Changes in the Gestational Age Distribution among U.S. Singleton Births: Impact on Rates of Late Preterm Birth, 1992 to 2002

Michael J. Davidoff, MPH,* Todd Dias, MS,* Karla Damus, RN, PhD,*,† Rebecca Russell, MSPH,* Vani R. Bettegowda, MHS,* Siobhan Dolan, MD, MPH,*,† Richard H. Schwarz, MD,§ Nancy S. Green, MD,*,†,‡ and Joann Petrini, PhD, MPH*,†

There is mounting evidence that infants born late preterm (34-36 weeks) are at greater risk for morbidity than term infants. This article examines the changing epidemiology of gestational length among singleton births in the United States, from 1992 to 2002. Analyzing gestational age by mode of delivery, the distribution of spontaneous births shifted to the left, with 39 weeks becoming the most common length of gestation in 2002, compared with 40 weeks in 1992 (P < 0.001). Deliveries at ≥40 weeks gestation markedly decreased, accompanied by an increase in those at 34 to 39 weeks (P < 0.001). Singleton births with PROM or medical interventions had similar trends. Changes in the distribution of all singleton births differed by race/ethnicity, with non-Hispanic white infants having the largest increase in late preterm births. These observations, in addition to emerging evidence of increased morbidity, suggest the need for investigation of optimal obstetric and neonatal management of these late preterm infants.

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hort gestation/low birth weight is the leading cause of infant mortality among black infants, the second leading cause of all infant mortality, and since 1999, the leading cause of neonatal mortality in the United States.¹ The preterm birth (<37 completed weeks of gestation) rate in the U.S. continues to rise, from 9.4% of live births in 1981 to 12.3% in 2003, increasingly divergent from the Healthy People 2010 target of no higher than 7.6%.² According to the National Center for Health Statistics, most of this 31% increase is due to increases in the rates of moderately preterm births (32-36 weeks), as the very preterm rate (<32 weeks) has stayed relatively constant during the past two decades, ranging from 1.8% to 2.0%.²

Much emphasis in the literature has been placed on the more vulnerable, very preterm births. For these infants, each additional week of gestational age at birth is associated with a significantly shorter hospitalization, and lower risk of long-term morbidities and associated costs.³ Accounting for about three-quarters of all singleton preterm births (Fig. 1), neonates delivered at 34 to 36 weeks gestation are often not considered to be at increased risk. However, a modest but growing body of research has focused on defining morbidity, mortality, complications, re-hospitalization, and costs associated with infants born at 34 to 36 completed weeks (referred to as “near term,” “mild preterm,” and in this report, “late preterm”). ³⁻¹¹ Specifically, some studies have documented a greater incidence of morbidity when compared with term infants, including respiratory distress syndrome (RDS), hypoglycemia, hypothermia, and hyperbilirubinemia. These late preterm infants have also been found to incur greater costs and longer length of stays in neonatal intensive care units (NICU).³

To better understand the changes in preterm birth rates in
the U.S. during the past decade, analyses were performed on the distributions of singleton live births by completed weeks of gestation, from preterm through post term, addressing selected maternal, management, and outcome factors. Our results describe a changing epidemiology for these births, taking into consideration the impact of shifting population demographics, including race/ethnicity and maternal age, and trends in obstetric management, as available on birth certificates. These analyses reveal trends in gestational length among spontaneous births and among births following premature rupture of membranes (PROM) and medical interventions (MI), including cesarean section and labor induction for singleton births in the U.S. for 1992, 1997, and 2002. Multifetal pregnancies, which accounted for 2.4% of live births in 1992 and 3.2% of live births in the U.S. in 2002, were intentionally excluded as they are known to be at increased risk of preterm birth.

**Materials and Methods**

Analyses were based on the U.S. National Center for Health Statistics (NCHS) natality data from 1992, 1997, and 2002. U.S. natality files contain data from all certificates of live births that were submitted through the Vital Statistics Cooperative Program. Only singletons were selected for analysis. To minimize variability in reporting over the study period, and to reduce misclassification errors, records were excluded if the gestational age was <23 weeks, >44 weeks, or if birth weight was <500 g or unknown.

