

# United States vital statistics and the measurement of gestational age

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## Summary

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Estimates of the gestational age of the newborn based on US Birth Certificate data are extensively used to monitor trends in infant and maternal health and to improve our understanding of adverse pregnancy outcome. Two measures of gestational age, the 'date of the last normal menses' (LMP) and the 'clinical estimate of gestation' (CE), have been available from birth certificate data since 1989. Reporting irregularities with the LMP-based measure are well-documented, and important questions remain regarding the derivation of the CE. Changes in perinatal medicine and in vital statistics reporting in recent years may have importantly altered gestational age data based on vital statistics. This study describes how gestational age measures are collected and edited in US national vital statistics, and examines changes in the reporting of these measures by race and Hispanic origin between 1990 and 2002. Data are drawn from the National Center for Health Statistics' restricted use US birth files for 1990–2002. Bivariable statistics are used.

The percentage of records with missing LMP dates declined markedly over the study period, overall, and for each racial/Hispanic origin group studied. A marked shift in the distribution of the CE of gestational age was also observed, suggesting changes both in the true distribution of age at birth, and in the derivation of this measure. Agreement between the LMP-based and CE estimates increased over the study period, especially among preterm births. However, a high proportion of LMP dates continue to be missing or invalid and the derivation of the CE is still uncertain. In sum, although the reporting of gestational age measures in vital statistics appears to have improved between 1990 and 2002, substantial concerns with both the LMP-based and the CE persist. Efforts to identify approaches to further improve upon the quality of these data are needed.

**Keywords:** *gestation, clinical estimate of gestation, LMP estimate of gestation.*

### Conflicts of interest:

the authors have declared no conflicts of interest.

## Introduction

Estimates of the gestational age of the newborn based on US Birth Certificate data are extensively used for surveillance of preterm birth, the major cause of neonatal mortality in the US, and to help advance our understanding of the aetiologies of adverse perinatal outcome.<sup>1–6</sup> Two measures of gestational age, the 'date of the last normal menses' (LMP) and the 'clinical estimate of gestation' (CE), have been available from birth certificate data since 1989. However, reporting irregularities with the LMP-based measure are long-standing

and well-documented<sup>7–10</sup> and fundamental questions remain regarding the derivation of the CE.<sup>9</sup> Furthermore, changes in reporting of vital statistics and in perinatal medicine in recent years may have altered gestational age data based on vital statistics.

A recent study using North Carolina vital statistics data suggested that reporting of gestational age improved during the 1990s, and that this change may have differentially affected race-specific rates of preterm birth.<sup>11</sup> The study was restricted to North Carolina data, however, and it is unclear whether

similar changes are seen in national data. Any such changes have important potential implications for the monitoring of preterm birth, a key indicator of the nation's maternal and infant health. The purpose of this study was to describe how vital statistics gestational age measures are collected and edited by the Centers for Disease Control and Prevention's (CDC) National Center for Health Statistics (NCHS) for national data release, and to examine recent changes in the reporting of national gestational age data by race and Hispanic origin.

### ***Background on the collection and editing of vital statistics data***

#### **Collection**

US vital statistics data are based on the official State and independent reporting area records of birth, deaths and fetal deaths. These data are collected through the national Vital Statistics Cooperative Program, a collaborative effort between the States and independent registration areas (New York City, the District of Columbia and the territories) and the federal government.<sup>12,13</sup> The registration of vital events is the responsibility of the individual States and independent registration areas (henceforth referred to as the States). The federal government, specifically the CDC/NCHS has no legal authority to register vital events, but is mandated by law to collect and disseminate national data based on vital records. The primary role of the NCHS is to disseminate national vital statistics data and to promote accuracy, timeliness, completeness and uniformity of data among reporting areas. The NCHS contracts with the States for these data, and in collaboration with State colleagues, develops standards for data collection such as the US Standard Certificate of Live Birth and Report of Fetal Death, handbooks, instruction manuals and edit specifications. The CDC/NCHS has no authority to mandate the use of the standard documents and procedures; each State modifies these products to suit individual State needs.

