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Birth Weight Has Increased Over a Generation

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The authors examined secular trends in birth weight for a geographically defined population over 40 years, controlling for migration effects. The study was an analysis first of all Illinois births between 1950 and 1990 and second of a subset of births for which two succeeding generations were born in the state. For the latter analysis, the authors created a transgenerational birth file by linking infant birth records to the birth records of their parents. Shifts toward bigger babies were observed in both data sets. For black births, the shift was larger in the transgenerational file; but for white infants, similar magnitude shifts were observed in the two files. In both analyses, there were larger birth weight shifts for whites than for blacks. Mean birth weight increases within families ranged from 33 g (black male infants compared with their fathers) to 74 g (white female infants and their mothers). The rate of births at very low birth weight (<1,500 g) decreased by 6% in the white population but increased by 56% in blacks. Results presented in this study demonstrate that even when migratory effects are eliminated, a secular increase in birth weight is observed. Moreover, the left tail of the birth weight distribution does not always follow the same temporal trend observed for the mode. *Am J Epidemiol* 1996;144:563–9.

birth weight; infant, low birth weight; infant, small for gestational age

Birth weight has remained one of the most pertinent tools for assessing the health status of populations because it is a strong predictor of infant morbidity and mortality (1–5). Factors that affect birth weight are multiple and include health, sociobehavioral, economic, geographic, and possibly genetic variables (1, 6–11). Several studies have shown that the birth weights of populations continually change over time. Mostly, the changes are toward bigger babies (12–14), reflecting increments in median birth weight values on the order of 40–100 g over decades (15). However, Lee et al. (16) reviewed US national natality data of 1950 and 1975 and found no improvement in the percentage of low birth weight births (< 2,500 g). Wilcox and Russell (4) have shown that comparing birth weight distributions by their means can give the opposite result from that obtained by comparing the low weight extremes of the same distributions. It remains unclear whether the lack of improvement in low birth weight described by Lee et al. represents the different behavior of different components of birth weight as suggested by the work of Wilcox and Russell or some other phenomenon, such as changing reporting practices (17).

Another largely unexplored factor in secular changes in birth weight is the impact of migration, which can cause significant changes in a birth population over time. Martyn et al. (18) demonstrated that individuals who migrated from their county of birth in Britain were of higher birth weight on average than those who did not. This finding is part of the broader phenomenon of selective migration of populations, resulting in skewing of geographically collected health statistics (19). Prior large scale studies of secular shifts in birth weight have not controlled for effects of selective migration. Selective migration of women bearing large children into regions of the United States, for example from Mexico or Eastern Europe into the Chicago metropolitan area, could result in a shift toward higher birth weights without any real change in the baseline population.

We used birth weight data published by the National Center for Health Statistics from 1950 onward to examine birth weight trends over several decades for all births in Illinois. Changes in registration and reporting of low birth weight births are not likely to have changed as much in this state as in some others inasmuch as 99.5 percent of all births occurred in hospitals as early as 1950 and the National Center for Health

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Abbreviations: LBW, low birth weight; VLBW, very low birth weight.

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Statistics estimated underreporting of live births in Illinois at only 1 percent that year (20). In addition, we used the excellent Illinois computerized birth records dating back to 1956 to examine weight trends across two generations within families residing in the state.

MATERIALS AND METHODS

We obtained data used in the first part of this study from the annual natality volumes of the Vital Statistics of the United States between 1950 and 1990 (21). We computed the low birth weight (LBW) (<2,500 g) and very low birth weight (VLBW) (<1,500 g) rates of whites and blacks in Illinois and the United States to observe the trends of these rates over time. Until 1969, blacks were summed with other nonwhite racial groups. Birth weight distribution curves were also generated for both race categories using the years 1950, 1965, 1976, 1985, and 1990. Birth weight was in 500-g categories with less than 500 g being the first group except for years between 1952 and 1963, when less than 1,000 g was the initial weight group.