Gestational age in the natality file was reported in completed weeks of gestation and was determined by NCHS to be the interval between the first day of the mother’s last normal menstrual period (LMP) and the infant’s date of birth; these data are available for about 95% of live births in all three of the study years. If only the month and year of the LMP are available, NCHS imputes, or ascribes the gestational age by assigning the weeks of gestation of the previous completed record in the file with a similar race and birth weight. In cases where the month, year, or entire LMP is missing, or when the calculated or assigned (imputed) gestational age appears to be inconsistent with birth weight, the clinical estimate of gestation is used, occurring in about 5% of live births. Note that, because gestational age is reported in weeks, each week-specific stratum is an amalgamation of live births with varying lengths of gestation when measured in days, and has a theoretical midpoint on the 4th day of the week. For example, any infant born between day 239 and day 245 (or 34 0/7 to 34 6/7) would be categorized as 34 weeks.

Based on birth certificate data, all births were classified into one of three mutually exclusive, hierarchical categories of delivery: (1) premature rupture of membranes (PROM), as defined on the birth certificate as PROM ≥12 hours before the onset of labor, regardless of delivery method or induction status; (2) medical intervention (MI), defined as labor induction and/or cesarean section without PROM; or (3) spontaneous, which included all vaginal deliveries not induced without PROM. Based on this classification scheme, all births following PROM were analyzed as a group whether delivered vaginally or by cesarean section and whether induced or not. The second category of births following medical intervention was defined as all that were either induced or delivered by primary or repeat cesarean section that did not experience PROM. The remaining births that did not meet any of the previous criteria were classified as spontaneous. Distributions of births by gestational week for each category were calculated for 1992, 1997, and 2002. Additionally, total cesarean section and induction rates among all singletons were calculated for each gestational week in 1992 and 2002.

The three categories of births were further stratified into six groups by completed gestational week: <32, 32 to 33, 34 to 36, 37 to 39, 40 to 41, and 42 to 44. Using more precise strata of preterm (<37 weeks), term (37-41 weeks), and post term (42-44 weeks) categories allows for a more detailed understanding of changes in the distribution of gestational age, including changes in late preterm births (34-36 weeks). In addition, 40 to 41 weeks was selected as a natural cut point because preliminary analyses demonstrated that the proportion of singleton births ≥40 weeks had decreased substantially.

The percent change in the proportion of births within each gestational age group was calculated between 1992 and 2002 and was directly adjusted for any changes in the distribution of maternal age and race/ethnicity during the study period. Maternal age was classified by five year increments: less than 20, 20 to 24, 25 to 29, 30 to 34, 35 to 39, and 40 and over. Race/ethnicity was defined as Hispanic, and then all other non-Hispanic groups, including white, black, Native American, including Aleuts and Eskimos, Asian and Pacific Islander, or race/ethnicity not stated. A direct adjustment was applied for 1992 and 2002 using maternal age and race/ethnicity combinations. In 1992, New Hampshire did not record Hispanic ethnicity. However, the number of births to
Hispanics in New Hampshire in 2002 was very small (503) relative to the total.

Additional analyses were done on the 2002 singleton study file to compare the gestational age distributions for Hispanic, non-Hispanic Black, and non-Hispanic white infants. All analyses were conducted using SPSS 12.0.1 (SPSS Inc., Chicago, IL). Statistical testing of differences was done by applying the test of proportions using StatCalc from EpiInfo Version 6. Statistical significance was conservatively set a priori at $P < 0.001$ because of the large sample sizes.

**Results**

In 2002, there were 3,808,473 singleton live births, of which 394,996 (10.4%) were delivered preterm. The largest proportion of these preterm births were delivered at 36 completed weeks gestation (40.1%), with infants delivered between 34 and 36 completed weeks accounting for about 74% of the total number of preterm births (Fig. 1). Very preterm births comprised 13.6% of all the eligible singleton preterm births.

The proportion of infants born at 40 to 44 weeks gestation within all delivery groups dropped dramatically between 1992 and 2002. The distribution of singleton births by category of delivery also changed significantly over this period of time. Among all singletons in 1992, 68.1% were classified as spontaneous, 28.9% as MI, and 3% as PROM. In 1997, 63.4% were classified as spontaneous, 33.9% as MI, and 2.7% as PROM. In contrast, in 2002, only 56.8% were classified as spontaneous, whereas MI increased to 41%, and 2.2% were identified as PROM. An increase in medical interventions has also been noted in other published reports.\(^{15,16}\)

Adjusting for race/ethnicity and maternal age had only a modest effect on the changes in the proportion of births delivered by gestational age group (Table 1). Spontaneous and PROM very preterm births (<32 weeks) were the most affected by changes in these demographics, whereas, for MI, these adjustments had the largest impact at 34 to 36 weeks.

