and Pacific Islanders.)[14] The two-to-one disparity between blacks and whites has persisted for more than forty years, exists at most maternal age ranges, cannot be explained by differences in rates of multiple births, and cannot be explained by socioeconomic status alone.[15] Even infants born to college-educated black women are at much greater risk than infants born to college-educated white women of being low birth weight.[16] Black mothers were 63 percent more likely to have preterm deliveries than white mothers (17.3 percent as against 10.6 percent) in 2000.[17] The rates of small-for-gestational-age births among infants born at term in 1998 were 17.4 percent among blacks and 9.0 percent among whites.[18]

Ethnicity

Rates of low birth weight also vary among women of different ancestral origins. The rate for women of Hispanic descent was 6.4 percent in 2000, on par with the rate for whites. But within that broad group, rates differ widely. In 2000, women of Cuban and Mexican descent had low birth weight rates of 6.5 percent and 6.0 percent, respectively, while Puerto Ricans had a rate of 9.3 percent.[19] The disparity between Puerto Ricans and Mexicans has baffled researchers because both groups are at high risk for adverse outcomes based on their socioeconomic status, and island-born Puerto Ricans, as U.S. citizens, have greater access than foreign-born Mexicans to Medicaid.[20] The disparity may have to do with unmeasured differences in culture, diet, stress, or lifestyle.[21] Researchers have termed the unexpectedly favorable rates among Mexican American women, despite their socioeconomic disadvantages and comparatively low use of prenatal care, the *epidemiologic* or *Hispanic paradox.*[22] Explaining this paradox could provide clues about how to blunt the negative effects of poverty on birth outcomes of other disadvantaged groups. Blacks of Puerto Rican or other Hispanic ethnicity have a lower probability of low birth weight than blacks who are non-Hispanic, but very few (3 percent) of the 622,598 births to black mothers in 2000 were to mothers who identified themselves as Hispanic.[23]

Several researchers, notably Gosta Rooth, have questioned the standard 2,500 gram cutoff for low birth weight, arguing that it does not account for variation in mean birth weights across countries that may be due to differences in, for example, maternal height.[24] That threshold may likewise not be appropriate for all racial and ethnic groups in the United States, but the "natural" underlying distributions are not known and may themselves be determined by factors such as health and socioeconomic status rather than

Figure 3. Extremely Low Birth Weight, Very Low Birth Weight, and Low Birth Weight Rates by Race, United States, 1980 and 2000



Sources: See figure 2.
Notes: Only single births are used. For 1980, race is based on both parents' races from birth certificates; for 2000, on mother's race from birth certificate.

biological predisposition. Nigel Paneth, in an excellent summary of this issue, suggests that there is not enough evidence to dismiss the glaring racial disparities in low birth weight in the United States as "normal."[25]

Nativity

In 2000 some 80 percent of U.S. births to white women and 88 percent of births to black women were to mothers born in the United States.[26] Many groups of immigrant mothers, particularly Mexicans, make less use of prenatal care and other health services than their U.S.-born ethnic counterparts because of multiple legal, language, socioeconomic, and cultural barriers.[27] Yet the birth outcomes of Mexican immigrants are even more favorable than those of U.S.-born Mexican mothers. In fact, for virtually every racial and ethnic group in the United States, immigrants have better birth outcomes than U.S.-born mothers.[28] Thus, although immigrants encounter numerous barriers to prenatal care, they have offsetting health, social, or lifestyle advantages that promote favorable birth outcomes.

Several studies have analyzed birth outcomes of black women by nativity.[29] Of particular interest, Richard David and James Collins found that African-born black mothers have rates of low birth weight much closer to those of U.S.-born white mothers than to those of U.S.-born black mothers of predominantly African descent. This suggests that black-white disparities in low birth weight may be due to social and environmental factors rather than biological predisposition, although one cannot rule out the possibility that the differences are due to selective migration.

