Matern Child Health J (2011) 15:29–41
DOI 10.1007/s10995-010-0570-2

Changing Trends in Low Birth Weight Rates Among Non-Hispanic Black Infants in the United States, 1991–2004

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Published online: 29 January 2010

Abstract We examined trends in low birth weight (LBW, <2,500 g) rates among US singleton non-Hispanic black infants between 1991 and 2004. We conducted Joinpoint regression analyses, using birth certificate data, to describe trends in LBW, moderately LBW (MLBW, 1,500–2,499 g), and very LBW (VLBW, <1,500 g) rates. We then conducted cross-sectional and binomial regression analyses to relate these trends to changes in maternal or obstetric factors. Non-Hispanic black LBW rates declined −7.35% between 1991 and 2001 and then increased +4.23% through 2004. The LBW trends were not uniform across birth weight subcategories. Among MLBW births, the 1991–2001 decease was −10.20%; the 2001–2004 increase was +5.61%. VLBW did not follow this pattern, increasing +3.84% between 1991 and 1999 and then remaining relatively stable through 2004. In adjusted models, the 1991–2001 MLBW rate decrease was associated with changes in first-trimester prenatal care, cigarette smoking, education levels, maternal foreign-born status, and pregnancy weight gain. The 2001–2004 MLBW rate increase was independent of changes in observed maternal demographic characteristics, prenatal care, and obstetric variables. Between 1991 and 2001, progress occurred in reducing MLBW rates among non-Hispanic black infants. This progress was not maintained between 2001 and 2004 nor did it occur for VLBW infants between 1991 and 2004. Observed population changes in maternal socio-demographic and health-related factors were associated with the 1991–2001 decrease, suggesting multiple risk factors need to be simultaneously addressed to reduce non-Hispanic black LBW rates.

Keywords Non-Hispanic blacks · Low birth weight · Preterm birth · Trend analyses · Prenatal care · Socioeconomic status

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

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Introduction

Reducing the high rates of adverse pregnancy outcomes, including low birth weight (LBW, <2,500 g) and preterm birth (PTB, gestational age <37 weeks), among non-Hispanic

black infants in the United States has been a focus of public health initiatives and clinical interventions over the past two decades [1–3]. Low birth weight and preterm birth are risk factors for infant mortality and morbidity and are also associated with increased risks for several adult chronic diseases [1, 4, 5]. In the US, non-Hispanic black infants continually have LBW and PTB rates that are above national averages. In 2004, the LBW rate for all non-Hispanic black infants was 13.7% (compared to a national average of 8.1%); the PTB rate for blacks was 17.9% (compared to a national average of 12.5%) [2].

Previous studies [6–13] of trends in non-Hispanic black rates of LBW or PTB have generally shown decreases during the 1990s although two studies [14, 15] showed an increase in the percentage of preterm, small for gestational age infants. We found no analyses of LBW or PTB trends after 2002 other than annual vital records reports [2]. However, there are questions about how misclassification or changes in gestational age measurement may have affected black PTB trends during the 1990s [12, 16–19].

Because of these questions regarding gestational age measurement among black infants, an examination of LBW trends may be informative. Birth weight has been measured more consistently and reliably over time, and with fewer missing values, than gestational age in vital statistics datasets [2, 20, 21]. Moreover, many public health programs at local, state, or national levels during the last two decades specifically sought to improve fetal growth by increasing access to prenatal care, reducing smoking, and improving maternal pregnancy weight gain and nutritional status [22–26]. There were also significant changes in welfare policy and in economic status which may have influenced perinatal outcomes for non-Hispanic blacks infants.

The risk factors for LBW are multifactorial and are reviewed elsewhere [2, 27, 28] Categorically these include factors at the individual, social, and community levels, including demographic (e.g., foreign-born, teens, older mothers); fertility (e.g., assisted reproductive technologies, changes in induced abortion rates); substance use (e.g., smoking); socioeconomic (e.g., low education, income/poverty); environmental (e.g., environmental tobacco smoke, air pollution); psychosocial (e.g., stress, racism); infectious (e.g., bacterial vaginosis); obstetric history (e.g., prior LBW/PTB); medical (e.g., obesity, chronic disease); nutritional (e.g., low pregnancy weight gain); health care (e.g., inadequate prenatal care, induction, c-section); and neighborhood (e.g., income inequality) factors. While the prevalences of many of these risk factors are generally higher among the black population, the effects of population changes in these factors on trends in LBW rates among non-Hispanic black infants need to be examined.

In this study, we describe recent trends in LBW rates among non-Hispanic black infants and the association of these trends with changes in the distribution of multiple maternal and obstetric factors, as available in vital statistics records.

Methods

Data

We conducted a cross-sectional and trends study of singleton births to US resident, non-Hispanic black women from 1991 to 2004 using the National Statistics Vital Records natality public use data files. We selected 1991 as the initial year of our study because it was the first year Hispanic origin was reported by 49 states. (Although New Hampshire did not report Hispanic origin in 1991, less than 0.1% of the state's population was Hispanic) [29]. We selected 2004 as the final year because the 2005–2006 public use datasets do not include variables on maternal birth place or metropolitan residence.