#### **Gestational age measures**

Birth certificate data on the date of the first day of the LMP and the CE of gestation have been available for most of the nation since 1989. The 2003 revision of the US Standard Certificate of Birth and Report of Fetal

Death, discussed later in this study, includes some modifications to these measures.<sup>14</sup>

The definition and instructions for completing the date of the LMP from the NCHS Handbook<sup>15</sup> for the 1989 revision of the US Standard Certificate of Live Birth is as follows:

Date last normal menses began (*month, day, year*)

Enter the exact date (month, day and year) of the first day of the mother's last normal menstrual period, as obtained from the physician or hospital record. If the information is unavailable from these sources, obtain it from the mother . . . If the exact day is unknown but the month and year are known, obtain an estimate of the day from the mother, her physician, or the medical record. If an estimate of the date cannot be obtained, enter the month and year only.

*This item is used in conjunction with the date of birth to determine the length of gestation, which is closely related to infant morbidity and mortality. Length of gestation is linked with birthweight to determine the maturity of the child at birth.*

The following is the handbook instruction for completing the CE of gestation:<sup>15</sup>

Clinical estimate of gestation (*weeks*)

Enter the length of gestation as estimated by the attendant at birth. Do not compute this information from the date of the last normal menses. . . . This item provides information on gestational age when the item on the date last normal menses began contains invalid or missing information. For a record with a plausible date last normal menses began, it provides a cross-check with length of gestation based on ultrasound or other techniques.

Birth certificate information is usually collected within 24–48 h of birth. If the birth occurs in a hospital, responsibility for completing the birth certificate rests with the hospital. Ninety-nine per cent of all births are delivered in hospitals. Most births are registered electronically; electronic preparation and transmittal of birth data were the norm for the 1990–2002-study period. Birth data are entered directly by hospital personnel into the electronic birth systems and transmitted to State registration offices where data are edited, re-coded, restructured and forwarded to NCHS. NCHS receives these electronic files from the States, performs quality review of the data and queries the States for unacceptable levels of non-reporting and other anomalies. Upon resolution of outstanding data issues, NCHS implements data editing procedures.

#### **NCHS edits of gestational age data**

The primary measure used to determine the gestational age of the newborn by NCHS for national data

**Table 1.** Proportion of records with imputed or missing gestational age data by race and Hispanic origin of mother, United States, 1990 and 2002

Race/Hispanic origin	% Weeks imputed <sup>a</sup>		% change 1990–2002	CE substituted <sup>b,c</sup>		% change 1990–2002	CE unknown <sup>c</sup>		% change 1990–2002
	2002	1990		2002	1990		2002	1990	
Non-Hispanic white	5.0	11.2	–55*	4.7	3.9	21*	0.3	1.8	–83*
Non-Hispanic black	6.9	16.5	–58*	6.7	6.0	12*	0.4	3.0	–87*
Hispanic	4.7	9.4	–50*	5.4	6.0	–10*	0.6	2.7	–79*
Total	5.2	11.7	–56*	5.3	4.6	15*	0.4	2.2	–82*

\* $P < 0.05$ .

<sup>a</sup>Gestational age in weeks is imputed for records for which day of month of the LMP is missing, but month and year are reported and valid.

<sup>b</sup>CE is substituted for the LMP-based estimate where the LMP is missing or inconsistent with birthweight.

<sup>c</sup>Data for 1990 exclude California and Oklahoma; data for 2002 exclude California.

release is the interval between the first day of the mother's LMP and the date of birth. These data are conservatively edited for LMP-based gestational ages which are clearly inconsistent with the infant's plurality and birthweight.<sup>16</sup> The CE of gestational age is substituted for the LMP-based estimate when the latter measure is unknown or appears to be inconsistent with birthweight and the CE is consistent with birthweight. This is done for normal-weight births of apparently short gestations and very-low-birthweight births reported to be full-term. Where the 'day' of the LMP is missing but the month and year are valid (i.e. the reported month is within the range of 1–12 and the year is the same or 1 year less than the year of birth) NCHS imputes and flags the number of weeks of gestation based on previous records with the same characteristics: computed months of gestation; maternal race (white, black and other); and birthweight within 500 g.