Low Birth Weight, Survival, and Race

Given the large disparity in low birth weight between blacks and whites and the small disparities between whites and other racial groups and between whites and Hispanics, in the remainder of this article I focus on black-white differences in school readiness. Whenever possible I focus on the lowest birth weight infants, because although they compose small proportions of all births, they suffer the highest rates of disability and therefore have the poorest long-term prognosis for school readiness and academic achievement. As figure 3 shows, the rate of low birth weight among blacks (single births) was the same in 2000 as in 1980; that for whites in-

creased slightly.[30] The black-white disparity occurs across all low birth weight groups but is even larger for the lowest weight groups. And while the overall rates of low birth weight have remained constant, the shares of births in lowest weight groups have increased, particularly for blacks. Between 1980 and 2000 the rate of extremely low birth weight rose almost 50 percent among blacks and a third among whites, while the rate of very low birth weight rose about 25 percent among blacks and 15 percent among whites. These higher rates may reflect increased obstetric intervention that prevents fetal loss. Overall reported fetal deaths at 20 or more weeks' gestation declined 12 percent over 1990–2000 alone; the decreases for non-Hispanic whites and non-Hispanic blacks were 10 percent and 5 percent, respectively.[31]

The rate of infant mortality (death in the first year) has fallen steadily for both blacks and whites over the past twenty-five years. In 1980, 18 out of 1,000 black singleton babies did not live to their first birthday; by 2000 that figure had fallen to 12 out of 1,000. For white babies the comparable rates were 9 out of 1,000 in 1980 and 5 out of 1,000 in 2000.[32] As with low birth weight, the two-to-one black-white disparity in infant mortality has persisted over time, although the *percentage* decline in infant mortality has been greater among whites than among blacks.

Birthweight-specific survival rates are remarkably equivalent for black and white singletons. In the past, black low birth weight infants had a paradoxical survival advantage, perhaps owing to differences in fetal health and differential rates of fetal loss. In 1980, 83 percent of black and 76 percent of white singleton infants of very low birth weight (here, 1,000–1,499 grams) survived their first year; for extremely low birth weight infants, the survival rates were 29 percent for blacks and 27 percent for whites. In 2000, survival rates for very low birth weight infants were 93 percent for whites and 94 percent for blacks; and for extremely low birth weight babies, 58 percent for whites and 57 percent for blacks. Even taking into account multiple births, recent figures show no indication of racial disparities in birth weight–specific survival or in birth weight–specific neonatal survival (the first 28 days of life).[33] The lifesaving advantages of neonatal care thus appear to be color-blind, at least in the aggregate. (These figures do not speak to whether there are disparities in newborn care more generally.) However, because black infants are much more likely to fall into the lowest weight groups, a disproportionate fraction of black survivors is at high risk for adverse health and developmental outcomes.

Among survivors born in 2000 (including multiple births), the share of black infants who were extremely low birth weight is 1.00 percent, more than three times that for whites (0.32 percent). The difference is similar for very low birth weight babies (2.31 percent for blacks, as against 0.89 percent for whites).[34] Thus among children born in 2000 who survived their first year of life, black children are more than two and a half times as likely as white children to have been extremely or very low birth weight—and therefore to be at risk of serious cognitive delays that could affect school readiness and academic achievement when they enter kindergarten in 2005.[35]

Low Birth Weight and School Readiness

Extensive research confirms that low birth weight children are at greater risk for cognitive and school performance problems than

are their normal birth weight peers, and that the risk for adverse outcomes increases as birth weight decreases.[36] A meta-analysis of case control studies reported from 1980 to November 2001 found that the mean IQ for school-aged children born very preterm is approximately two-thirds of a standard deviation below that of controls who were born at term.[37] A population-based study using linked birth certificate and school records from Florida found that the risk of specific school-identified disabilities increases as birth weight decreases.[38] Enrollment in special education also follows a birth weight gradient, with the lightest babies being most likely to be placed in such programs.[39] While all of these findings are based on cohorts born before the major advances in neonatal intensive care of the 1990s, research on later cohorts yields similar results.[40]

Children born preterm have greater difficulty completing tasks involving reading, spelling, and math than their full-term peers.