We used the race/ethnicity variable to identify women as non-Hispanic black. In 2003, the birth certificate was revised to include the option of multiple race coding. For states with multiple coding, we used the "bridged" racial/ethnic classification in 2003 and 2004, as reported in the final natality reports. The bridged classification recodes multiple races into categories comparable with earlier data.

Birth weight was missing from the records of approximately 0.1% non-Hispanic black infants. After excluding these records, there were 8,162,756 eligible births from 1991 through 2004. The largest yearly birth cohort was 647,246 in 1991; the smallest was 554,747 in 2003.

We examined trends in the percentages of LBW, moderately LBW (MLBW, 1,500–2,499 g), and very LBW (VLBW, <1,500 g) and changes in the distribution of selected maternal demographic, obstetric history, prenatal care, antepartum medical risk factors, and obstetric procedure variables between 1991 and 2004. Demographic factors included maternal age, education, birth place, metropolitan county residence, marital status, and any tobacco smoking during pregnancy. Obstetric history and prenatal care (PNC) variables were parity, previous LBW/PTB infant, first-trimester PNC use, and the Adequacy of Prenatal Care Utilization Index (APNCU) [30, 31]. We classified parity as primiparous, low parity, or high parity [29, 32]. The original APNCU has four categories: inadequate, intermediate, adequate, and intensive (adequate plus) [30, 31] We included the "intermediate" PNC subgroup within the "inadequate" subgroup, thus creating a variable to distinguish all mothers without adequate care (inadequate) from those with at least adequate care (adequate or intensive).

We categorized pregnancy weight gain as <15, 15–40, and ≥41 lbs. Because information on maternal height and pre-pregnancy weight was not collected nationally before the 2003 birth certificate revision, we could not calculate the body mass index (BMI) for all years. Thus, we focused on women who gained <15 or ≥41 lbs since these categories were independent of BMI in the Institute of Medicine guidelines for this time period [24].

We considered preterm birth (yes, no) as a potential intervening variable in our analyses. To assess this, we used gestational age as reported in annual vital statistics reports and derived by the National Center for Health Statistics from an algorithm which uses the date of the last menstrual period, in comparison to birth weight, and the clinical estimate of gestation length [2]. To correct for potentially misclassified gestational ages, we used the Alexander method and considered births above the 95th percentile of the birth weight—gestational age distribution for gestational ages between 20 and 44 weeks as implausible (recoded to unknown) [33].

The birth certificate was revised in 2003. By the end of 2004, the 2003 birth certificate version had been implemented in nine states [Florida, New Hampshire, Idaho, Kentucky, New York (excluding New York City), Pennsylvania, South Carolina, Tennessee, and Washington]. Data on PNC, education, and tobacco smoking collected from the 2003 version and from the 1989 version are not comparable [34]. Because of this limitation, when we compared 2004 data on maternal characteristics and obstetric variables with corresponding data from earlier years, we excluded data from the nine states that used the 2003 birth certificate version. For these subanalyses, this exclusion represented 21% of singleton births.

Statistical Methods

We used Joinpoint regression (version 3.0) to identify significant ($P < 0.05$) changes in the annual percentages of LBW, MLBW, and VLBW between 1991 and 2004 among all states. Details on Joinpoint regression are available elsewhere [35]. Briefly, Joinpoint regression determines changes in yearly linear trends, including the direction and amount of change, by modeling a series of potential straight line segments, connected at points called joinpoints. Joinpoints identify significant changes in linear trends. We used the Bayesian Information Criterion model selection method to select the Joinpoint model with the best fit to the observed data [33, 36]. Joinpoint regression estimated the average annual percent change (APC) in birth weight rates, with 95% confidence intervals (CIs), from the slopes of the regression trend lines. Because there are no standards for characterizing trends in perinatal epidemiology, we followed National Cancer Institute guidelines [37].

To assess changes in the distribution of the maternal characteristics and obstetric variables described above, we calculated the percentage distributions and APCs for selected years based on our results (1991, 2001, and 2004).

We used multivariable binomial regression, with the log link function, to assess the effects of potential confounders on the changes in outcome rates between the selected years (exposure) and to calculate adjusted prevalence rate ratios [38]. Each potential confounder was individually examined in regression models with the birth year variable, as independent variables, to assess effects on the year variable coefficients. We then built multivariable models based on these results. Because potential confounders could increase or decrease the magnitude of trends, we first added variables that reduced the trend magnitude (toward the null prevalence ratio of 1.0) and then added remaining potential confounders in the following order based on univariable results and reliability concerns: maternal demographic characteristics; PNC, induction, and c-section; and obstetric history. To adjust for changes in fertility rates, we included the separately reported, year- and age-specific birth rates for non-Hispanic black women as an additional potential confounder in regression models [2].

Although several antepartum maternal complications increased in prevalence over time and are associated with increased risk of LBW, we do not report results for the confounding effects of these factors because of concerns about potential factors in etiologic pathways and about the reliability and validity of these variables on the birth certificate [20, 28]. We did not examine effect modification because the large sample size made most interaction terms statistically significant and thus difficult to interpret. Instead, we report stratified results indicating how outcome rates varied by selected characteristics.

In addition to the Joinpoint software, we used SAS (version 9.1) and Microsoft Excel 2003 for calculations.

