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Discordance Between LMP-based and Clinically Estimated Gestational Age: Implications for Research, Programs, and Policy

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Synopsis

This study examines the comparability between the last menstrual period-based and clinically estimated gestational age as collected on certificates of live birth. It explores whether sociodemographic or delivery characteristics influence their agreement and contrasts health status and health care utilization indicators, such as preterm, small for gestational age, and adequacy of prenatal care percentages, produced by each gestational age measure. The 1989-91 South Carolina public use live birth files were used for this analysis. A total of 169,082 single births to resident mothers were selected for investigation.

The clinically estimated gestational age distribution exhibited a higher mean and a tendency toward even number digit preference. The last menstrual period-based measure produced higher preterm and postterm percentages. More than 60 percent of the last menstrual period-based preterm births were classified as preterm by the clinical estimate. The sensitivity of the clinical estimate was 27 percent for postterm births. The overall concordance (the percentage of cases with the same value for both measures) was 47 percent, but it varied considerably by gestational age. Between 30 and 35 weeks, the clinical estimate exceeded the last menstrual period-based value by 2 weeks or more for more than 40 percent of the cases. Concordance also varied by race of mother, hospital delivery size, trimester prenatal care began, and birth weight.

The last menstrual period-based and the clinically estimated gestational age distributions exhibited notable dissimilarities, produced marked differences in health status indicators, and varied in concordance by gestational age and by sociodemographic, prenatal care, and hospital characteristics. These systematic differences suggest that a transition from the traditionally used last menstrual period-based measure to the clinical estimate or a composite measure will not produce uniform results across geo-political areas and at-risk groups but will be appreciably influenced by population and health care characteristics.

DURATION OF PREGNANCY, calculated in completed weeks as the interval between the mother's reported date of last normal menses (DLNM) or last menstrual period (LMP) and the date of birth, has been used conventionally as the operational definition of the gestational age of the newborn.

The limitations of this measure of gestational age, however, have been recounted widely in the scientific literature (*1–19*). It has been reported that approximately 20 percent of live birth certificates in the United States have a missing or incomplete date of LMP (*19*). Further, LMP-based computations of gestational age often have been shown to produce values inconsistent with birth weight (*10,14*). Such improbable LMP-based gestational age values have been attributed to recall error, variations in the preovulatory interval, sporadic bleeding during pregnancy, and unrecognized abortions (*5,15–18*). These reporting problems have been observed to occur more frequently among women of lower educational and socioeconomic status (*9–14,19*).

In spite of these obstacles to obtaining a valid

Table 1. Quality of last menstrual period-based (LMP) and clinically estimated (CE) gestational age measures for 169,082 single, resident live births, South Carolina, 1989–91

Characteristic	LMP		CE	
	Number	Percent	Number	Percent
Within range (20–45 weeks)[1]	161,333	95.42	157,854	93.36
Out of range (< 20 or 45 weeks)	1,739	1.03	84	0.05
Birth weight inconsistent[2]	1,074	0.64	114	0.07
Missing or incomplete	4,936	2.92	11,030	6.52
Total	169,082	100.01	169,082	100.00

[1]Excludes birth weight inconsistent cases.
[2]Cases with a birth weight value outside of the stated range for their specific gestational age are delineated as having grossly inconsistent gestational age-birth weight values. The determination of the birth weight ranges was based on distribution characteristics and clinical recommendations.

Table 2. Gestational age distribution and related risk measures by last menstrual period-based (LMP) and clinical estimate (CE) for 150,898 single, resident live births with both LMP and CE values between 20 and 45 weeks, South Carolina, 1989–91

Characteristics	LMP	CE
Weeks (mean)	38.95	39.05
Weeks (median)	39	40
5th and 95th percentile	35-42	35-41
Standard deviation	2.62	2.27
Skewness	−1.86	−3.01
Kurtosis	7.74	14.61
Very preterm (less than 33 weeks) percent	2.55	2.17
Preterm (less than 37 weeks) percent	11.43	8.40
Term (37–41 weeks) percent	78.96	87.43
Postterm (42 weeks or more) percent	9.61	4.18
Small for gestational age[1] percent	5.91	5.73
Prenatal care[2] percent:		
Adequate	58.34	58.15
Intermediate	29.66	29.77
Inadequate	9.79	9.88
No care	1.78	1.78
Missing	0.43	0.43

[1]Small for gestational age (SGA) based on Brenner, 1976 (*42*).
[2]Adequacy of prenatal care utilization based on modified Kessner Index (*20,43*).

gestational age measurement, the length of pregnancy duration continues to be an important piece of information for public health and clinical practice. It is used to calculate the proportion of preterm births in a population and to determine an individual newborn's risk status. In addition, it is used in the computation of measures of intrauterine growth and adequacy of prenatal care (*5,7,14,20–23*).