To eliminate the effects of migration on birth weight patterns for the state over time, we examined birth weight trends within Illinois families residing in the state over at least a generation using a transgenerational birth file. To produce this file, we obtained approximately five million computerized birth records from the Illinois Department of Vital Statistics—all births between 1956–1976 and 1989–1991. We then matched birth records of babies born between 1989 and 1991 (the infant generation) to those of their parents born in Illinois between 1956 and 1976 (the parent generation), using a matching technique similar to that applied by Klebanoff and Yip (22) to Kentucky births. There were 338,028 potentially matchable infants whose mothers were born in Illinois. We were able to link 267,604 (79 percent) of these infants to the birth records of their mothers by using her first name, last name, and exact date of birth. Of the 267,604 mother-infant pairs, 152,562 had fathers born in Illinois. Of these, 128,152 (84 percent) were successfully linked to the mother-infant records, yielding the final data set for analysis (23). Failure to match often arose from minor spelling variations in parent and infant records. Matching efficiency was also influenced by certain social and demographic factors. For example, it was easier to match fathers who were older, married, more educated, white, and resided outside Chicago. Nonetheless, even for black infants born to unwed parents, matching was 53 percent complete. Duplicate matches occurred in 0.09 percent and were eliminated (23).

Analysis

From the appropriate Vital Statistics tables for each year, we added up the number of VLBW and LBW births and divided these by the total births with known birth weight (about 99.9 percent of births for most years) to obtain the corresponding proportions. The values for the races were analyzed separately for both the state and the United States. Birth weights are also presented as complete frequency distribution curves.

Using the transgenerational file, we repeated tabulations for each race by 250-g category to construct similar distribution curves. We also computed mean birth weights for each race and sex subgroup so that we could compare birth weights of female infants with their mothers' birth weights and the males' with their fathers'. Because of the artificial skewing of the parent generation birth weight distribution, both infant and parent generations were truncated at 1,500 g before means were calculated. This skewing results from the failure of the smallest babies to survive infancy during the years 1956–1976. Mortality rates for infants born <1,500 g during the 1960s and 1970s were in the range of 20–60 percent (14). Because of the high mortality rate of these births, fewer of these babies would have survived to procreate, thus never appearing in the transgenerational file. This causes the birth weight distribution of the parent generation of the transgenerational file to be attenuated at the lower end. By truncating both generations at 1,500 g, we accept a slight shift toward higher mean weights in both parents and infants but eliminate the biased shift (for the parent generation only) present in the raw transgenerational file.

We were unable to evaluate whether very low birth weight rates were affected by migration inasmuch as the birth weights of parents in the transgenerational file are skewed away from the lower weight categories, as described above.

RESULTS

As shown in figure 1, the LBW rate for blacks in Illinois paralleled that for all US black births, first rising from 1950 to the late 1960s, declining from the 1970s until the mid-1980s, then showing an apparent rising trend once again into the 1990s. There was a similar rise in LBW rates for whites up until the late 1960s after which there has been a decline. In figure 2 are shown trends in the lowest weight groups, live births weighing 1,500 g or less. The proportion of these tiniest births rose 56 percent (from 1.99 to 3.10 per 100 births) for blacks but fell 6 percent for whites (from 1.02 to 0.96) over the period of study. In figure 3, A and B, are shown the behavior of the entire birth

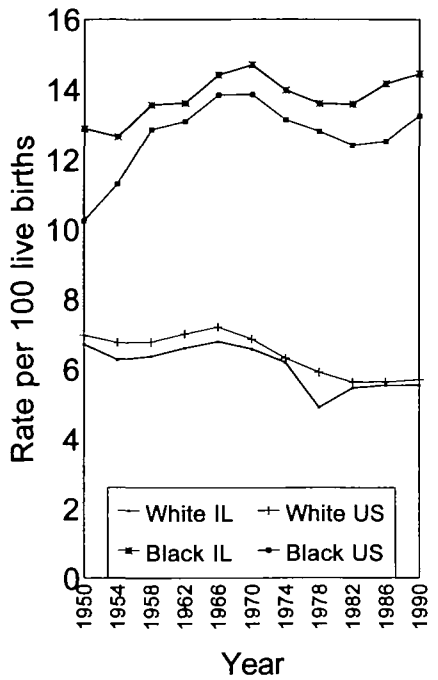

FIGURE 1. Four-decade trends in low birth weight rate in the United States and in Illinois.