Results

Between 1991 and 2004, the number of singleton non-Hispanic black births in the US declined 12%, from 647,246 to 566,831. The number of all births to non-Hispanic black women declined 13% over the same time period [2].

Using Joinpoint regression, we found a slightly decreasing trend in LBW rates among singleton non-Hispanic black infants from 1991 to 2001. The LBW rate declined from 12.15% in 1991 to 11.55% in 1996 (APC −0.92, 95% CI −1.25, −0.59) (Fig. 1). Between 1996 and 2001, the LBW rate declined more slowly, from 11.55% in 1996 to 11.19% in 2001 (APC −0.55, 95% CI −1.05, −0.03). Overall, the LBW rate decreased −7.35% from 1991 to

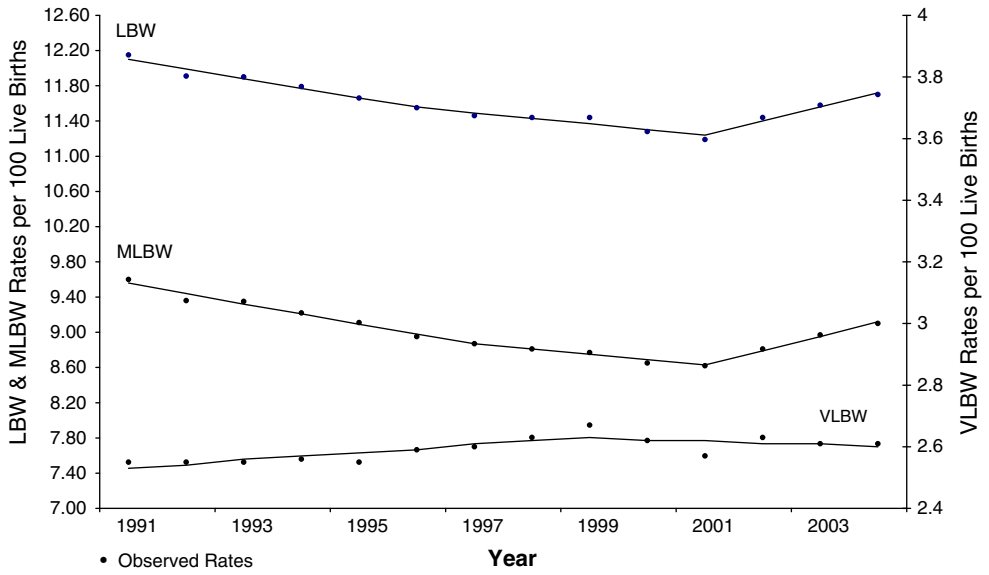

Fig. 1 Trends in birth weight outcomes, singleton births, US non-Hispanic black infants, all states, 1991–2004. *LBW* low birth weight (*left Y*-axis, %), *MLBW* moderately LBW (*left Y*-axis, %), *VLBW* very LBW (*right Y*-axis, %)

2001. The LBW rate then slightly increased from 11.19% in 2001 to 11.70% in 2004 (APC 1.41, 95% CI 0.59, 2.23), a total increase of 4.23%. Mean birth weight increased from 3,121 g in 1991 to 3,136 g in 2001 and then decreased to 3,115 g in 2004.

These trends were not uniform across birth weight subcategories. The trends in MLBW rates were similar to those of LBW. MLBW rates slightly decreased from 9.60% in 1991 to 8.87% in 1997 (APC −1.25, 95% CI −1.52, −0.97) and continued declining more slowly between 1997 and 2001 (APC −0.69, 95% CI −1.54, 0.18) (Fig. 1). The total 1991–2001 decline in MLBW rates was −10.20%. The MLBW rate then increased from 8.62% in 2001 to 9.10% in 2004 (APC 1.87, 95% CI 0.98, 2.76), a 5.61% increase (based on the Joinpoint APC). The VLBW rate increased minimally, from 2.55% in 1991 to 2.67% in 1999 (APC 0.48, 95% CI 0.22, 0.74), a total increase of 3.84% (based on the Joinpoint APC), and then was relatively stable through 2004 (Fig. 1). The APC for VLBW rates between 1999 and 2004 was −0.22 (95% CI −0.76, 0.33), a decrease of 1.1%.

Because our goal was to assess factors associated with changing trends over time, we focused the rest of our analysis on the 1991–2001 decrease and the 2001–2004 increase in MLBW rates since changes in MLBW rates explain the changes in LBW rates.

In examining demographic, prenatal care, and other health-related changes among non-Hispanic black mothers between 1991 and 2001 (all states) and 2001 and 2004 (selected states), we found the distribution of most characteristics changed (Table 1). Between 1991 and 2001, the percentage of mothers who were teenagers, were tobacco smokers, had <12 years education, or had inadequate prenatal care decreased (APC ≤ -1.5). The percentages of mothers ≥35 years, who were foreign-born, had >12 years of education, received first-trimester care, received adequate or intensive prenatal care, did not smoke, gained <15 or ≥41 lbs, or had diabetes, chronic or pregnancy-induced hypertension, lung disease, labor induction or c-section increased (APC ≥ 1.5). The PTB rate slightly decreased between 1991 and 2001 (APC −0.79). The percentage distributions in 2001 were similar between all states and the selected states.