Children born preterm have greater difficulty completing tasks involving reading, spelling, and math than their full-term peers, though math scores are more consistently related to preterm birth or very low birth weight than are reading achievement scores.[41] Preterm children tend to have language difficulties related to grammar and abstraction.[42] They also tend to be more inattentive, aggressive, and hyperactive, as well as less able to handle leadership roles than their full-term peers.[43]

Some cognitive deficits are the direct result of medical disorders.[44] Compromised motor skills in many preterm infants, for example, may lead to learning disabilities and handicaps.[45] Studies of the brains of preterm and full-term children have identified areas that correspond to the cognitive deficits observed. Brain volume tends to be reduced, resulting in larger ventricles containing more cerebrospinal fluid, thinning of the corpus callosum (which indicates less white matter), and a reduction in gray matter. The sensorimotor cortex, amygdala, and hippocampus are also often reduced.[46] These anatomical deficiencies are most likely a result of immaturity, physiological instabilities, or stressful experiences as neonates.[47]

Birth weight may also have indirect effects on cognitive development through parenting. The medical, developmental, and behavioral problems of a very light infant may heighten parental stress, which may in turn impair the child's learning. Research in this area is in its infancy. According to one recent study, mothers of very low birth weight infants suffered more psychological distress than mothers of term infants at one month, at two years, and at three years, with the severity of stress positively related to the child's developmental outcomes.[48]

Collectively, past studies based on hospital or regional cohorts have found that among extremely low birth weight infants, 8 to 18 percent have IQ scores under 70 (a cutoff often used to define mental retardation), and 25 to 29 percent have IQs in the 70–84 (borderline) range at school age (generally ages six or eight to ten). The corresponding figures for very low birth weight infants (here, 1,000–1,499 grams) are 5 percent and 19 percent; for moderately low birth weight infants, 5 percent and 17 percent; and for normal

birth weight infants, 0 to 4 percent and 4 to 14 percent (the figures for very low and moderately low birth weight infants are based on only one study).[49]

Birth Weight and Socioeconomic Status

Birth weight is but one of many risk factors for cognitive impairment. One of the most salient risk factors is low socioeconomic status. Disentangling the effects of birth weight from those of the many socioeconomic disadvantages linked with low birth weight is difficult. Research to date indicates that very low birth weight (and—much less so—moderately low birth weight) does have independent deleterious effects on early cognitive outcomes, such as IQ and PIAT scores.[50] But while it might be interesting from a variety of vantage points to disentangle the effects of birth weight and socioeconomic status, the two are so highly correlated that it may not be relevant for policy purposes to do so.

Low Birth Weight and Aggregate Educational Outcomes

Clearly, individual children born low birth weight can be seriously disadvantaged with respect to schooling. But because most serious birth weight–related disabilities tend to occur at the lowest weight ranges and therefore affect a very small proportion of children, low birth weight may not explain much of the observed variation in educational attainment at the aggregate level. A recent study of children born in the 1958 British birth cohort, for example, found that children born at low birth weight passed significantly fewer O-level exams. But being born at low birth weight, or being born to a mother who smoked during pregnancy (also a predictor of poor educational outcomes), explained only 2.5 percent of the variation in O-level results.[51]

Low Birth Weight and the Black-White Gap in Test Scores

Only two studies of which I am aware have presented data indicating the potential effect of low birth weight on racial test score gaps. Yolanda Padilla and her coauthors, in a study using National Longitudinal Survey of Youth (NLSY) child data and focusing on the effects of the Mexican-American birth weight advantage on early childhood development, found that low birth weight explains less than 1 percent of the (unadjusted) black-white gap in scores on the Peabody Picture Vocabulary Test-Revised (PPVT-R) among three- and four-year-olds in the late 1980s and early 1990s.[52] Jeanne Brooks-Gunn and her coauthors presented a similar estimate in a recent analysis of the contributions of family and test characteristics to the black-white test score gap.[53] Also using NLSY child data, they found that low birth weight and gender together explain less than 2 percent of the unadjusted racial gap in PPVT-R scores at age five.

My own estimate of the potential impact of birth weight on the racial gap in one test of cognitive ability—full-scale IQ score—is similar, though somewhat higher. My subject is all black and white infant survivors born in 2000, including multiples. In contrast to Padilla and Brooks-Gunn I do not use the NLSY data, because although that data set has actual test scores, it may underrepresent the very lightest babies. Instead I use vital statistics data, which provide exact race-specific birth weight distributions for surviving infants in the United States, though test scores must be imputed. I assigned an IQ score to each survivor, based on the infant's birth weight. I then computed the racial gap in imputed IQ scores and divided this figure by the total observed racial gap in IQ scores, to compute the maximum proportion of the overall gap that can be explained by birth weight.[54] Using various dis-

tributions of IQ scores based on past research and a range of assumptions, I found that birth weight explains a maximum of 3 to 4 percent of the racial gap in IQ scores, or one-half a point in IQ.