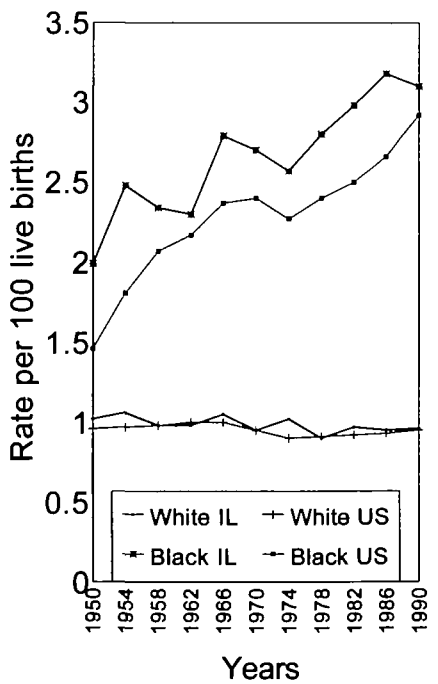

FIGURE 2. Four-decade trends in very low birth weight rate in the United States and in Illinois.

weight distributions for Illinois black and white births over time. Unlike the behavior of the LBW tail, the mode and upper end of the distributions shifted toward heavier weights over the four decades of observation. The shift was positive for infants of both races, although its magnitude was somewhat greater for whites. The proportion of Illinois black births greater than 3,500 g increased from 22.0 to 23.5 per 100 live births over the four decades shown, a 6.8 percent rise. The corresponding values for Illinois whites were 37.5–44.9 per 100 live births, an increase of 19.7 percent.

The shifts in birth weight distributions of the infants (1989–1991) compared with their parents (1956–1976) from the transgenerational birth file are shown in figure 4, A and B. There was a rightward shift in the mean and mode of the distributions in both races, but the shifts were more pronounced for whites than for blacks. We found larger birth weight shifts for black infants in the transgenerational file (figure 4A) than we had observed in the complete Illinois birth files (figure 3A). The corresponding shifts for white infants were more similar in magnitude (figures 4B and 3B, respectively). The rise in the proportion of births weighing more than 3,500 g in the infant generation compared with their parents was from 24.0 to 26.4 per 100 live births for blacks and from 40.6 to 46.5 per 100 live births for whites, increases of 10.0 and 14.5 percent, respectively.

The observed rightward shift in the distributions was reflected in an increase in mean birth weight when babies from the infant generation were compared with parents of the same sex. In table 1, the mean birth weights and the differences between the two generations according to sex and race are shown. The increase ranged from 33 g (between black fathers and their sons) to 74 g (between white mothers and their daughters). The p values are highly significant in all groups. Males were always heavier than females and whites, heavier than blacks. The difference in mean birth weight between the two racial groups was 256 g in the infant generation, an increase from the 230-g difference between blacks and whites in the parent generation.

DISCUSSION

We observed an upward trend in birth weights in Illinois over a 40-year period. However, the shift in weights was inconsistent. The mode of the birth weight curve moved to the right for both blacks and whites, but reductions in the proportion of very low birth weight infants declined only for whites. When the analysis was repeated comparing births in succeeding generations of the same families, mean birth weight increased among blacks and whites of both sexes over the two generations.

Using the transgenerational birth file, we can conclude that the increase in mean birth weight was not caused by migration effects. Indeed, for blacks, weight

