Title

Perinatal morbidity associated with late preterm deliveries compared to deliveries between 37–40 weeks

Journal
Bjog, 118(12)

ISSN
1471-0528

Authors
CHENG, Yvonne W
KAIMAL, Anjali J
BRUCKNER, Tim A
et al.

Publication Date
2011-08-22

Peer reviewed

NIH Public Access
Author Manuscript
BJOG. Author manuscript; available in PMC 2012 November 01.

Published in final edited form as:
BJOG. 2011 November ; 118(12): 1446–1454. doi:10.1111/j.1471-0528.2011.03045.x.

Perinatal morbidity associated with late preterm deliveries compared to deliveries between 37–40 weeks

Yvonne W CHENG, MD, MPH[1], **Anjali J KAIMAL, MD, MAS**[2], **Tim A BRUCKNER, MPH, PhD**[3], **Donna R Halloron, MD, MSPH**[4], and **Aaron B CAUGHEY, MD, PhD**[5]

[1]Division of Maternal-Fetal Medicine, Department of Obstetrics, Gynecology and Reproductive Sciences, University of California, San Francisco

[2]Division of Maternal-Fetal Medicine, Department of Obstetrics and Gynecology, Massachusetts General Hospital

[3]Department of Public Health & Planning, Policy, and Design, School of Social Ecology, University of California, Irvine

[4]Department of Pediatrics, St. Louis University

[5]Department of Obstetrics and Gynecology, Oregon Health and Science University

Abstract

Objective—To estimate the risk of short-term complications in neonates born between 34 and 36 weeks by week of gestation.

Design—This is a retrospective cohort study.

Setting—Deliveries in 2005 in the United States of America.

Population—Singleton live births between 34 and 40 weeks gestational age.

Methods—Gestational age was subgrouped into 34, 35, 36 and 37–40 completed weeks. Statistical comparisons were performed using chi-square test and multivariable logistic regression models, with 37–40 weeks gestational age designated as referent.

Main Outcome Measures—Perinatal morbidities, including 5-minute Apgar scores, hyaline membrane disease, neonatal sepsis/antibiotics use, and admission to the intensive care unit.

Results—There were 175,112 neonates born between 34 and 36 weeks in 2005. Compared to neonates born between 37 and 40 weeks, neonates born at 34 weeks had higher odds of 5-minute

Corresponding author: Yvonne W. Cheng, MD, MPH, Division of Maternal-Fetal Medicine, Department of Obstetrics, Gynecology and Reproductive Sciences, University of California, San Francisco, 505 Parnassus Avenue Box 0132, San Francisco, CA 94143-0132, Page: (415) 443-3937, Fax: (415) 476-1811, Home: (415) 567-6568, yvecheng@hotmail.com.

Reprints not available

Disclosure of Interests
There are no conflicts of interest to disclose for all authors.

Contribution to Authorship
YWC: performed the statistical analysis and composed the majority of this manuscript.
AJK: helped with the statistical analysis and composition with this manuscript.
TAB and DRH: helped with the composition of this manuscript and provided specialty/subject-specific advises as well as knowledge regarding statistical analysis.
ABC: helped with developing the design of this research question and with editing/composition of the manuscript as well as knowledge regarding statistical analysis.

Details of Ethnics Approval
This study was approved by the Committee on Human Research at the University of California, San Francisco on November 4, 2009.

Apgar<7 (adjusted odds ratio [aOR]=5.51, 95% CI [5.16–5.88]), hyaline membranes disease (aOR=10.2 [9.44–10.9]), mechanical ventilation use >6 hours (aOR=9.78 [8.99–10.6]) and antibiotics use (aOR=9.00 [8.43–9.60]). Neonates born at 35 weeks were similarly at risk of morbidity, with higher odds of 5-minute Apgar <7 (aOR 3.42 [3.23–3.63], surfactant use (aOR 3.74 [3.21–4.22], ventilation use >6 hours (aOR 5.53 [5.11–5.99] and NICU admission (aOR 11.3 [11.0–11.7). Further, neonates born at 36 weeks remain at higher risk of morbidity compared to deliveries at 37–40 weeks.

Conclusions—While the risk of undesirable neonatal outcomes decreases with increasing gestational age, the risk of neonatal complications in late preterm births remains higher compared to infants delivered at 37–40 weeks gestation.

Keywords

late preterm births; perinatal outcomes

INTRODUCTION

Late preterm birth, defined as delivery between 34 (0/7) and 36 (6/7) weeks gestation,(1) accounted for more than 70% of all preterm births in the U.S. in 2006.(2) The risk of infant death among late preterm births is three-fold higher than the risk among term births. Moreover, late preterm births comprise almost ten percent of all infant deaths in the U.S. (3). While there appears to be a small (3%) decrease between 2006 and 2008 (4), late preterm delivery has increased 25% since 1990 in the U.S., and it continues to comprise a significant portion of the overall rise in the preterm birth rate.(5) While the majority of late preterm births result from spontaneous preterm labor, premature rupture of the membranes, as well as preterm deliveries due to maternal or fetal indications,(6) it has been estimated that in Latin America up to 18% of births at this gestational age are iatrogenic.(7)

While the American Congress of Obstetricians and Gynecologists (ACOG) does not define an upper limit of gestational age for the use of tocolysis,(8) most authorities do not recommend the use of tocolysis or antenatal corticosteroids (9) beyond 34 weeks gestation due to the expectation of favorable outcomes for infants delivered at this gestational age.(1,7,10) With improved neonatal care, infants born beyond 34 weeks have been considered “near term” or “functionally full term,” and less emphasis has been placed on potential neonatal morbidity when making decisions regarding delivery. Although perinatal outcomes in neonates born after 34 weeks are certainly improved when compared to infants born before this gestational age, recent studies suggest that neonates born in the late preterm period are less mature both physiologically and metabolically when compared to neonates delivered at term. Late-preterm neonates are thus at higher risk of morbidity and mortality than term neonates.(1,11,12,13)

To further explore the association between late preterm births and perinatal outcome by gestational age, we conducted a population-based study of all low-risk, singleton, live-born deliveries that occurred in the United States in 2005 using birth certificate data. We hypothesized that the risk of perinatal morbidity associated with preterm delivery is a continuum, and perinatal complications decrease with increasing gestational age in a continuous, rather than a threshold manner. Thus, compared to neonates born at 37–40 weeks, neonates born in the late preterm period remain at risk of complications.