Determinants of Low Birth Weight

Researchers have identified and analyzed many social, medical, and behavioral risk factors for low birth weight, some of which could contribute to racial disparities in low birth weight, and ultimately to school readiness. Many of these risk factors are intricately intertwined, and for the most part I will not attempt to establish or disentangle causal effects.

Socioeconomic Status

Women of low socioeconomic status are at increased risk for delivering low birth weight babies, whether socioeconomic status is defined by income, occupation, or education.[55] Education may also have independent effects, above and beyond income, because more highly educated mothers may know more about family planning and healthy behaviors during pregnancy. In 1998, the rate of low birth weight among mothers with less than a high school education was 9 percent, as against 7.9 percent among high school graduates, and 6.5 percent among mothers with at least some college.[56] In 2000, 78.6 percent of white women giving birth, and 74.5 percent of black women giving birth, had twelve or more years of education.[57] Black Americans are much more likely than whites to come from a disadvantaged socioeconomic background, but that does not fully explain the racial disparity in low birth weight.[58]

Marital Status

Marital status is also a key correlate of birth weight. In 1992, the rate of low birth weight babies among unmarried mothers in the United States was 10.4 percent, as against 5.7 percent among married mothers.[59] In 2000, 27.1 percent of low birth weight babies born to white mothers and 68.5 percent of low birth weight babies born to black mothers had unmarried parents.[60] The marital status disparity may reflect either the greater likelihood of unmarried mothers to be poor or other characteristics that vary by marital status.[61]

Maternal Age

In 2000, 19.7 percent of births to black women and 10.6 percent to white women in the United States were to teens. The rate of low birth weight babies among teen mothers was 35 percent higher than that among mothers aged twenty to twenty-nine (9.6 percent as against 7.1 percent). The rate among the youngest teens—those fifteen and younger—was 14.1 percent, higher than in any age group except forty-five to fifty-four.[62] Teen mothers' birth weight disadvantage has several explanations. A pregnant teenager who is still growing may compete for nutrients with the fetus. Becoming pregnant within two years after menarche increases the risk for preterm delivery.[63] Many teen pregnancies are unplanned, unwanted, or discovered late, and pregnant teens are more likely than older mothers to be poor, to be undereducated, or to lack access to resources or services—all, in themselves, risk factors for low birth weight.[64]

In 1992 Arline Geronimus found, surprisingly, that black teen mothers seem to have a paradoxical advantage in birth outcomes over older black mothers. She speculated that this finding may be due to "weathering" among black women—more rapid age-related deterioration in health than among white women because of greater cumulative exposure to

harsh living conditions. Thus young maternal age may not be as much a risk factor among black mothers as it is among whites.[65] Unadjusted national figures for black mothers from 2000 do not reflect this pattern; low birth weight rates among black mothers were lowest among mothers in their twenties.[66] If the national sample were restricted to disadvantaged black mothers, however, the Geronimus weathering pattern might become apparent.

On the other end of the age spectrum, women who give birth in their late thirties or older are also at increased risk for having low birth weight babies. In 2000, 9.7 percent of births to black women and 13.9 percent of births to white women in the United States were to women aged thirty-five and over.[67] For these women the risks are biological: older ova and a greater likelihood of medical risk factors such as hypertension.[68] Older women also have more unintended pregnancies—itself a risk factor for low birth weight—than do women in their twenties and early thirties.[69]

One study found that women aged thirty and older are at greater risk for poor birth outcomes than teens of the same race, though offsetting factors such as higher socioecoomic status mask this risk.[70] That same study, which controlled for such socioeconomic characteristics as whether the birth was covered by Medicaid, found evidence of the Geronimus weathering phenomenon. Black mothers aged fifteen to nineteen were at lower risk of delivering low birth weight babies than were black mothers in their twenties. Given the complicated relation between maternal age and low birth weight, it is difficult to assess the extent to which black mothers are at increased risk in this regard.