## Methods

To examine potential changes in reporting of national measures of gestational age we analysed data derived from the birth certificates of US residents for 1990 and 2002 as collected through the Vital Statistics Cooperative Program and compiled and edited by the CDC/NCHS. The analysis was restricted to singleton births only ( $n = 4\,061\,319$  for 1990, and  $3\,889\,191$  for 2002). Racial and Hispanic origin information of the mother was presumed to be self-reported. Categories used were: non-Hispanic white, non-Hispanic black and Hispanic. These groups were selected for analysis because of the large differences observed among them in reporting of gestational age measures.

Information on both the CE of gestation and the date of the LMP are available on the vast majority of births for the study period (Table 1). Oklahoma did not report the CE for 1990; California did not report the CE for 1990 and 2002. Therefore, data based on the CE and data comparing the CE with the LMP-based estimate of gestational age exclude California and Oklahoma for 1990 and California for 2002. Data for 1990 by Hispanic origin of the mother excluded New Hampshire and Oklahoma which did not report Hispanic origin for that year.

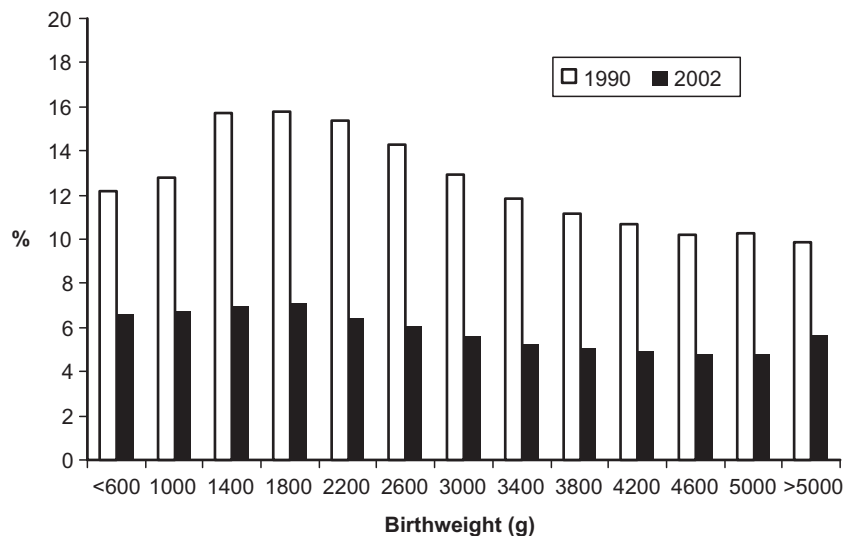
Birthweight and gestational age data were edited for biologically implausible values. Birthweight was edited for a range of 227–8165 g; values outside this range were changed to 'unknown'. Following the imputation procedures described above, gestational age data were edited for a range of 17–47 weeks; values outside this range were also changed to 'unknown'. Preterm delivery was defined as <37 completed weeks' gestation; very preterm (VPT) as <32 weeks and moderately preterm delivery (MPT) as 32–36 weeks. All differences discussed in the text are statistically significant at  $P < 0.05$  unless otherwise noted.

## Results

### *Changes in reporting of the LMP-based and CE measures of gestational age*

Between 1990 and 2002 the percentage of records for which gestational age was imputed because the day of month of the LMP was unknown declined 56%, from 11.7% to 5.2% of all records (Table 1). As shown in Fig. 1, substantial declines of at least 50% were seen for

**Figure 1.** Distribution of records for which gestational age is imputed because the 'day' of month of the LMP is unknown, by birthweight: United States, 1990 and 2002.