**Table 1** Changes in Gestational Age Groups among Singleton Live Births by Delivery Categories: Spontaneous, PROM, and Medical Intervention, United States, 1992-2002*

<table>
<thead>
<tr>
<th>Category/Weeks</th>
<th>1992</th>
<th>1997</th>
<th>2002</th>
<th>Unadjusted†</th>
<th>Adjusted‡</th>
</tr>
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<td>6.9</td>
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<tr>
<td>37-39</td>
<td>43.4</td>
<td>48.1</td>
<td>51.8</td>
<td>19.4</td>
<td>18.6</td>
</tr>
<tr>
<td>40-41</td>
<td>39.0</td>
<td>36.0</td>
<td>32.6</td>
<td>−16.4</td>
<td>−16.0</td>
</tr>
<tr>
<td>42-44</td>
<td>8.9</td>
<td>6.9</td>
<td>6.1</td>
<td>−31.5</td>
<td>−30.7</td>
</tr>
<tr>
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<td>100.1</td>
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<td>&lt;32</td>
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<td>9.0</td>
<td>9.1</td>
<td>3.4‡</td>
<td>5.7</td>
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<td>40-41</td>
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<td>42-44</td>
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<tr>
<td>MI</td>
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</tr>
<tr>
<td>&lt;32</td>
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<td>1.6</td>
<td>1.5</td>
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<td>1.3</td>
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<td>6.8</td>
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<td>47.2</td>
<td>53.2</td>
<td>23.1</td>
<td>22.1</td>
</tr>
<tr>
<td>40-41</td>
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<td>35.3</td>
<td>30.4</td>
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<td>−16.2</td>
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<tr>
<td>42-44</td>
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<td>6.2</td>
<td>−43.6</td>
<td>−43.1</td>
</tr>
<tr>
<td>Total</td>
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<td>100.1</td>
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<td>28.9</td>
<td>33.9</td>
<td>41.0</td>
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</tr>
</tbody>
</table>

*Due to rounding, gestational week totals may not be equal to 100 percent.
†All rates between 1992 and 2002 significantly different ($P < .001$) except when indicated.
‡Adjusted for maternal race/ethnicity and maternal age.
¶Rates not significantly different between 1992 and 2002.

For births classified as spontaneous, there has been a shift toward earlier gestational weeks in the distribution of singleton live births among the years 1992, 1997, and 2002 (Table 1 and Fig. 2), largely occurring among births at 34 to 44 weeks gestation. The largest increase occurred between 34...
and 39 weeks, and the largest decrease occurred between 40 and 44 weeks. Notably, the peak of the distribution shifted from 40 weeks (25% of births) in 1992 to 39 weeks (25.9%) in 2002. The mean gestational age among spontaneous births changed significantly, from 39.2 to 38.9 weeks ($P < 0.001$).

The percent of spontaneous singleton live births born at 42 to 44 weeks gestation had the largest percent decrease (31.5%, $P < 0.001$) between 1992 and 2002, and births between 37 to 39 weeks had the largest percent increase (19.4%, $P < 0.001$) (Table 1). Although adjustments for maternal race/ethnicity and age had only a modest impact on the distribution of spontaneous births delivered between 1992 and 2002, the largest effect was on gestational ages <32 weeks. For these infants, changes in the distribution of maternal race/ethnicity and age among very preterm births accounted for approximately 46% of the change.

**PROM**

The distribution of births with PROM for each of the three study years was bimodal (Fig. 3). For those births denoted as PROM (regardless of induction status), the larger of the two peaks was centered at 39 weeks gestation, and unlike spontaneous births, did not shift during the study period. How-
ever, when induced births were excluded from the PROM category (20.7% of PROM total in 1992, 23.7% in 1997, and 23.6% in 2002), the remaining births without induction resembled a more normal distribution as seen among spontaneous births. Similar to the spontaneous category, between 1992 and 2002, the peak of the new distribution for PROM singleton births without induction shifted from 40 weeks (23.6%) in 1992 to 39 weeks (25.5%) in 2002.