Medical Conditions

Among the medical risk factors for low birth weight and preterm birth are prior low birth weight or preterm delivery, cervical abnormalities, hypertension, anemia, and bacterial infections.[71] Chronic physical or psychological stress also increases the risk.[72] Among the risk factors for fetal growth retardation are previous low birth weight births, infections, sexually transmitted diseases, poor maternal hematological status, hypertension-related complications, renal disease, heart disease,

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third trimester bleeding, and sickle cell disease.[73] Nutritional inadequacy can also impair fetal growth.[74]

Most, but not all, of these medical risk factors are more prevalent among blacks than whites. Most are rare. In 2000, for example, 3.8 percent of black mothers and 2.1 percent of white mothers were anemic during pregnancy; 1.4 percent of black mothers and 0.7 percent of white mothers had chronic hypertension. Black mothers had higher rates of acute or chronic lung disease, genital herpes, hydramnios or oligohydramnios (too little or too much amniotic fluid), hemoglobinopathy (a blood disorder), pregnancy-associated hy-

pertension, eclampsia, incompetent cervix, and previous preterm babies or growth-retarded infants. White mothers had higher rates of cardiac disease, renal disease, Rh sensitization, and uterine bleeding.[75] Bacterial vaginosis, a mild bacterial infection more common among black women than white women, has been linked with preterm delivery of low birth weight infants.[76]

Prenatal Substance Use

Maternal cigarette smoking during pregnancy decreases fetal growth rates and substantially increases the risks of spontaneous abortion, preterm delivery, low birth weight, placental ruptures, placenta praevia, and perinatal death. Prenatal alcohol and drug use are also linked with poor birth outcomes, though the relationships are less clear-cut and not as dose-response specific as that of smoking.[77] Substance abuse during pregnancy, particularly of alcohol and illicit drugs, is notoriously underreported. Based on reported rates of smoking, black mothers do not appear to be at increased risk for low birth weight. In 2000, 9.1 percent of black mothers and 13.2 percent of white mothers in the United States reported smoking cigarettes (at all) during pregnancy. The proportion of black and white mothers who reported consuming alcohol at all during pregnancy according to birth records in 2000 was virtually identical—about 1 percent of each group.[78] However, these rates are nowhere near the proportion (16.3 percent) of pregnant women aged eighteen to forty-four who reported alcohol consumption in the past month in the 1995 Behavioral Risk Factor Surveillance System.[79] For this reason, prenatal alcohol consumption has since been removed from the U.S Standard Certificate of Live Birth. In the 2001 National Household Survey on Drug Abuse, reported rates of current illicit drug use were similar among white (4.0 percent) and black (3.7 percent) pregnant women.[80]

Intergenerational Health

Several studies have found strong associations between parents' (generally mothers') birth weight and the birth weight of their child.[81] A recent study comparing maternal cousins (children whose mothers are sisters), and thus filtering out much of the confounding effect of socioeconomic status, found that maternal and paternal low birth weights together explain a much larger share of the racial disparity in low birth weight than do individual characteristics and socioeconomic variables combined.[82] This finding suggests that there is a biological transmission of low birth weight across generations, which may contribute to racial differences in low birth weight. This is an important finding that can be used to target interventions, but given the strong association between birth weight and socioeconomic status, it should not be used to dismiss racial disparities as immutable.

Promising Directions for Future Research on Risk Factors

Other risk factors warrant further study and ultimately may offer strategies for reducing rates of low birth weight and narrowing racial disparities in low birth weight and school readiness. For the most part, research on these risks is in its infancy, and the associations being explored should not be interpreted as causal.