Alternative approaches to estimating gestational age of the newborn have been developed. Pediatric assessments of gestational age, based on the physical and neurological characteristics of the newborn, have been devised (*24–26*). A number of investigators have raised questions, however, regarding the accuracy of these procedures, particularly among preterm and ethnically disparate populations (*27–32*). Ultra-sonography has been touted more recently as a preferred gestational age measurement strategy (*33*), although the accuracy of this technique is dependent on its early application. It should be noted that these alternative approaches to gestational age measurement are conceptually distinct from the direct measure of duration of pregnancy. Instead, they approximate duration by referencing a standard period of time assumed necessary to achieve the observed extent of fetal growth or newborn maturity (*34*). The LMP-based gestational age typically has been used to validate these alternative, indirect assessments of pregnancy duration, which convert their observed measurements to a scale of numeric values that correspond to the typical range of the LMP-based values, for example 20–45 weeks (*24,35–37*).

One of the traditional sources of gestational age data on populations in the United States has been certificates of live birth. Vital record-based studies from the 1960s and 1970s indicated a clear preference for LMP-based gestational age data compared with clinically derived estimates of gestational age (*4,8*). More recent comparisons of LMP-based and clinically estimated gestational age data contained on State vital record reports of fetal death and induced abortion also observed particularities with the clinical estimate (CE), for example, even number digit preference and marked variation between the indicators by residence status and race of mother, thereby precluding an unequivocal recommendation for their use over the LMP-based gestational age in population based studies (*38,39*).

Nevertheless, with the greatly increased availability and use of ultra-sonography to determine gestational age in the United States during the last decade, the latest revision of the U.S. Standard Certificate of Live Birth included an item for the recording of the 'clinical estimate of gestation'(*40*). Reporting instructions from the National Center for Health Statistics (NCHS) to hospitals and physicians indicate that "this item provides information on gestational age when the item on date of last normal menses began contains invalid or missing information" and, "for a record with a plausible date of last normal menses began provides a cross-check with length of gestation based on ultrasound or other techniques" (*40*). Instructions for ascertaining the CE are not provided, and this item, as recorded on vital records, may therefore reflect a variety of diverse or mixed

techniques. Individual States may provide additional instructions for the use of the CE that supplement the guidance provided by NCHS, although this was not the case for South Carolina.

The CE measure of gestational age is now widely available on State vital record data bases. For reporting of natality data for the United States, NCHS has substituted the CE value for the LMP-based gestational age when the date of LMP was incomplete or incompatible with birth weight (*41*). It is unclear to what extent public health planners and researchers in each State have followed this strategy.

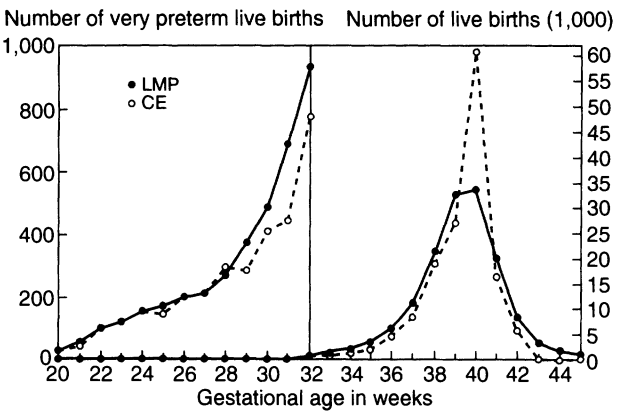
The purpose of our study is to examine the comparability of the LMP-based and the CE of gestational age as collected on one State's vital records since the inclusion of the latter item on the certificate of live birth in 1989. We investigated the concordance between these measures and explored whether sociodemographic or delivery hospital characteristics influenced their agreement. Further, we used these measures separately and in combination to compute and contrast population health status and health care utilization indicators. These included the percentages of preterm delivery, small for gestational age, and adequacy of prenatal care.