Between 1992 and 2002, the proportion of singleton live births with PROM delivered at 42 to 44 weeks declined by 26.8% ($P < 0.001$) (Table 1). The largest percent increase in the distribution occurred at 32 to 33 weeks (10.5%, $P < 0.001$) and 34 to 36 weeks (10.4%, $P < 0.001$). Adjusting for maternal race/ethnicity and age had the greatest impact on the percent change for gestational ages 37 to 39 weeks and <32 weeks.

**MI**

The gestational age distributions for singleton live births with MI (data not shown) followed a normal distribution similar to that of spontaneous births, centered at 39 weeks between 1992 (22.9%) and 2002 (25.4%). For MI births, a larger proportion of infants in 2002 were born at earlier gestational ages when compared with 1992 and the mean gestational age significantly changed from 39.2 to 38.8 weeks ($P < 0.001$).

Similar to the spontaneous and PROM categories, singleton live births with MI had the greatest decline in births at 42 to 44 weeks (43.6%, $P < 0.001$). The greatest increase in births occurred at 37 to 39 weeks (23.1%, $P < 0.001$) (Table 1). Adjustment for maternal race/ethnicity and age had the greatest significant impact on the percent change for gestational ages between 37 and 39 weeks.

Births delivered by cesarean section made up the largest proportion of births in the MI category (58.9% in 2002), thus the distribution of MI births in 1992, 1997, and 2002 closely mirrors that for the cesarean deliveries (data not shown). When births delivered by cesarean section and induced births over that period of time were analyzed separately, both groups were found to have followed a trend toward earlier gestations. The peak of the distribution of induced births shifted from 40 weeks in 1992 (22.9%) to 39 weeks in 2002 (24.6%) (data not shown), whereas the peak for cesarean section deliveries remained at 39 weeks throughout the study years.

When week-specific cesarean and induction rates were analyzed separately in 1992 and 2002 for all singleton live births (Fig. 4), cesarean section rates increased more at earlier gestations, whereas week-specific induction rates increased more at later gestations.

### Gestational Age-Specific Distributions by Race/Ethnicity

The distribution of gestational age for Hispanic, non-Hispanic white, and non-Hispanic black singleton live births in 2002 is shown in Figure 5. All three of these distributions were centered at 39 weeks, with a relatively larger proportion of non-Hispanic black births delivered between 31 and 36 completed weeks gestation. When compared with the 1992 distributions (data not shown), the proportion of births at ≥30 weeks decreased and the proportion of births born at 37 to 39 weeks increased among all three racial/ethnic groups.

Focusing specifically on preterm births, Figure 6 shows the change in the singleton preterm birth rate between 1992 and 2002 by race/ethnicity, with specific detail provided for late preterm births. The largest change over time occurred among non-Hispanic white infants, where the proportion of singleton live births substantially increased at 34 to 36 weeks, from 5.8% to 7.0% of all singleton live births.
births. Since non-Hispanic white infants account for the majority of U.S. singleton births throughout the study period, these births largely account for the total increase in late preterm births.

In contrast, the overall rate of late preterm birth among non-Hispanic black births decreased from 10.9% of singleton live births to 10.5%. The proportion of non-Hispanic black births stayed the same or decreased at every gestational length <36 weeks, only increasing at 36 weeks, from 5.1% to 5.3%. Among Hispanic singleton births, late preterm births increased from 7.4% to 7.9%, with the increase occurring at 36 weeks gestation.

**Discussion**

Traditionally, Naegle’s rule has been used in clinical practice to estimate gestational age, stating that the duration of pregnancy for women with a regular 28-day cycle should be 280 days (40 weeks) after LMP. Other studies that collectively examined more than 400,000 singleton births found the median duration of human spontaneous singleton pregnancies to be 282 days following LMP.

Our analysis of singleton births documents that 39 rather than 40 weeks has become the most common length of gestation in the United States, even for those births categorized from the birth certificate as spontaneous deliveries. Over the past 10 years, the proportions of births at postdates, 42 to 44 weeks, and at 40 to 41 weeks have markedly decreased. These trends are paralleled by significant increases in the proportion of births on the earlier side of term at 37 to 39 weeks gestation, and those at 34 to 36 weeks gestation. In 1992, late preterm births comprised 6.9% of all singleton births (71% of singleton preterm births), whereas in 2002...
they were 7.7% of all singleton births (74% of singleton preterm births).