For the 2001–2004 period, the earlier trends essentially continued, although the APCs were often quite different (Table 1). The percentages of non-Hispanic black mothers who were teenagers, had <12 years education, or were smokers still decreased (APC ≤ 1.5). The percentage of mothers with >12 years education, were foreign-born, gained <15 lbs, or who had diabetes, chronic hypertension, labor induction or a c-section still increased (APC ≥ 1.5). The PTB rate minimally increased between 2001 and 2004 (APC 0.36). The APCs for the increasing rates of first-trimester care and adequate PNC were lower in 2001–2004 compared to 1991–2001.

The 1991–2001 MLBW rate reduction occurred among all maternal education, marital status, birth place, smoking status, and PNC initiation subcategories (Table 2). The decrease in MLBW rates was observed only among infants classified as term births.

Between 2001 and 2004, most stratum-specific MLBW rates increased at least minimally, although rates were

Table 1 Percentage distribution and annual percent change in maternal characteristics, prenatal care, and obstetric procedures among non-Hispanic black singleton births, United States, 1991, 2001, 2004

Maternal characteristics	1991[a] ($N = 647,246$) %	2001[a] ($N = 568,849$) %	APC	2001[b] ($N = 449,409$) %	2004[b] ($N = 440,305$) %	APC
Age						
<20 years	23.44	19.18	−1.82	19.03	17.41	−2.84
20–24	32.16	33.02	0.27	32.92	32.65	−0.27
25–29	23.72	22.53	−0.50	22.55	23.75	1.77
30–34	14.39	15.43	0.72	15.59	15.98	0.83
35+	6.29	9.84	5.64	9.91	10.21	1.01
Education						
<12 years	29.80	24.53	−1.77	24.36	23.01	−1.85
12	42.02	39.23	−0.66	38.67	37.78	−0.77
>12	26.09	34.58	3.25	35.39	37.13	1.64
Unknown	2.09	1.66		1.58	2.08	
Married	31.77	31.29	−0.15	31.52	30.84	−0.72
Place of birth						
US	92.71	88.29	−0.48	89.18	87.85	−0.50
Foreign	6.78	11.28	6.64	10.40	11.76	4.36
Unknown	0.52	0.43		0.41	0.39	
Metropolitan county	85.16	87.38	0.26	86.86	87.26	0.15
Parity						
Primiparous	37.37	38.07	0.19	38.10	38.81	0.62
Low	36.55	36.31	−0.07	36.42	35.78	−0.59
High	26.07	25.62	−0.17	25.48	25.41	−0.09
Prior PTB/LBW						
Yes	1.31	1.42	0.92	1.32	1.20	−3.03
No	56.70	59.76	0.54	59.89	59.08	−0.13
Primiparous	37.37	38.07	0.19	38.10	38.81	0.62
Unknown	4.62	0.75		0.69	0.91	
1st trimester care						
Yes	59.78	71.97	2.04	72.46	73.96	0.69
No	36.93	24.83	−3.28	24.50	22.87	−2.22
Unknown	3.29	3.19		3.04	3.18	
Prenatal care adequacy						
Inadequate	41.30	31.00	−2.49	30.82	29.78	−1.12
Adequate	29.53	34.38	1.64	34.42	34.34	−0.08
Intensive	23.64	29.32	2.40	29.73	30.48	0.84
Unknown	5.53	5.31		5.03	5.40	
Tobacco smoking						
Yes	11.70	8.57	−2.68	8.44	7.81	−2.49
No	68.33	85.39	2.50	84.11	84.68	0.23
Unknown	19.98	6.04		7.46	7.51	
Weight gain						
<15 lbs	9.43	12.08	2.81	11.97	12.87	2.51
15–40	55.76	58.54	0.50	58.27	59.39	0.64
41+	10.97	15.69	4.30	15.55	15.45	−0.21
Unknown	23.84	13.70		14.21	12.29	
Diabetes	1.87	2.82	5.08	2.70	2.99	3.58

Table 1 continued

Maternal characteristics	1991[a] ($N = 647,246$) %	2001[a] ($N = 568,849$) %	APC	2001[b] ($N = 449,409$) %	2004[b] ($N = 440,305$) %	APC
Hypertension						
Chronic	1.00	1.45	4.50	1.39	1.71	7.67
Pregnancy-induced	2.50	3.96	5.84	3.85	3.87	0.17
Lung disease	0.47	1.60	24.04	1.52	1.56	0.88
Labor induction	7.11	17.31	14.35	16.76	18.03	2.53
C-section	20.55	24.51	1.93	24.52	29.31	6.51
Preterm birth						
Yes	16.04	14.77	−0.79	14.76	14.92	0.36
No	77.00	79.44	0.32	79.29	79.82	0.22
Unknown or excluded	6.96	5.79		5.95	5.27	

APC annual percent change, *lbs* pounds, *PTB/LBW* preterm birth/low birth weight

[a] All States

[b] We excluded data from Florida, Idaho, Kentucky, New Hampshire, New York State (not New York City), Pennsylvania, South Carolina, Tennessee, and Washington in our estimates of changes in variables between 2001 and 2004 because these states used the 2003 birth certificate revision in 2004

stable for mothers ≥35 years or who had labor induction. The MLBW rate increased among both preterm and term infants. High APC increases were observed among several low risk categories, particularly ages 25–29, low parity, first-trimester PNC, adequate PNC, and nonsmokers.