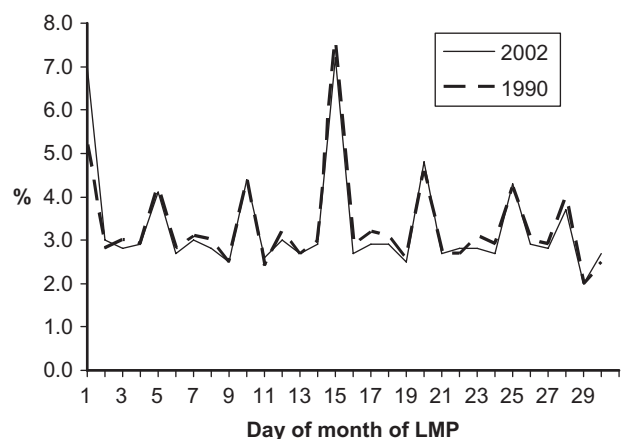
most birthweight categories. Despite the decline, slightly more than 5% of all 2002 birth records were missing values for the complete date of the LMP, and this information continues to be more likely to be missing among lower-birthweight, higher-risk infants. For 2002, 6.9% of infants born at <1500 g were missing information on the complete date of the LMP compared with 5.2% of infants born at  $\geq 2500$  g.

Pronounced declines were observed in the percentage of records imputed due to an incomplete date of LMP for each of the racial/ethnic groups studied between 1990 and 2002 (Table 1). Whereas differences among groups narrowed somewhat over the study period, non-Hispanic black mothers continued to have the highest levels of missing 'days': 6.9% compared with 5.0% for non-Hispanic white mothers and 4.7% for Hispanic mothers.

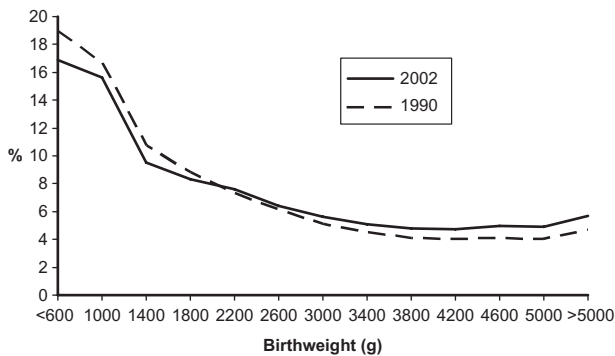
Despite the apparent improvement in reporting of the complete LMP date, the tendency for digit preference in the reporting of the day of month of the LMP, long observed in vital statistics data, was not appreciably ameliorated (Fig. 2). For records with valid LMP dates, distinct digit preference is apparent throughout the study period, particularly for the first and the fifteenth day of the month. For 2002, the proportion of all records for which the fifteenth day of the month was reported was 7.2%, down only modestly from 1990 (7.6%); the percentage of records reported at the fourteenth and sixteenth day was about 3% in both 1990 and 2002. Similar patterns and trends in digit preference are seen for each racial/Hispanic origin group studied (data not shown).

The percentage of records for which the CE was substituted for the LMP-based gestational age because the LMP-based age was missing or invalid increased over the study period, from 4.6% for 1990 to 5.3% for 2002 (Table 1, Fig. 3). This increase is the result of more complete reporting of the CE; only 0.4% of records were missing CE information in 2002 compared with 2.2% in 1990 (Table 1). Non-reporting of the CE dropped sharply for each race group.