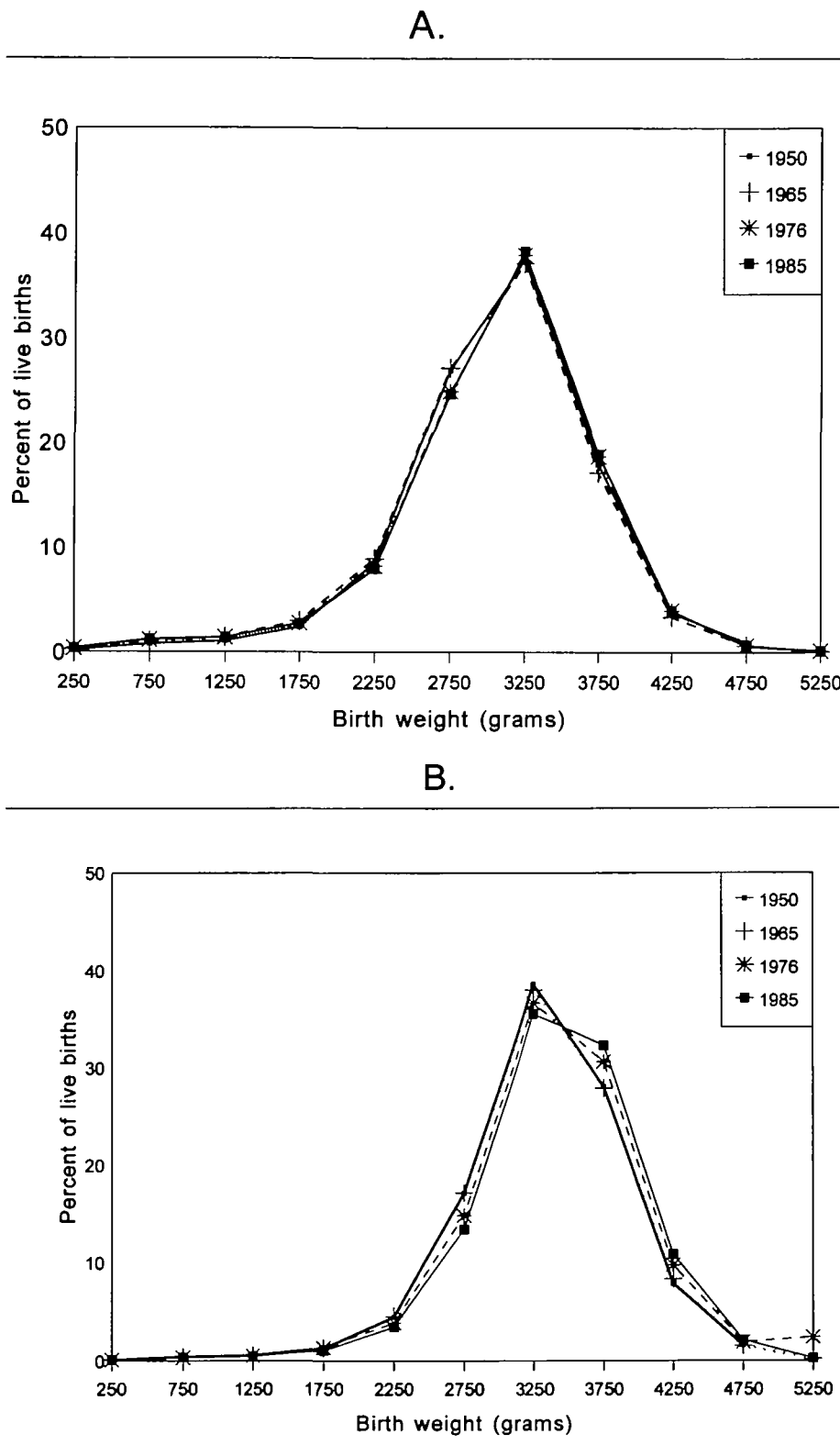

FIGURE 3. A, birth weight distributions of all black Illinois births, 1950–1985. B, birth weight distributions of all white Illinois births, 1950–1985.

shifts in the transgenerational file were more striking than in the overall geographically defined population, the opposite of what we would have expected had an influx of higher birth weight families into Illinois