The shifts in the distribution of duration of gestation occurred among all three categories of delivery: spontaneous, MI and PROM. Examining these trends by categories of delivery for spontaneous and MI births, the largest increases in the proportion of births were at 37 to 39 weeks, followed by those at 34 to 36 weeks. In contrast, births with PROM had the largest increases in the distribution at 32 to 33 weeks and at 34 to 36 weeks. Excluding induced births from the PROM category resulted in a normal distribution that resembled the distribution among spontaneous births. These two observations together demonstrate a consistent increase in induced births with PROM between 32 and 36 weeks. Since the PROM study category represents less than 3% of all analyzed singleton births, the main increase in all late preterm births, as well as all births at 37 to 39 weeks, can be attributed to the spontaneous and MI birth categories.

An increase in medical interventions since the mid- to late-1980s among preterm singleton births has been associated with a decrease in stillbirths and perinatal mortality. Although this is an obvious and important objective, if the trends toward delivery at early gestations around term continue, the proportion of late preterm births would be predicted to grow. If true, then the overall preterm birth rate would be predicted to rise without a clear understanding of the impact of this trend on neonatal health. Fig. 6 shows that non-Hispanic white infants are driving much of the increase in late preterm births, as more modest increases were found in late preterm birth among Hispanic infants and decreases among non-Hispanic black infants delivered at 34 to 36 weeks.

The increase in both labor induction and cesarean section deliveries during the study period is well documented. The greatest increase in cesarean sections occurred at earlier gestations and inductions at later gestations (Fig. 4). These two trends in interventions would be predicted to shift the distribution toward 37 to 39 weeks, and even earlier to 34 to 36 weeks, as was observed from the shifts in distributions of the gestational-age specific distributions of MI and PROM categories. There may be additional factors affecting induction and cesarean rates in term and possibly late preterm births that are not readily assessed from birth certificate data, such as patient issues related to preference, obesity and other demographic trends, scheduled deliveries, and even policy changes impacting VBAC.

Over the past two decades, obstetric management of postterm deliveries has evolved following reports of a higher incidence of cesarean section and perinatal mortality in postterm deliveries. However, not all studies had similar findings. Some other factors that may have influenced clinical management include practice guidelines from both the American College of Obstetrics and Gynecology (ACOG) and the Society of Obstetricians and Gynecologists of Canada (SOGC). In 1989, ACOG recommended labor induction in low-risk pregnancies in the 43rd week of gestation, and later updated these guidelines in 1997, recommending that fetal health assessments begin at 42 weeks gestation. That same year, SOGC recommended routine induction of labor at 41 weeks gestation. These studies and guidelines may have contributed to a sustained increase in inductions correlated with increasing gestational age, with the end result being reduced rates of postterm delivery. Active management of risk in pregnancy at term may also contribute to increased rates of induction in term infants to reduce cesarean section rates in the post term pregnancy.

As for all analyses utilizing vital records, there are a number of limitations that could impact the results. The underreporting of inductions and PROM is of greatest concern as this may minimize some of the differences reported between 1992 and 2002 among spontaneous births, and make findings among other delivery categories more conservative. There is no evidence that the completeness of reporting has changed during the study period, so the trends observed likely reflect real changes. Estimating gestational age using LMP, although considered by some to be less accurate than estimates based on early ultrasound, is likely to be consistent during the study period. Increasing use of early ultrasound to estimate gestational age has also been shown to reduce rates of postterm delivery. The current analysis ascertained gestational age using the interval between LMP and the date of delivery in 95% of births, making any systematic change due to ultrasound utilization unlikely. Therefore, despite these and other limitations, the findings support the significant impact of later preterm births on the overall increase in preterm birth between 1992 and 2002.

**Conclusion**

In summary, there has been a considerable shift over the past decade in the distribution of births away from postterm
births and toward earlier gestational ages, including substan-
tial increases in earlier term and especially preterm birth
rates, but not in very preterm births. This trend is true for all
categories of delivery examined here. The increase in
births at 34 to 36 weeks is especially notable in non-Hispanic
white infants. Clearly, these changes have been accompanied
by decreasing infant mortality and stillbirth.1,20 However, the
impact on infant health may be mixed, with rising rates of
preterm birth and low birth weight off-setting the decreasing
rates of postdate infants, as well as the emerging data on
obstetric and neonatal care. More investigation is needed to
better assess the risks of late preterm birth so that obstetric
and pediatric clinical management can be better directed to-
toward optimal outcomes.

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