A small but significant decline between 1990 and 2002 is seen in the percentage of records for which the CE was substituted for the LMP-based gestational age because the LMP-based age was inconsistent with birthweight (i.e. the LMP-based age was not compat-



**Figure 2.** Percentage of births by day of month of LMP: United States, 1990 and 2002.

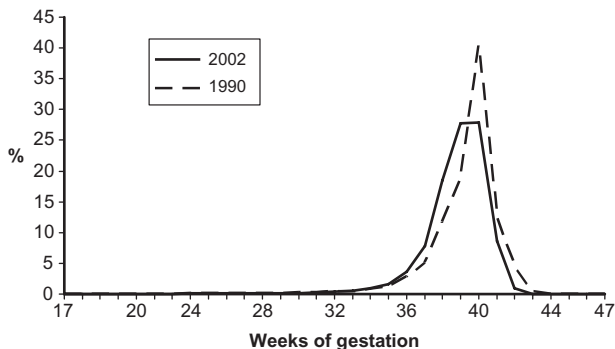


**Figure 3.** Distribution of records for which the CE is substituted for the LMP-based gestational age by birthweight: 49 States and the District of Columbia, 1990 and 2002.

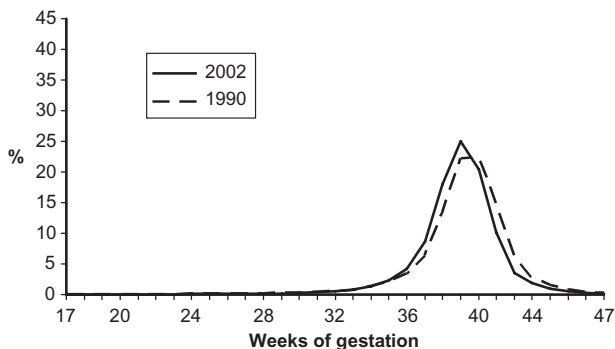
ible with birthweight whereas the CE was compatible). This level declined from 0.198% to 0.145% (tabular data not shown).

**Changes in the distributions of the CE and the LMP-based measures of gestational age**

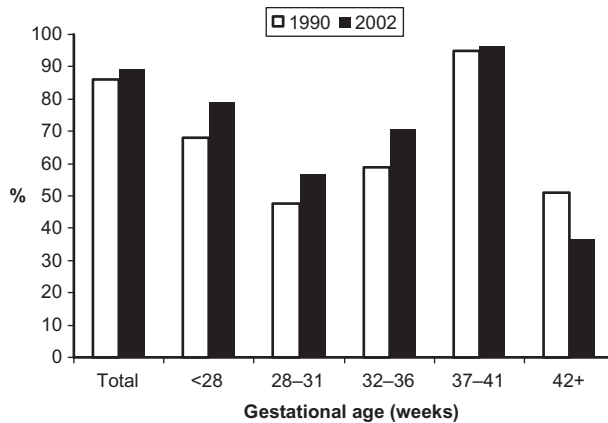
As shown in Table 2 and Fig. 4, the distribution of the CE of gestational age changed dramatically between



**Figure 4.** Distribution of the clinical estimate of gestational age: 49 States and the District of Columbia, 1990 and 2002.



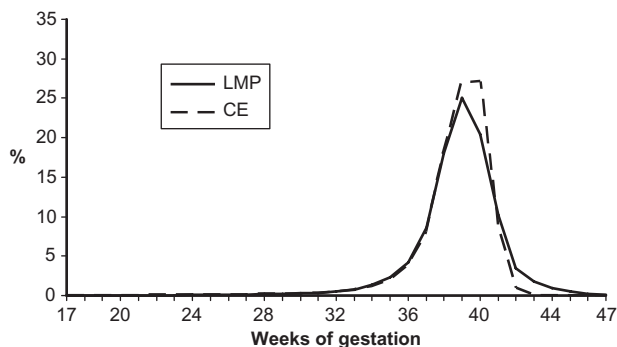
**Figure 5.** Distribution of the LMP-based estimate of gestational age: United States, 1990 and 2002.



**Figure 6.** Agreement between the LMP-based and clinical estimates of gestation within 2 weeks: 48 States and the District of Columbia, 1990 and 2002. Note: excludes data for California and Oklahoma.