Methods

Our study used the 1989-91 South Carolina public use live birth files. A total of 169,082 single births to resident mothers were selected initially for investigation. For comparisons between the LMP-based and the CE gestational age measures, a subset of 150,898 cases that contained both CE and LMP-based values with a range of 20 to 45 weeks were selected after excluding cases with a gestational age value by either estimation method that was grossly inconsistent with birth weight.

Solely because of its longer history and wider use to verify other measures of gestational age, the LMP-based measure was chosen as the standard for comparison in this study. LMP-based gestational age values were calculated in completed weeks from the interval between the date of last normal menses and the date of birth. With one exception, no attempt was made to impute a LMP-based gestational age value for women that did not have a complete date of LMP recorded. Solely for the investigation of a composite LMP-CE gestational age measure, missing LMP-based gestational age values were imputed using the preceding case method (*14,19*). Small for gestational age (SGA) was based on the 10th birth weight percentiles for gestational age as determined by Brenner and coworkers (*42*). Adequacy of prenatal care use

Figure 1. Gestational age distribution, last menstrual period–based (LMP) and clinical estimate (CE), resident live births, South Carolina, 1989–91



was calculated using a modification of the index by Kessner and collaborators that was proposed by Alexander and Cornely (*20,43*).

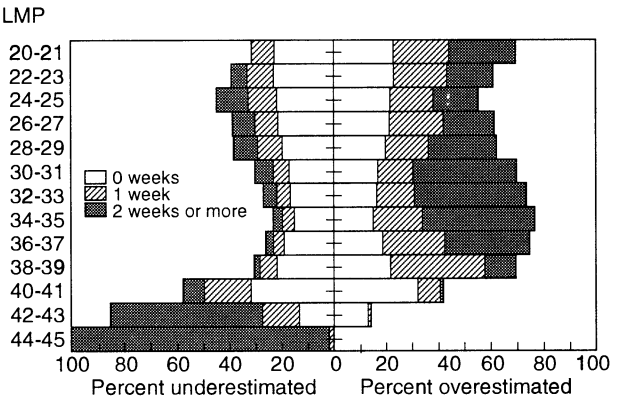
Results

Table 1 depicts the number and proportion of cases with missing or incomplete, out of range, birth weight inconsistent and within-range values. More than twice as many cases were missing a CE value as compared with a date of LMP (6.5 versus 2.9 percent). The proportion of cases with a missing or incomplete date of LMP was much lower than the 20 percent national average (*19*) and in line with previous reports noting the relatively high completeness of reporting of this variable on South Carolina vital records (*14,22*).

The distribution characteristics of the two gestational age measures are detailed in table 2. Compared with the LMP distribution, the CE distribution exhibits a slightly higher mean and a 1-week higher median. The LMP distribution has a larger standard deviation and a wider range between the 5th and 95th percentiles of the distribution. These differences are evident in the distributions illustrated in figure 1, which indicate a greater concentration of cases around the 40-week median of the CE distribution. A modest tendency toward even number digit preference was observed in the very preterm range of the CE distribution.

These variations between the LMP and CE gestational age distributions translate into marked differences in preterm and postterm percentages (table 2). Higher preterm (less than 37 weeks), very preterm (less than 33 weeks), and postterm (42 or more weeks) percentages are found for the LMP distribution, while the CE distribution yields a greater

Figure 2. Percentage of live births, South Carolina, 1989–91 where clinical estimate overestimated or underestimated last menstrual period–based gestational age (LMP) by a week or more



'It (valid gestational age measurement) is used to calculate the proportion of preterm births in a population and to determine an individual newborn's risk status. In addition, it is used in the computation of measures of intrauterine growth and adequacy of prenatal care.'

proportion of term cases. The small for gestational age percentage was slightly lower for the CE distribution. Only modest differences in adequacy of prenatal care percentages were detected when each of the two gestational age measures was used in the calculation of the index.

The correlation between the two gestational age measures was relatively high (r = .77). The CE exhibited a higher correlation with BW than the LMP-based measure (r = .65 versus r = .55). The overall concordance (the same value for both measures) between the two gestational age measures was 47.3 percent but varied considerably by gestational age. The percentage of cases with a LMP-based gestational age value either underestimated or overestimated by the clinical estimate by 1 or 2 or more weeks is provided in figure 2. For more than 40 percent of the cases in the 30–35 week range, the CE overestimated the LMP by 2 or more weeks. The LMP value of the vast majority of postterm births was under-estimated by 2 or more weeks by the CE.