Between both 1991–2001 and 2001–2004, smaller magnitudes of trend changes (APCs) were observed for mothers with >12 years education or who were married, foreign-born, or primiparous (Table 2). Larger magnitudes of change for both time periods were observed for mothers with <12 years education or who were single or US-born.

Binomial Regression Results

For the 1991–2001 MLBW rate decrease, no observed variable singularly eliminated the observed trend. Increases in the prevalence of first-trimester PNC, maternal education, and foreign birth place were the single factors, without a high proportion of unknown values, which produced the largest reductions of the crude MLBW prevalence ratio (data not shown). When simultaneously entered into a multivariable model, these three factors resulted in an adjusted 1991–2001 MLBW rate decrease of −4.4% (Table 3, prevalence rate ratio (RR) of 0.956). When smoking and weight gain were added to this model, the decreasing trend was eliminated (RR of 1.019). Thus, the 1991–2001 MLBW rate decrease was associated with increases in the prevalences of first-trimester care, maternal education, and foreign-born mothers, decreases in maternal smoking, and pregnancy weight gain changes. Similar results were observed when the 1991–2001 binomial regression models were restricted to term infants (data not shown).

For the 2001–2004 MLBW rate increase, single adjustments for c-section, prenatal care adequacy, and weight gain were each associated with a slight reduction in the crude MLBW prevalence ratio (data not shown). After simultaneously adjusting for these three factors, our estimate of the 2001–2004 MLBW rate increase was reduced to 4.1% (Table 3, RR of 1.041). However, with the addition of other factors, the adjusted 2001–2004 increase in MLBW rates was 5.5% (RR of 1.055) and similar to the unadjusted increase of 5.9% (RR of 1.059) indicating adjustment for the risk factors listed had little effect on the observed increase.

Similar regression results were observed when all missing values were excluded from the 1991–2001 and the 2001–2004 models (data not shown).

Discussion

The US non-Hispanic black LBW rate slightly declined between 1991 and 2001 but then increased between 2001 and 2004. PTB trends showed similar patterns. The 1991–2001 *decrease* in LBW among non-Hispanic black infants is in contrast to the national singleton LBW rate for all racial groups together which consistently *increased* during this time period [2]. The decreasing 1991–2001 LBW trend was limited to MLBW infants, and possibly term MLBW infants. In contrast, the non-Hispanic black VLBW rate increased minimally from 1991 to 1999, and then remained stable through 2004.

Table 2 Stratified analysis of moderately low birth weight rates among non-Hispanic black singleton births, United States, 1991, 2001, 2004

	1991[a] (*N* = 647,246) %	2001[a] (*N* = 568,849) %	RR (95%CI)	APC	2001[b] (*N* = 449,409) %	2004[b] (*N* = 440,305) %	RR (95%CI)	APC
Crude Rate	9.60	8.62	0.90 (0.89, 0.91)	−1.02	8.63	9.13	1.06 (1.04, 1.07)	1.93
Maternal characteristics								
Age								
<20 years	9.95	9.86	0.99 (0.97, 1.01)	−0.09	9.88	10.74	1.09 (1.06, 1.12)	2.90
20–24	8.87	8.45	0.95 (0.93, 0.97)	−0.47	8.43	8.96	1.06 (1.04, 1.09)	2.10
25–29	9.19	7.45	0.81 (0.79, 0.83)	−1.89	7.48	8.23	1.10 (1.07, 1.13)	3.34
30–34	10.56	8.09	0.77 (0.74, 0.79)	−2.34	8.13	8.33	1.02 (0.99, 1.06)	0.82
35+	11.34	10.24	0.90 (0.87, 0.94)	−0.97	10.25	10.33	1.01 (0.97, 1.05)	0.26
Education								
<12 years	11.51	10.36	0.90 (0.88, 0.92)	−1.00	10.42	11.16	1.07 (1.04, 1.10)	2.37
12	9.44	8.72	0.92 (0.91, 0.94)	−0.76	8.77	9.35	1.07 (1.04, 1.09)	2.20
>12	7.55	7.22	0.96 (0.93, 0.98)	−0.44	7.19	7.60	1.06 (1.03, 1.08)	1.90
Marital status								
Married	7.27	6.92	0.95 (0.93, 0.97)	−0.48	6.93	7.25	1.05 (1.02, 1.07)	1.54
Single	10.68	9.39	0.88 (0.87, 0.89)	−1.21	9.41	9.98	1.06 (1.04, 1.08)	2.02
Place of birth								
U.S.	9.82	8.95	0.91 (0.90, 0.92)	−0.89	8.94	9.54	1.07 (1.05, 1.08)	2.24
Foreign	6.33	5.94	0.94 (0.89, 0.98)	−0.62	5.92	6.03	1.02 (0.97, 1.07)	0.62
Metropolitan county								
Yes	9.65	8.53	0.88 (0.87, 0.90)	−1.16	8.54	8.99	1.05 (1.04, 1.07)	1.76
No	9.31	9.21	0.99 (0.96, 1.02)	−0.11	9.20	10.10	1.10 (1.06, 1.14)	3.26
Parity								
Primiparous	9.44	9.38	0.99 (0.98, 1.01)	−0.05	9.38	9.74	1.04 (1.02, 1.06)	1.28
Low	8.90	7.58	0.85 (0.84, 0.87)	−1.48	7.57	8.21	1.08 (1.06, 1.11)	2.82
High	10.80	8.94	0.83 (0.81, 0.85)	−1.72	9.01	9.51	1.06 (1.03, 1.08)	1.85
Prior PTB/LBW	27.85	22.53	0.81 (0.77, 0.85)	−1.91	22.16	24.11	1.09 (1.02, 1.16)	2.93
1st trimester care								
Yes	8.49	8.17	0.96 (0.95, 0.98)	−0.38	8.16	8.73	1.07 (1.05, 1.09)	2.33
No	11.08	9.57	0.86 (0.85, 0.88)	−1.36	9.69	10.10	1.04 (1.02, 1.07)	1.41
PNC adequacy								
Inadequate	10.08	8.12	0.81 (0.79, 0.82)	−1.94	8.17	8.39	1.03 (1.00, 1.05)	0.90
Adequate	5.66	5.05	0.89 (0.87, 0.92)	−1.08	5.04	5.57	1.11 (1.07, 1.14)	3.51
Intensive	12.94	12.87	0.99 (0.98, 1.01)	−0.05	12.86	13.54	1.05 (1.03, 1.07)	1.76