1990 and 2002, shifting markedly to the left towards shorter gestational ages. The sharp peak at 40 weeks' gestation observed in 1990 data is substantially altered, dropping from 40.4% in 1990 to 28.0% in 2002. Births at  $\geq 41$  weeks also dropped markedly, whereas an increase of 52% in gestational ages 37–39 weeks is observed (from 35.5% to 53.9%). The CE also shows a 24% increase in moderately preterm births and a small decline among very preterm deliveries between 1990 and 2002.

The LMP-based estimate shows a similar, but less pronounced shift towards earlier gestational ages (Table 2, Fig. 5). Births delivered at  $\geq 41$  weeks declined by 34%, whereas 37- to 39-week deliveries increased 24%. As measured by the LMP, births <32 weeks declined, whereas the percentage of 32- to 36-week births rose significantly.



**Figure 7.** Percentage distributions of the LMP-based and the clinical estimates of gestational age: 49 States and the District of Columbia, 2002.

**Table 2.** Percentage distribution, mean and standard deviation of the clinical estimate and the LMP-based estimates of gestational age by race and Hispanic origin of mother, United States, 1990 and 2002

Gestational age in weeks	2002 <sup>a</sup>			1990 <sup>a</sup>		
	CE	LMP	% Difference CE/LMP	CE	LMP	% Difference CE/LMP
<b>All races</b>						
<28	0.60	0.56	7*	0.59	0.57	4*
28–31	0.73	0.98	-26*	0.76	1.08	-30*
32–36	7.03	9.02	-22*	5.66	8.04	-30*
37–39	53.94	51.68	4*	35.53	41.64	-15*
40	27.95	20.45	37*	40.42	22.27	81*
41+	9.74	17.32	-44*	17.04	26.40	-35*
<32	1.33	1.54	-14*	1.35	1.65	-18*
<37	8.37	10.55	-21*	7.01	9.70	-28*
Mean	38.71	38.81		39.19	39.21	
(SD)	(2.08)	(2.45)		(2.16)	(2.62)	
<b>Non-Hispanic white<sup>b</sup></b>						
<28	0.40	0.37	8*	0.38	0.35	9*
28–31	0.57	0.74	-23*	0.54	0.72	-25*
32–36	6.54	8.01	-18*	4.71	6.44	-27*
37–39	54.35	52.34	4*	34.65	40.91	-15*
40	28.17	21.08	34*	41.23	23.61	75*
41+	9.96	17.46	-43*	18.49	27.97	-34*
<32	0.98	1.11	-12*	0.92	1.07	-14*
<37	7.52	9.12	-18*	5.63	7.51	-25*
Mean	38.79	38.91		39.34	39.41	
(SD)	(1.91)	(2.27)		(1.94)	(2.38)	
<b>Non-Hispanic black<sup>b</sup></b>						
<28	1.49	1.44	3*	1.44	1.54	-6*
28–31	1.47	1.94	-24*	1.66	2.55	-35*
32–36	9.49	12.63	-25*	9.27	13.85	-33*
37–39	53.13	50.37	5*	37.27	42.89	-13*
40	25.61	17.97	43*	37.44	17.66	112*
41+	8.81	15.67	-44*	12.92	21.52	-40*
<32	2.96	3.37	-12*	3.10	4.08	-24*
<37	12.46	16.00	-22*	12.37	17.93	-31*
Mean	38.34	38.35		38.66	38.47	
(SD)	(2.68)	(3.03)		(2.82)	(3.33)	
<b>Hispanic<sup>b</sup></b>						
<28	0.53	0.49	8*	0.53	0.51	4
28–31	0.68	1.00	-32*	0.75	1.09	-31*
32–36	6.69	9.52	-30*	5.94	9.08	-35*
37–39	52.62	50.14	5*	37.30	43.40	-14*
40	29.41	20.39	44*	40.59	21.25	91*
41+	10.08	18.46	-45*	14.88	24.67	-40*
<32	1.21	1.49	-19*	1.28	1.60	-20*
<37	7.89	11.01	-28*	7.23	10.68	-32*
Mean	38.78	38.84		39.13	39.11	
(SD)	(2.02)	(2.47)		(2.12)	(2.61)	

\* $P < 0.05$ .<sup>a</sup>Data for 1990 excludes California and Oklahoma; data for 2002 excludes California.<sup>b</sup>Data for 1990 by Hispanic origin exclude New Hampshire and Oklahoma.