The efficacy of the CE to identify gestational age risk categories as determined by LMP is given in table 3. Approximately 60 percent of the LMP-based preterm births were classified as preterm by the CE (sensitivity 60.51 percent). The sensitivity of the CE was 26.52 percent for postterm births. Of the births that the LMP-based measure classified as other than term, that is, less than 37 weeks or 42 weeks or more, only 45.79 percent of these births were also so classified by the CE (specificity). The remaining cases were delineated as term (37–41 weeks) births. Of those infants designated as SGA using the CE, nearly three-quarters were SGA by LMP (positive predictive value: 74.20 percent).

Figure 3 displays the mean difference between the CE and LMP (difference = CE – LMP) by race of mother, hospital size (the number of live births delivered per year), trimester prenatal care began, and divergence in gestational age-specific BW, defined as the difference between each infant's BW and the mean BW of all infants at the same gestational age by LMP (difference = individual BW – population mean gestational age-specific BW). For both race of mother groups, the mean difference between the CE and LMP exceeded zero prior to 40 weeks gestation by LMP, indicating that, on the average, the CE surpassed the LMP in this gestational age range. Further, between 24 and 37 weeks, the mean difference for nonwhites exceeded that of whites, indicating a greater overestimation of the LMP by CE for nonwhites in this gestational age range. Within the 28–35 week range, there was a notable variation in the amount of difference between the two measures among the hospital size groups. Hospitals with 2,000 or more deliveries had a markedly lower mean difference than smaller delivery size hospitals.

Among prenatal care groups, the mean difference between the CE and LMP values was the lowest after 28 weeks for the no prenatal care group, which presumably had no antenatal information available to consider in the determination of the CE. The mean difference in the gestational age measures was also found to differ markedly by the degree to which an infant's BW varied from the mean BW of other infants of a similar gestational age by LMP. Particularly among preterm infants, the CE of infants with a BW heavier than average tended to exceed the LMP, while the CE of infants with a BW lighter than average tended to be lower than the LMP.

A CE-LMP composite gestational age measure was developed using the following criteria. The LMP-based gestational age was selected if the CE was either missing or agreed with the LMP-based value within 1 week. The CE was used if the LMP-based value was missing or if there was discordance between the two measures by 2 or more weeks.

The rationale for selecting the CE measure over the

LMP-based measure in situations of discordance reflects the arbitrary assumption that the determination of the CE incorporated knowledge of the date of LMP and other relevant gestational age-related information and deliberately rejected the LMP-based gestational age value for a value that was different by 2 or more weeks. Birth weight inconsistent values by either measure were considered as missing. In this specific analysis, a LMP-based gestational age value had already been imputed for those records missing only the day of LMP. This imputation was performed prior to the comparison of the LMP value with the CE for selection as the basis of the composite measure and was accomplished by substituting the LMP-based gestational age value of a preceding case with a similar BW, month of LMP, and race of mother (*14,19*).

This approach resulted in a composite gestational age value for 168,678 cases (99.8 percent of the total), of which 22 percent were based on the CE measure. The composite gestational age indicator's mean was 38.96 weeks (standard deviation: 2.35). The preterm (9.0), very preterm (2.3), postterm (4.3) and SGA (5.5) percentages that were calculated using the composite measure most closely mirrored those produced by the CE distribution of values (table 2). The use of the composite measure to calculate adequacy of prenatal care percentages did not produce any appreciable differences from those constructed from either of the individual gestational age measures.

Discussion

The LMP-based and the CE gestational age distributions exhibited notable dissimilarities that produced marked differences in health status indicators. The substitution of the CE measure or a LMP-CE composite measure for the conventionally used LMP-based measure resulted in a conspicuous reduction in the percentage of preterm and other gestationally at-risk births.

The concordance between the two measures varied over the gestational age range and further differed by sociodemographic, prenatal care, and hospital characteristics. These systematic differences are particularly noteworthy in regards the use of gestational age-based health status indicators for policy and programmatic need assessments and evaluations. They suggest that a transition from the traditionally used LMP-based measure to the CE or a composite CE-LMP measure will not produce similar results across geopolitical jurisdictions and will be appreciably influenced by population and health care characteristics.