MATERNAL LIFESTYLE. Despite the beneficial effects of employment on income, mothers who work in strenuous occupations, including those that involve prolonged standing, are at heightened risk for both preterm delivery and having low birth weight babies.[83] Occupational exposures to toxic substances and solvents have also been linked

to preterm delivery.[84] Given that a greater share of black women than white women (in 2002, 9 percent as against 5 percent) in the United States work as operators, fabricators, and laborers, black mothers may be more likely than white mothers to encounter strenuous working conditions and toxic exposures.[85]

NEIGHBORHOODS. Living in a poor neighborhood may pose health risks above and beyond those associated with individual poverty. Houses and other buildings in poor neighborhoods tend to be old and in poor condition; environmental toxins tend to be high; and access to medical care and other services tends to be limited.[86]

One study of Chicago in 1990 found that living in different neighborhoods accounted for as much as 30 percent of the difference in mean birth weight between non-Hispanic blacks and whites, though it is unclear whether these "neighborhood effects" reflect social, economic, or physical characteristics of neighborhoods or unobserved individual-level risk factors that vary by neighborhood.[87] Neighborhood socioeconomic characteristics, such as census tract–level income, are important predictors of low birth weight, even after controlling for many individual-level characteristics.[88] In Chicago, violent crime in neighborhoods has been found to have a negative association with birth weight, while a combined measure of social interaction and community involvement has a positive association.[89] Many studies have linked low birth weight to residential environmental exposures, including air pollution, substances in drinking water, and industrial chemicals.[90] Three-quarters of the residents of high-poverty neighborhoods in the United States are minorities, and the number of blacks living in poor areas increased from 2.4 million in 1970 to 4.2 million in 1990. Thus black women are at high risk for delivering low birth weight babies on the basis of the neighborhoods in which they live.[91]

PATERNAL FACTORS. Finally, a growing body of research suggests that paternal behaviors and occupational exposures before conception may affect infant health. Male reproductive toxicity can have three mechanisms—nongenetic (seminal fluid), genetic (gene mutations or chromosomal abnormalities), and epigenetic (effects on gene expression, genomic imprinting, or DNA methylation).[92] One study linked paternal drinking and low birth weight, but its finding has not been replicated.[93] Others have found associations between paternal smoking and low birth weight, although it is difficult to disentangle potential direct effects of paternal smoking from indirect effects through maternal exposure to secondhand smoke.[94] Paternal occupational exposures are also a risk factor. Excess rates of preterm delivery, growth retardation, and low birth weight have been found in occupations that involve paternal exposure to pesticides, solvents, and lead.[95] In 2002, 28 percent of employed black men, as against 16 percent of employed white men in the United States, worked as operators, fabricators, and laborers, perhaps making black fathers more likely than white fathers to be exposed to toxic substances at work.[96]

Interventions

Child health policymakers and practitioners have implemented many programs both to prevent low birth weight and to improve the life chances of low birth weight babies, especially in the areas of school readiness and achievement. To the extent that the programs succeed, they could help narrow racial gaps in school readiness by as much as 3 to 4 percent, as noted.

Preventing Low Birth Weight

Recognizing the close links between low birth weight and socioeconomic status, policymakers have emphasized a strategy of expanding prenatal care eligibility and services for poor pregnant women. The expansion of Medicaid eligibility and outreach to pregnant women in the late 1980s and early 1990s increased access to prenatal care, improved services, and helped more women begin care earlier in their pregnancies.[97] Rates of both early and adequate use of prenatal care increased substantially between 1981 and 1998 for both blacks and whites, and, except for some groups of young mothers, racial disparities in the use of prenatal care decreased.[98] In 2000, 85.0 percent of white mothers and 74.3 percent of black mothers who gave birth in the United States began prenatal care in the first trimester of pregnancy; 3.3 percent of white mothers and 6.7 percent of black mothers had late or no prenatal care.[99] Nevertheless, the U.S. rate of low birth weight, even for singletons, has not declined—perhaps owing in part to the declining rate of fetal mortality—and remains higher than that of most other developed countries.

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It is difficult to ascertain the effectiveness of prenatal care in reducing low birth weight. Randomized controlled trials—the gold standard in such research—are rarely feasible because of ethical concerns about depriving women of care. In a rare randomized trial, Lorraine Klerman and colleagues compared augmented and standard prenatal care provided to Medicaid-eligible African American women. The augmented care improved women's satisfaction with care and knowledge about risk conditions but did not reduce the rate of low birth weight.[100]

Studies other than randomized controlled trials face several methodological challenges, including selection bias. With *favorable selection,* women with the best expected outcomes are the most likely to seek prenatal care and to do so early, so the estimated effect of care could be overstated. With *adverse selection,* women with the worst expected outcomes are most likely to seek care and to do so early, so the estimated effect of care could be understated.