SD, standard deviation.

In sum, both the CE and the LMP-based measures show marked shifts to the left in gestational age distributions. Both measures demonstrate sharp declines in births reported at  $\geq 40$  weeks, increases in MPT and modest declines in VPT births. The measures differ importantly on the magnitude of these changes, however, with the LMP-based estimate resulting in a larger decline in VPT and a smaller increase in MPT than the CE.

Both the CE and LMP show shifts in gestational distributions from  $\geq 40$  weeks to 37–39 weeks among each of the racial/ethnic groups studied. The measures were also generally in accord on the direction, although not the magnitude, of change for births of  $< 37$  weeks for each group, with a notable exception. Among non-Hispanic black births the LMP indicates a significant decline in MPT whereas the CE indicates a small, but significant increase (Table 2).

The overall variation between the two measures appears to have narrowed somewhat over the study period. When simple agreement between the two measures is examined, the CE is found to be within 2 weeks of the LMP-based measure for 86.0% of all births in 1990, compared with 89.1% in 2002. The greatest improvement in agreement was among births reported to be preterm (Fig. 6). Agreement continued to vary markedly by gestational age, however, with agreement least likely at 28–31 and 42+ weeks for both time periods. For the more recent year, the CE continued to show substantially lower proportions of pre- and post-term deliveries compared with the LMP-based estimate (Fig. 7). For example, the proportion of births reported as preterm by the CE was 8.4%, compared with 10.6% based on the LMP-based estimate.

## Discussion

This study demonstrates that substantial changes in the reporting of vital statistics-based measures of gestational age occurred between 1990 and 2002. These changes, probably reflecting improvements in these data, include marked declines in non-reporting of both the day of month of the LMP and the CE of gestation; a decline in the proportion of records for which the LMP-based gestational age was inconsistent with birthweight (based on the very conservative NCHS cut points); and greater concordance between the LMP-based and CE of gestational age.<sup>17,18</sup>

The factors underlying the general improvement in reporting of vital statistics gestational age data are not

altogether clear. Heightened awareness of the importance of measuring the duration of the pregnancy independent of birthweight may have contributed to the observed changes in reporting of gestational age in vital statistics. For many years, preterm birth and low birthweight were synonymous concepts,<sup>19</sup> but our understanding of the importance of assessing gestational age independently of birthweight has evolved, as has the ability to better assess gestational age in routine obstetric practice.<sup>20,21</sup> Furthermore, as more reliable national measures of preterm birth have become available, these data have revealed a troubling trend: a steady climb in the US preterm birth rate during the 1980s and 1990s (a rise of 13% for 1981–89 and 16% for 1990–2002<sup>3</sup>). The ongoing deterioration of this indicator, whether real or an artefact of the data, has not gone unnoticed. For example, reducing the preterm birth rate is now a Healthy People 2010 objective<sup>1</sup> (preterm birth was not a Healthy People 2000 objective<sup>22</sup>). Also, in 2003 The March of Dimes officially launched a 5-year national prematurity campaign calling for increased awareness of the problem and a reduction in the rate of preterm birth.<sup>23</sup>

The phasing in of State electronic birth registration systems and enhanced quality control mechanisms at the federal level also may have played a role in lowering levels of non-stated and invalid gestational age data. During the 1990s, NCHS intensified its quality control programmes, working more rigorously with the States to improve reporting.