Table 3. Efficacy of clinical estimate (CE) to identify risk categories as determined by last menstrual period (LMP) for 150,898 single, resident live births with both LMP and CE values between 20 and 45 weeks, South Carolina, 1989–91, by percentage

Characteristic	Gestational age-based risk categories				
	Very preterm	Preterm	Term	Post term	SGA[1]
Sensitivity[2]	72.28	60.51	96.28	26.52	71.93
Specificity[3]	99.67	98.33	45.79	98.20	98.43
+ Predictive value[4]	84.98	82.40	86.95	60.97	74.20
– Predictive value[5]	99.28	95.07	76.62	92.63	98.24

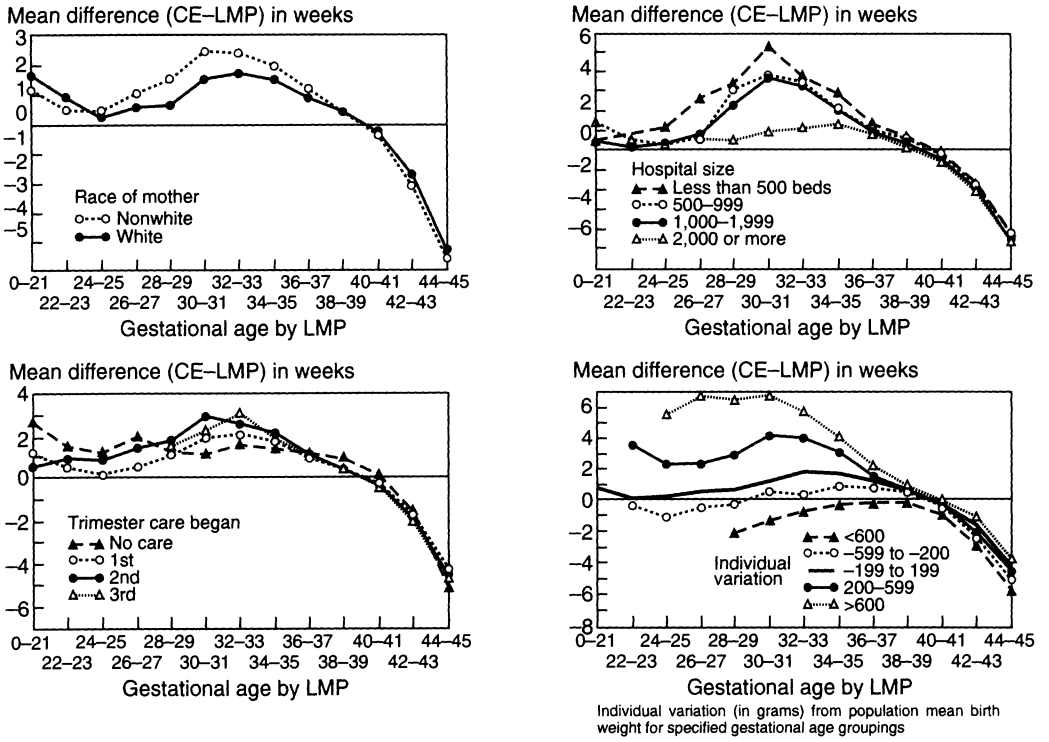
[1]Small for gestational age.
[2]Sensitivity—percentage of cases placed in the category by LMP that were also so identified by CE.
[3]Specificity—percentage of cases excluded from the category by LMP that were also excluded by CE.
[4]+ Predictive value—percentage of cases placed in the category by CE that were also so identified by LMP.
[5]– Predictive value—percentage of cases excluded from the category by CE that were also excluded by LMP.

Further, in comparison to the LMP-based measure, the CE and the CE-LMP composite measures may indicate markedly less ethnic disparity in preterm percentages.

These data cannot adequately address the question of which gestational age measure most faithfully represents the true distribution of gestational age duration in this study population. One may argue that the CE measure provides a gestational age distribution that is closer to conventional expectations. The CE measure has fewer implausible out-of-range and BW inconsistent values and is more highly correlated with BW. However, some of these attributes are a source of concern. To the extent that the CE measure more closely corresponds to BW and in some or many cases could conceivably have been estimated after delivery based upon knowledge of the BW, the variation in BW for each gestational age decreases. It has been shown that variations in BW by gestational age, for example SGA, are important indicators of morbidity and mortality risk (*7*). Any reliance on BW to estimate gestational age could result in overly censored intrauterine growth curves and in the loss of important risk information about the newborn.