Table 2 continued

	1991[a] (*N* = 647,246) %	2001[a] (*N* = 568,849) %	RR (95%CI)	APC	2001[b] (*N* = 449,409) %	2004[b] (*N* = 440,305) %	RR (95%CI)	APC
Smoking								
Yes	16.72	14.42	0.86 (0.84, 0.89)	−1.38	14.61	15.20	1.04 (1.00, 1.08)	1.35
No	8.36	8.10	0.97 (0.96, 0.98)	−0.31	8.12	8.64	1.06 (1.05, 1.08)	2.13
Weight gain								
<15 lbs	15.36	12.43	0.81 (0.79, 0.83)	−1.91	12.54	13.17	1.05 (1.02, 1.08)	1.67
15–40	8.98	8.64	0.96 (0.95, 0.98)	−0.38	8.68	9.15	1.05 (1.04, 1.07)	1.80
41+	4.02	4.86	1.21 (1.15, 1.26)	2.09	4.91	5.19	1.06 (1.01, 1.11)	1.90
Diabetes	7.70	8.60	1.12 (1.03, 1.21)	1.17	8.53	9.81	1.15 (1.06, 1.24)	5.00
Hypertension								
Chronic	16.96	16.99	1.00 (0.93, 1.08)	0.02	17.04	18.90	1.11 (1.03, 1.19)	3.64
Pregnancy-induced	17.35	20.00	1.15 (1.10, 1.20)	1.53	20.30	20.67	1.02 (0.98, 1.06)	0.61
Lung disease	12.43	10.24	0.82 (0.74, 0.92)	−1.76	10.37	10.81	1.04 (0.95, 1.15)	1.41
Labor induction								
Yes	10.00	8.33	0.83 (0.81, 0.86)	−1.67	8.39	8.33	0.99 (0.96, 1.03)	−0.24
No	9.54	8.68	0.91 (0.90, 0.92)	−0.90	8.68	9.31	1.07 (1.06, 1.09)	2.42
C-section								
Yes	10.17	10.11	0.99 (0.97, 1.02)	−0.06	10.09	10.53	1.04 (1.02, 1.07)	1.45
No	9.43	8.15	0.86 (0.85, 0.87)	−1.36	8.17	8.56	1.05 (1.03, 1.07)	1.59
Preterm birth								
Yes	31.41	31.90	1.02 (1.00, 1.03)	0.16	31.77	33.21	1.05 (1.03, 1.06)	1.51
No	5.46	4.68	0.86 (0.84, 0.87)	−1.43	4.72	5.02	1.06 (1.04, 1.09)	2.12

RR prevalence rate ratio, *CI* confidence intervals, *APC* annual percent change, *lbs* pounds, *PTB/LBW* preterm birth/low birth weight

[a] All states

[b] We excluded data from Florida, Idaho, Kentucky, New Hampshire, New York State (not New York City), Pennsylvania, South Carolina, Tennessee, and Washington in our estimates of changes in variables between 2001 and 2004 because these states used the 2003 birth certificate revision in 2004

Table 3 Adjusted prevalence rate ratios for moderately low birth weight between 1991 and 2001 and between 2001 and 2004, singleton births, US non-Hispanic blacks