The more pronounced shift in the distribution of the CE compared with the LMP, particularly the drop in the proportion of births reported as delivered at precisely '40 weeks', also suggests positive change. One likely explanation for this shift is that the source for these data has modified over the study period, specifically, that as ultrasound has become more widespread (52% of pregnant women were reported to have received an ultrasound in 1990 compared with 68% in 2002),<sup>3,24</sup> it is more likely to be used as the basis for the CE. Gestational age dating based on early ultrasound is more likely than the LMP to indicate that a birth is preterm, and less likely as post-term.<sup>10,25</sup> This tendency may partially explain the larger shift to the left of the CE distribution compared with the LMP over the study period.

Despite the apparent progress made in recent years in improving gestational age measures in vital statistics, much more is needed. For 2002, an unacceptably high 10% of all records did not have a full or valid LMP

date. Whereas the more complete reporting of LMP dates suggests that hospital personnel may be more likely to query mothers for the full date, or to extract the information from the mother's medical records, the lack of improvement in digit preference suggests that reporting of the day too often may be little more than the guess of the mother or hospital staff. Additionally, other recent studies demonstrate that although lowered, substantial levels of misclassified data persist.<sup>17</sup> Furthermore, the derivation of the date of the LMP and to a larger extent, the CE is not always apparent. In practice, instruction manuals may not always be available to the hospital personnel responsible for collecting it. As one result, sources may vary by hospital, and even by clinician. Anecdotally we understand that the LMP date reported on the birth certificate is still at times determined by a pregnancy 'wheel' or simply by subtracting 40 weeks from the date of delivery<sup>26</sup> and that the CE on occasion may be based on the time between the date of delivery and the LMP. These concerns continue to undermine the usefulness of these data.

This study also found pronounced declines in incomplete reporting of gestational age measures among each of the largest racial/Hispanic origin groups. Of note is the finding that whereas the LMP and CE agree on the direction if not the magnitude of preterm birth rates for non-Hispanic white and Hispanic mothers, the two measures differ slightly on trends for non-Hispanic black births. That is, the CE indicates a small increase in moderately preterm births, whereas the LMP-based measure shows a small decline. This inconsistency may be related to the continued higher levels of incomplete data for non-Hispanic black mothers and makes it difficult to gauge the true trend of preterm birth for this group.

The substantial changes recommended for the 2003 Revision of the Certificate of Live Birth beginning to be implemented by the States should encourage further improvement in the reporting of gestational age.<sup>14,27</sup> The new revision retains the 'Date of the LMP' as on the previous revision, but has replaced the 'Clinical Estimate of Gestation' with the 'Obstetric Estimate of Gestation'.<sup>28,29</sup> The modification was made to emphasise that the estimate should be based on perinatal factors rather than the neonatal examination. Other key enhancements to the revised birth systems include separate worksheets for the mother and for the hospital staff to encourage the gathering of information from the best sources (e.g. prenatal care records for the date

of LMP) and a user-friendly guidebook for use by the birthing facility. This guidebook includes detailed definitions and instructions, specific recommended sources for items (e.g. prenatal care record under menstrual history) and keywords to help the hospital staff locate the correct information in the medical records. Finally, detailed specifications for electronic birth systems were developed. These specifications include recommended standards for queries concerning data entry for unusual values (e.g. higher than expected birthweight for gestational age). These 'soft' edits were developed to encourage the user to review and modify, where appropriate, questionable entries immediately upon data entry when the accurate information is still available.<sup>14</sup> Although issues inherent in the reporting of the LMP date such as irregular menstrual cycles and spotting after conception will inevitably persist, improved collection techniques should serve to further improve data quality.

National implementation of the 2003 revision has been delayed; two States revised for 2003 and seven additional States for 2004. Nationally representative revised data are not expected to be available until at least 2008. Therefore, data were not available to assess changes to gestational age measures resulting from the revision.

The reporting of gestational age in vital statistics continues to evolve. This ongoing process may continue to result in discontinuities in these data across time and among groups. Further studies will be necessary to help to disentangle the impact of these changes on measures such as the preterm birth rate and to identify ways to continue to improve upon the quality of these essential data.

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