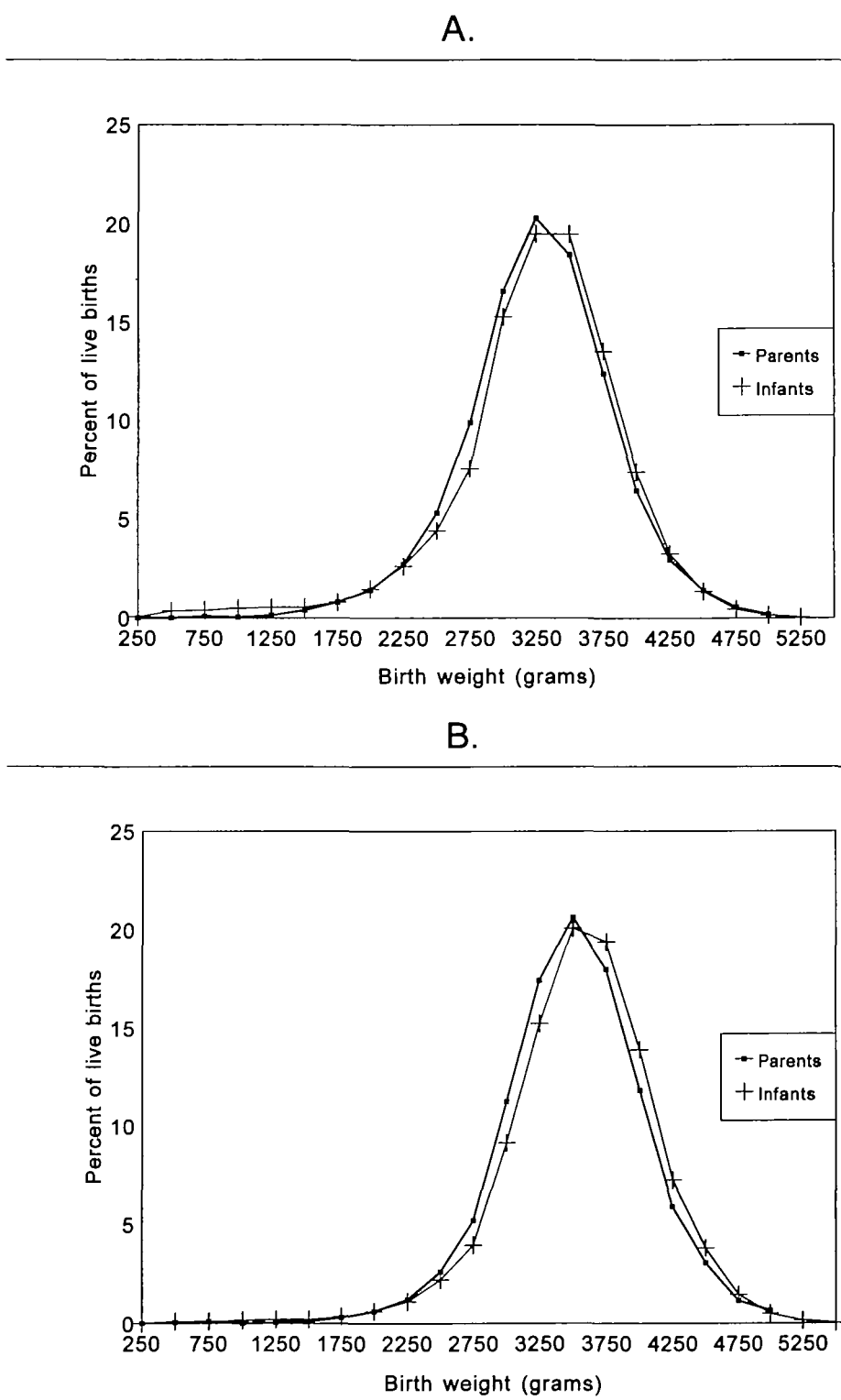

FIGURE 4. A, birth weight distributions in the Illinois transgenerational file for black infants (born in 1989–1991) and their parents (born in 1956–1976). B, birth weight distributions in the Illinois transgenerational file for white infants (born in 1989–1991) and their parents (born in 1956–1976).

contributed to the overall weight change during the period of study. Migration over the period of observation was significant. Black births in the state increased from 19,899 to 37,596, an 89 percent increase,

TABLE 1. Mean birth weight of parents and infants from the Illinois transgenerational file of all linked births between 1956–1976 and 1989–1991

Group (birth years)	White (g)	Black (g)
Mothers (1956–1976)	3,304	3,089
Baby girls (1989–1991)	3,378	3,133
Difference	74*	44*
Fathers (1956–1976)	3,461	3,217
Baby boys (1989–1991)	3,516	3,248
Difference	55*	31**

* $p < 0.0001$.
** $p < 0.0002$.

between 1950 and 1968. This change was a reflection of the major northern migration of African-Americans to urban centers in the North from predominantly rural communities in southern states, most notably Mississippi and the Carolinas (17). Later migrations of comparable magnitude involved ethnic groups classified as white, immigrations from Latin America and Eastern Europe. Births to these groups of mothers rose from 3.7 to 12.5 percent of all Illinois white births between 1955 and 1981 (21). Thus, our inability to demonstrate an effect of immigration of healthier mothers does not result from the lack of immigration into the Illinois population. Our findings suggest that the effects of selective migration on secular changes of the birth weight curve are either quantitatively insignificant or more complex than the "healthy immigrant" hypothesis would suggest. In fact, it has been suggested that selection toward less healthy immigrants may exist side by side with its opposite (19).