Research on the effects of expanded Medicaid eligibility and services on birth weight has produced mixed findings. Collectively, studies indicate only modest positive effects, stronger among blacks than whites.[101] One reason for the inconsistent findings may be that prenatal care varies widely—in the services and interventions offered, in the settings in which it is provided, and in quality. Moreover, interventions targeted at low-income families often lose clients by attrition, and programs are not always implemented as intended. Two recent studies have found that legislated changes in providers—one through hospital desegregation in Mississippi in the Civil Rights era and another, more recently, through changes in Medicaid hospital payments in California—reduced rates of low birth weight among African American children.[102]

Unquestionably, prenatal medical care can benefit certain mothers and their babies enormously. All women, pregnant or not, should get preventive and regular medical care. But standard prenatal care cannot be expected to improve *aggregate* birth outcomes because most treatable medical conditions during pregnancy affect only a small proportion of women.[103] A recent comprehensive review found no evidence that prenatal educational or psychosocial services, home visiting programs, or any medical interventions, even those to prevent infections, prevented either preterm birth or fetal growth retardation.[104] Researchers have recently found that progesterone supplementation reduces preterm birth among women who have had a previous preterm birth, but studies of its effectiveness and safety are still ongoing.[105] One promising way to reduce aggregate rates of low birth weight is to reduce smoking.[106] Another is through better nutrition. Three recent studies found that participation in the Supplemental Nutrition Program for Women, Infants, and Children (WIC) raised birth weight.[107]

The point is not that prenatal care programs have no positive effects. Rather, variations in content, implementation, or compliance make it difficult to pinpoint their effects. They may improve maternal health by connecting mothers to the health care system. They may reduce fetal death. Those that include family planning and other psychosocial services that could affect future fertility and prenatal behaviors could, in turn, improve maternal or infant health and increase the use of pediatric care. At the minimum, women of childbearing age should receive standard medical care beginning well before pregnancy, as well as smoking cessation and nutritional services as needed. But prenatal care—even enhanced care—will not automatically offset a lifetime of maternal health disadvantages.

Improving Cognitive Outcomes Associated with Low Birth Weight

Practitioners have established many early intervention programs to enhance the cognitive development of low birth weight infants and to improve their school readiness. Many programs pertaining to low birth weight and school readiness have been designed as randomized clinical trials, making them relatively straightforward to evaluate.

A broad review of such interventions found modest success overall, with the most effective programs involving parents as well as children.[108] One such "two-generation" intervention, the Infant Health and Development Program (IHDP), targeted low birth weight premature infants at eight sites. In the treatment group, 377 children received two years of high-quality center-based care at ages two and three. Family support, including home visits and parent group meetings, was also provided. The 608 children in the control group received none of these services. Both groups received the same medical care.

Many researchers have examined the readiness-related effects, both cognitive and behavioral, of the IHDP. Jeanne Brooks-Gunn and her coauthors found that the mean IQ of the intervention group at age three was 93.6, while that of the control group was 84.2; and that heavier low birth weight infants benefited more than lighter infants (those weighing less than 2,000 grams).[109] For both black and white subsamples, children whose mothers had a high school education or less gained more from the intervention than those whose mothers had attended college, with the latter showing no significant enhancement in IQ scores at age three.[110] Several studies found

that the intervention improved cognitive scores at ages twenty-four months and thirty-six months, and one found lower (more favorable) behavior problem scores at twenty-four and thirty-six months.[111] Children who had large gains on IQ score, cognitive skills, school achievement, and behavior at age three, however, generally did not sustain the gains at age eight, although the heavier low birth weight intervention group still outscored the control groups on measures of cognition and school achievement.[112] And another study found that children at age eight who had attended the program for at least 400 days scored 7 to 10 points higher on IQ tests than those in the control group. Again, effects were greater for the heavier low birth weight infants (about 14 points) than for the lighter low birth weight infants (about 8 points).[113]

Combining home visits with hospital-based intervention also appears to be effective in enhancing the cognitive function of low birth weight children. In a randomized controlled trial of an intervention in Vermont that provided four home visits and seven hospital sessions, the experimental low birth weight group scored higher on several standardized tests at age seven than did a control group that received no treatment; differences in outcomes first became statistically significant at age three.[114] The experimental group also scored as high as a normal birth weight comparison group. A recent review of interventions targeting socially deprived families concluded that home visits accompanied by early stimulation in the neonatal unit, as well as by preschool placement, appeared to improve the cognitive development of low birth weight and premature children.[115]

In sum, early intervention can improve the cognitive and behavioral development of low birth weight children. Two-generation programs, which serve both mothers and children, and those that combine home visits with either center-based day care or hospital-based therapy appear particularly effective, with more pronounced gains for heavier low birth weight children.