A further concern about the CE measure is the uncertainty about the basis for its derivation. The types of information that could be used to establish the CE include ultrasound, obstetric measures, for example fundal height and fetal heart tones, and pediatric examinations of the physical and neurological characteristics of the newborn. Although any or all of these clinical methods could be considered, if available, in the determination of the final CE, it is unclear which methods are most typically available, which methods are given the most weight when some or all are

Figure 3. Mean difference in clinically estimated and last menstrual period (CE-LMP) gestational age by various characteristics



Individual variation (in grams) from population mean birth weight for specified gestational age groupings

present, and how the availability and use of these methods vary among hospitals. In 1991, 98.9 percent of the births in the United States occurred in hospitals (*44*).

It should be underscored that the basis of the CE measure is limited to what is known by the person completing the Certificate of Live Birth, which may not include the full range of gestational age-related information compiled during the pregnancy. The availability of prenatal care information, the hospital specific procedures for determining the CE value and completing the certificate, and the training of the person designated for this task may result in considerable and systematic reporting variation among hospitals and subpopulations. It is quixotic to assume that for every certificate an appropriately trained and equivalently experienced clinician evaluated all amassed gestational age information and made an informed judgement in a standardized manner about the duration of gestation for entry on the Certificate of Live Birth. In this study, hospital and population specific factors were found to influence the CE in systematic ways. Although the LMP-based measure, compared with the CE measure, may be less reliable, it may also be contended that errors inherent in the LMP-based measure are more random and less influenced systematically by these characteristics.

For research purposes, the accurate classification of infants into at-risk categories, for example preterm, term, and postterm, is critical. Previous reports have indicated that the LMP-based measure is deficient in this capacity, particularly in the accurate identification of postterm births (*14*). For single hospital studies, where known and consistent procedures for clinically estimating gestational age prevail, the strengths of the CE measure are emphasized, although the limited generalizability of the results is a problem. The CE measure may be less preferable for large population-based studies that draw cases from multiple hospitals and diverse populations.

The search for a valid and reliable measure of pregnancy duration has a long history (*45*). Accurate knowledge of gestational age is crucial for clinical as well as numerous public health functions, including (*a*) the assessment of intrauterine growth curves and related problems in populations, such as delineating whether infants of a given low birth weight are either preterm or growth retarded, (*b*) the assessment of adequacy of prenatal care utilization in populations, (*c*) the adjustment for prematurity when assessing gross motor milestone attainment and determining at-risk status for potential developmental delay related to targeting populations in need of followup and intervention services covered under Part H of the

Individuals with Disabilities Education Act (*46*), and (*d*) the conduct of needs assessments and evaluations related to policy setting and program planning. In spite of the clinical and public health importance of gestational age, the prevailing lack of confidence in the LMP-based measure is exemplified by the absence of gestational age-related indicators in the United States year 2000 health objectives (*47*).

The recent re-inclusion of a measure of clinically estimated gestational age on States' certificates of live birth is a laudable and needed stride in the search for a means to better document gestational age on a population-wide basis.

Notwithstanding, at this time we do not recommend its general use over the LMP-based measure. The current CE measure is similar to that collected on vital records two decades ago and, notwithstanding the clear and persistent limitations of the LMP-based measure, the traditional arguments to prefer the LMP measure remain persuasive until there is more compelling evidence than could be found in this investigation to warrant an unequivocal recommendation to abandon the current measurement paradigm for another (*8,20,21,48*). While States with higher proportions of missing or incomplete dates of LMP than South Carolina may be tempted to substitute CE values in such cases, the result may be dramatic and unpredictable changes in health status indicators. More research is needed from States that have a longer experience with the collection of the clinical estimate and have differing sociodemographic, health care system, and vital record reporting completeness characteristics. An examination of the mortality risk of cases categorized as gestationally at-risk by each gestational age measure, a limitation of this study, may provide further insight into their utility.

Lastly, the importance of efforts to improve the accuracy of the reporting of the date of last normal menses should not be overlooked. A woman's knowledge of the value of monitoring her menstrual cycle is an integral component of reproductive health promotion activities. Well beyond the possible improvements to gestational age data quality, the potential benefits of educational efforts in this area need to be considered in terms of their impact on preventing reproductive morbidity and mortality and enhancing women's health.

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