	N	RR (95% CI)
1991–2001[a]		
Unadjusted (Crude)	1,216,095	0.898[b] (0.888, 0.908)
Sequentially adjusted models		
First-trimester PNC, education, birth place	1,154,806	0.956 (0.944, 0.967)
+ Tobacco smoking	1,005,726	0.990 (0.977, 1.002)
+ Weight gain	905,179	1.019 (1.005, 1.033)
+ Maternal age, marital status, metro	905,179	1.000 (0.986, 1.013)
+ PNC adequacy, induction, C-section	882,379	0.982 (0.969, 0.996)
+ Parity, prior PTB/LBW	874,778	0.990 (0.977, 1.002)
+ Birth rate	874,778	0.984 (0.971, 0.999)
2001–2004[c]		
Unadjusted (crude)	889,714	1.059[d] (1.045, 1.073)
Sequentially adjusted models		
C-Section, PNC adequacy	839,766	1.046 (1.032, 1.061)
+ Weight gain	737,186	1.041 (1.025, 1.056)
+ Maternal age, education, birth place	728,518	1.052 (1.036, 1.067)
+ Marital status, metro	728,518	1.046 (1.031, 1.061)
+ 1st Trimester PNC, induction	728,169	1.048 (1.033, 1.064)
+ Parity, prior PTB/LBW	724,995	1.049 (1.033, 1.064)
+ Smoking	724,296	1.054 (1.038, 1.069)
+ Birth rate	724,296	1.055 (1.040, 1.071)

RR revalence rate ratios, *CI* confidence intervals, *Metro* metropolitan county residence, *PNC* prenatal care, *PTB/LBW* preterm/low birth weight

[a] All States

[b] A prevalence rate ratio of 0.898 corresponds to a 10.2% decrease in the MLBW rate between 1991 (referent) and 2001

[c] We excluded data from Florida, Idaho, Kentucky, New Hampshire, New York State (not New York City), Pennsylvania, South Carolina, Tennessee, and Washington in our estimates because these states used the 2003 birth certificate revision in 2004

[d] A prevalence rate ratio of 1.059 corresponds to a 5.9% increase in the MLBW rate between 2001 (referent) and 2004

Although we could not analyze 2005–2006 data because of data limitations, the annual statistics reports indicate the MLBW rate among non-Hispanic black singletons increased to 9.19% in 2005 and 9.24% in 2006. Thus, the increasing rates observed from 2001 to 2004 continued at least 2 more years [39, 40].

The decline in number of live births from 1991 to 2004 among non-Hispanic black women raised a question of how this change affected the risk profile of these women. Although the prevalence of some maternal risk factors (e.g., smoking, teen births) declined during the study period, the prevalence of others (e.g., age ≥35 years, antepartum conditions) increased throughout the study period. The prevalence of some protective factors, such as early and adequate PNC and higher education, also increased throughout the period. Thus, trends in maternal risk factors do not easily explain both the 1991–2001 decrease and 2001–2004 increase in MLBW rates. Adjustment for the changing birth rates, as a consideration of the decrease in live births, did not affect our findings.

Our results add to those from previous studies showing declining rates of non-Hispanic black LBW or PTB during the late 1980s and 1990s [6, 7, 9–11, 13, 15]. In these, the declining trends remained after standardization or adjustment for maternal age, parity, education, PNC initiation, prior PTB/LBW, smoking, marital status, c-section, labor induction, and antepartum or intrapartum conditions. Our results showed the 1990s decrease in MLBW continued to 2001 and, moreover, that changes in several modifiable risk or protective maternal factors (i.e., smoking, education, first-trimester PNC, and pregnancy weight gain) were associated with this decrease in multivariable models. The increasing percentage of foreign-born mothers, with a lower MLBW risk, was another important factor in this trend [41–46].

We cannot explain the 2001–2004 MLBW rate increase on the basis of birth certificate variables. Because MLBW rates increased among women with and without a c-section, without labor induction, and among both preterm and term births (Table 2), changes in these factors are not simple

explanations for the 2001–2004 increase. Analyses of other population-based datasets and/or linkages of the birth certificates to other data, such as Census or Pregnancy Risk Assessment Monitoring System (PRAMS) data, will be necessary to ascertain factors related to the 2001–2004 trend [47–49].

The association of the 1991–2001 MLBW rate decrease with maternal education suggests changes in socioeconomic status (SES) may have influenced the observed trends. Paralleling the MLBW trends, the SES of US blacks improved during the 1990s but then worsened following the 2001 economic recession [50–52]. Among blacks aged 18–64, the poverty rate decreased from 25.1% in 1991 to 18.7% in 2001 but then increased to 20.3% in 2004 [52]. Among black female-headed households, the poverty rate decreased from 54.8% in 1991 to 37.4% in 2001 and then increased to 39.7% in 2004 [52]. Similarly, black women's employment rates increased between 1991 and 2000 and then decreased through 2004 [53]. In addition, welfare time limits began to expire in 2001, 5 years after the introduction of welfare reform and the Temporary Assistance for Needy Families (TANF) program [54]. Interestingly, the slowing of the 1991–2001 MLBW decrease in 1997 followed closely upon the late 1996 introduction of TANF. Determining whether these parallels in economic trends, welfare reform events, and MLBW trends are related requires additional research involving data unavailable on vital records (such as linkages to Census, Medicaid, or PRAMS data)[47, 48, 55–57].

There have been numerous program initiatives designed to improve pregnancy outcomes among high-risk women during this time period (1991–2004). These include Healthy Start [58], home visiting or family case management [25, 59, 60], state or local infant mortality- or LBW-reduction programs [25, 26, 61–63], teen pregnancy-prevention programs [64, 65], and the Special Supplemental Nutritional Program for Women, Infants, and Children (WIC) [66]. Program intervention components are multiple and include enhanced social support and clinical services, health and social referrals, nutritional counseling and increased access to select foods, smoking and drug-use cessation, family planning, and community involvement. Improvements in non-Hispanic black birth weight or preterm outcomes have been found in several, but not all, programs [58, 61, 63, 66–68]. Although changes in many relevant risk factors are apparent in our analysis, additional research and program data linkages are necessary to ascertain any specific effects of program initiatives.