Implications and Recommendations

The message of this article is mixed and cautious. Although racial disparities in low birth weight are large and persistent, they explain, at most, 3 to 4 percent of the racial gap in IQ scores. Resolving the problem of low birth weight will thus close only a small portion of the racial gap in school readiness. The adverse cognitive outcomes associated with low birth weight are being addressed successfully by several types of early intervention programs, but their benefits are greatest for heavier children, whereas it is the lightest children who are at the greatest risk.

Overall, there is both good and bad news about low birth weight. The encouraging news is that over the past two decades

- Infant mortality rates among both blacks and whites have declined.
- Birth weight–specific survival rates of both black and white infants have increased dramatically.
- Birth weight–specific survival rates show no racial disparities. Black and white infants appear to benefit equally in terms of survival, at least in the aggregate, from neonatal care technology.
- Thanks to public health campaigns and the Medicaid expansions of the 1980s and 1990s, levels of prenatal care use are high among both blacks and whites.

The discouraging news is that

- Black babies continue to be twice as likely as white babies to die before their first birthday. Despite declining infant mortality rates among both blacks and whites, the infant mortality rate among blacks in 2000 was still higher than that among whites twenty years earlier. Although the absolute racial gap in infant mortality has narrowed somewhat, the proportional gap has increased by half.

- Rates of low birth weight in the United States have not declined over the past twenty years—overall, for blacks or for whites. This apparently bad news may be due, at least in part, to declining rates of fetal death. However, the aggregate rate of low birth weight in the United States exceeds that of most other developed countries.

- Black babies continue to be twice as likely as white babies to be low birth weight. Racial disparities are most pronounced at the lowest birth weight ranges—those associated with the poorest child health and developmental outcomes.

I offer several recommendations for improving maternal and child health generally and for combating low birth weight as a way to reduce racial disparities in school readiness. First, policymakers and practitioners must focus on maternal health risks well before conception. It is extremely difficult, if not impossible, to counteract a lifetime of disadvantage during the gestational period. The emphasis must be on women's health rather than on prenatal care. Many analysts have made this same point, but its importance cannot be overemphasized. Second, researchers must pay more attention to maternal and paternal environmental exposures and to the biological role of fathers, more broadly, in infant health and child health and development. Third, reducing rates of low birth weight would improve cognitive and behavioral outcomes among the entire population of school-aged children. At the same time, it would narrow racial gaps in school readiness, particularly if it were part of a multipronged, integrative approach focusing on the many inputs to school readiness reviewed in this volume.

Although the 3 to 4 percent potential contribution of low birth weight to the racial gap in IQ scores may not seem large, eliminating one source of the disparity is a step in the right direction. Moreover, beyond the question of school achievement, low birth weight is a problem that must be addressed to meet the national goals of increasing quality and years of healthy life and eliminating racial, ethnic, and socioeconomic disparities in health.[116]

Early intervention can and has improved cognitive and behavioral outcomes among low birth weight children. Ideally, such interventions should be available to all children who could benefit. That said, they appear to be of greater benefit to heavier low birth weight children than to lighter ones. Because black infants are more likely than white infants to fall into the lowest weight ranges, *preventing* low birth weight—when we learn how to do so—is likely to be more effective than remedial intervention at narrowing racial gaps in school readiness.

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15. In 2000 the 2:1 ratio was present in the following maternal age groups: twenty to twenty-four, twenty-five to twenty-nine, thirty to thirty-four, thirty-five to thirty-nine, and forty to forty-four. The disparities are narrower for very young and very old mothers. For mothers younger than fifteen, the black-white low birth weight ratio is 1.4, for mothers aged fifteen to nineteen it is 1.7, and for mothers forty-five to fifty-four it is

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