To some extent the better birth weight shift observed in the linked file compared with the unselected state birth file may be limited by the built-in selection bias in constructing the transgenerational file. Our analysis of that file shows that infants for whom match was unsuccessful were more likely of low socioeconomic status and thus more prone to low birth weight (23). This would not weaken the main finding, namely that the best improvement over time in birth weights is seen in subpopulations that have not been improved by addition of "healthy immigrants." However, it limits that conclusion somewhat in that it is based on observations confined to the less disadvantaged portion of the population.

The birth weight frequency of a population usually assumes a near normal or Gaussian distribution with a slight skew to the left. Although general convention uses 2,500 g as the lower limit of "normal" birth weight, it has become evident that morbidity and mortality risk are concentrated at very low birth weight (24–26). Wilcox (11) has shown that the birth weight distribution curve of any population can be separated into two component distributions. One is a perfectly symmetrical Gaussian curve defined by two parameters, the mean and the variance. The other component distribution is referred to as residual births and is defined by a parameter called "p," which represents the proportion of births that is responsible for the leftward skew of a typical birth weight curve thereby preventing it from having a perfect Gaussian configuration. Wilcox and Russell (4) showed that the <1,500-g births are mostly part of this "p" population. However, births in the moderately low birth weight range are mostly part of the underlying normal distribution (4). When population birth weight comparisons are undertaken, the two components of the birth weight curve should be considered because they may vary independently. For example, female babies have a lower mean birth weight than male babies and thus, a higher LBW rate. However, the percentage of females in the residual distribution, "p," is less than for males, which is why their mortality is lower (27).

Kleinman and Kessel (10) found it informative to look at low birth weight as being comprised of two components, the very low birth weight (<1,500 g) and moderately low birth weight (1,500–2,500 g) (10). They found that moderately low birth weight was more common among mothers with less education while very low birth weight increased with teenage births and high parity. The unwed state had the same negative effect on both moderately low and very low birth weight rates.

Our study adds to these earlier observations. Not only can the two components of the birth weight distribution be distinguished as having different risk factors, as Kleinman and Kessel showed, but also there can be different patterns of variation between populations defined by sex, ethnicity, or social class, as demonstrated by Wilcox and Russell. Our findings indicate that these two components of the birth weight distribution may show different secular trends for a given population as well, as we found for black births in Illinois over the past generation.

The reasons for deteriorating VLBW rates among black women remain unclear. Biased underreporting, in particular differences in assigning tiny babies to the "live birth, early neonatal death" versus "fetal death" category, depending on hospital of delivery, has been reported previously (28). However, such misassignment is unlikely in our population inasmuch as trends in the reported rates of extremely low birth weight fetal deaths by race parallel the live births trends rather than showing a mirror image trend (expected in the case of changing reporting practices). The <1,000-g stillbirth rates for Illinois whites in 1955 and 1987 were 3.0 and 2.5 per 1,000 births, respectively. The

corresponding values for Illinois blacks were 4.0 and 5.7 per 1,000 births (21). Evidence points to the disquieting conclusion that some key measures of black infant health are indeed worsening. A number of social trends have had a more adverse impact on blacks than on whites over the previous decades (29), and a reflection of this in birth outcomes would not be unexpected (30–32).

Our findings lend little support for the importance of migration in explaining secular trends toward greater mean birth weights in populations. Studies focusing on the social, nutritional, or cultural environments of various ethnic subpopulations may elucidate the basis of these secular birth weight changes. Such studies must analyze behavior of the VLBW end of the birth weight distribution separately from the mode and upper end of the curve. The widening gap in US black and white perinatal mortality can only be narrowed after factors that lead to the increasing excess VLBW births for blacks are identified and eliminated.

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