Nationally, the Medicaid coverage expansions of the late 1980s and 1990s provided increased financial access to PNC for low-income women [69, 70]. After expansion, PNC utilization improved but studies of the effects on national birth outcomes have shown inconsistent results [70, 71]. Our results suggest that for non-Hispanic black women, the effects of Medicaid expansions may have been positive. First-trimester PNC, which increased throughout the time period, was associated with the 1991–2001 MLBW decrease in our multivariable results. First-trimester PNC may also have been influenced by increases in maternal education and/or the changes in employment rates. Our analyses indicate the APCs for improvement in first-trimester PNC and for reduction in PNC inadequacy were dramatically lower in the 2001–2004 period compared to 1991–2001. Subgroup analyses of PNC trends by education and marital status, as markers for SES status [70], preliminarily indicate the lower 2001–2004 APCs for the PNC variables occurred across all SES subgroups (data not shown). Thus, additional research, such as linkage to state Medicaid or PRAMS data, is needed to understand the roles of changes in Medicaid coverage, education, employment, and insurance coverage in the observed trends.

The persistence of the 2001–2004 MLBW rate increase, despite adjustment for available confounders, led us to examine other potential explanations. The same trends remained when we excluded states using multiple race categories in 2003–2004 from all years of data (1991–2004, data not shown). It is unlikely that national trends were affected by the September 11, 2001 terrorist attacks and subsequent environmental toxin exposures or psychosocial stress [72–79]. Trends for the five States (Connecticut, New York, New Jersey, Virginia, Maryland) and the District of Columbia (in closest residential proximity to the crash sites) and for the remaining States were the same (data not shown). Long-term national psychosocial stress effects specifically from Sept. 11th events are unlikely [80, 81].

Trends in induced abortion rates are unlikely to explain the 2001–2004 MLBW rate increase [82, 83]. While information on infertility treatments is not available on birth certificates at a national level over this time period, it is also unlikely the 2001–2004 trend was related to an increase in births among non-Hispanic black women receiving infertility treatments [84]. Although non-Hispanic black women have higher rates of infertility than women in other racial/ethnic groups, they have lower use of infertility services and there is no evidence this use increased since 2001 [1]. We also considered whether changes in fetal death (FD) rates may have influenced the MLBW trends. The non-Hispanic black FD rate declined between 1991 and 2004 and cannot explain the overall 1991–2004 MLBW trends [85, 86]. However, additional research is needed to determine if the 2001–2004 MLBW increase was affected. A disproportionate shift of potential FDs into the live birth MLBW category through medical interventions could potentially increase the MLBW rate [87]. That c-section initially explained some of the 2001–

2004 increase in adjusted models (Table 3) may partially support this hypothesis.

One strength of our analysis was the use of Joinpoint regression which allowed detection of significant changes in trend and avoided use of 'eyeball' decisions. Another strength was the use of national birth certificate data that provided a large population size to enable detection of small, yet consistent, changes in LBW rates over time. However, use of birth certificate data also has several limitations, including questions about the validity and reliability of the data. Studies have found high validity and reliability for birth weight and demographic variables [20, 21]. Other variables, such as gestational age, prenatal care use, substance use, maternal morbidity, and obstetric procedures, have been shown to be less reliable or valid [17]. We did not have information on many variables, such as maternal income, prepregnancy BMI and preconception health status, insurance status, and participation in intervention or social programs. We cannot determine if the increases in antepartum complications resulted from increases in detection and recording, in population prevalence, or both. Other studies have shown increases in the prevalence of diabetes, asthma (lung disease) and hypertension among pregnant and reproductive age women throughout this time period [88–93]. And finally, because there are no standards for interpreting the magnitude of trend changes in perinatal outcomes, we applied standards from cancer trend analyses.

Our results suggest that multiple risk factors need to be addressed simultaneously to reduce non-Hispanic black MLBW rates. The 1991–2001 decrease was associated with changes in foreign-born status and in the modifiable risk factors of maternal smoking, PNC initiation, education, and pregnancy weight gain. Increased efforts to improve these modifiable risk factors are needed.

We cannot relate the 2001–2004 MLBW increase among non-Hispanic black infants to changes in variables reported on birth certificates. Possible relationships between these trends and changes in SES (at both personal and community levels) and in public policies deserve further evaluation, especially given the high percentage of poverty in the non-Hispanic black population. Future analyses of the impacts of welfare reform and economic recessions at state and local levels will be important for understanding changes in perinatal risks among non-Hispanic black mothers and infants [55, 56, 94].

The data reported here suggest that improvements in the socioeconomic status of non-Hispanic black women are likely to contribute to improvements in pregnancy outcomes. Economic solutions as well as adoption of multiple simultaneous strategies which address social and environmental exposures, chronic disease and preconception preventive health, general health care access and quality, life course, and health policy and program changes are all likely to be necessary to improve non-Hispanic black LBW rates. These efforts will require the integration of both population-based and targeted high-risk approaches to prevention [95–98].

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