MATERIAL AND METHODS

This is a retrospective cohort study of low-risk women with singleton live births delivered in 2005 in the United States using the Vital Statistics Natality birth certificate registry provided by the Center of Disease Control and Prevention (CDC). The 2005 natality data include births to U.S. and non-U.S. residents which occurred in the 50 United States, the District of Columbia, the Virgin Islands and U.S. territories. Details regarding compilation of this data have been published elsewhere.(14) We excluded multiple gestations and deliveries prior to $34^{0/7}$ weeks of gestational age (GA) or after $40^{6/7}$ weeks of gestation. Pregnancies complicated by the following medical or obstetric conditions were also excluded: cardiac, pulmonary, or renal diseases, chronic hypertension, pregnancy-associated hypertension (includes gestational hypertension and preeclampsia), eclampsia, pre-gestational and gestational diabetes mellitus, premature rupture of the membranes, cord prolapse, placental abruption, and placenta praevia. Institutional Review Board (IRB) approval was obtained from the Committee on Human Research at the University of California, San Francisco.

In the 2005 Natality data, there were two entries for gestational age, one based on menstrual dates, the other based on obstetric/clinical dates. For this study, the gestational age was based on the obstetric/clinical dating since studies have shown that obstetric/clinical estimates provide a good approximation to the menstrual dating, and when ultrasound dating is designated as the “gold standard,” menstrual dating tends to overestimate gestational age.(15,16) The gestational age at delivery was subgrouped into 34, 35, and 36 completed weeks of gestation; infants delivered between 37 and 40 weeks gestation were designated as the referent group.

We examined maternal outcomes and neonatal outcomes, including 5-minute Apgar scores. In the 2005 Natality data, California did not collect information on Apgar scores, resulting in 525,904 births (16.0%) that were excluded from the analysis on 5-minute Apgars.(13) The definition and diagnostic criteria of outcomes in the birth data were based on definitions complied by a committee of Federal and State Health Statistics.(17,18) For example, “Fetal intolerance of labour” is one of the fields which the National Center for Health Statistics collects as a check field under “Characteristics of Labor.” It is characterized as “Fetal intolerance of labor such that one or more of the following actions was taken: in-utero resuscitative measures, further fetal assessment, or operative delivery.”(17)

Incidence proportions of these outcomes were examined and compared by gestational age using the Cochran-Armitage test for trend of linearity, or dose-response fashion, with $p<0.05$ as the threshold for statistical significance. Multivariable logistic regression models were used to control for potential confounding bias. Model building and selection was based on step-wise backward elimination process starting with a full model which includes all potential confounding variables to derive a restricted model, with p-value <0.10 as the threshold. Second-order interaction terms were generated but not included in the final model as these did not reach statistical significance for model selection. Births with missing outcomes of interest were excluded from such analysis. Deliveries that occurred between 37 and 40 weeks GA were designated as the reference group as we aimed to compare outcomes associated with late preterm deliveries to those delivered at term. We did not designate 40 weeks as referent and compare 34 weeks to 40 weeks, 35 weeks to 40 weeks, 36 weeks to 40 weeks, and extending this to term gestations (37 weeks to 40 weeks, and so forth) since such comparisons have previously been reported in term pregnancies. (19) Statistical analysis was performed using STATA v9.0 (StataCorp, College Station, TX). Statistical significance was indicated using $p<0.05$ and 95% confidence intervals (CI) that did not contain the null value.

RESULTS

There were 3,167,615 live, singleton births delivered in the United States in 2005 between the gestational age of 34 and 40 weeks that met study criteria and served as the study population. Of these, 175,112 neonates were born between $34^{0/7}$ and $36^{6/7}$ weeks GA:

23,574 (13.6%) delivered at 34 weeks, 44,705 (25.4%) delivered at 35 weeks, and 106,833 (61.0%) delivered at 36 weeks. The maternal characteristics are shown in Table 1.

A small fraction of women received tocolysis beyond 34 weeks gestation, with decreased frequency of tocolysis with advancing gestational age, while induction of labour became more frequent with increasing gestational age (Table 2). The frequency of primary caesarean delivery and caesarean delivery for fetal intolerance of labour as an indication was highest at 34 weeks, then decreased with increasing gestation at 35, 36, and 37 weeks (Table 2). A similar pattern was seen when primary caesarean delivery was stratified by parity. In contrast, the frequency of operative vaginal deliveries increased with advancing GA (Table 2).

When neonatal outcomes were examined by gestational age at delivery, we observed that neonates delivered at 34 weeks had a higher frequency of low 5-minute Apgar scores (3.4% for Apgar<7 and 1.5% for Apgar<4) than those delivered at 35, 36 or 37 weeks gestation (Table 3). The frequency of hyaline membrane disease (3.9%) and need for mechanical ventilation >6 hours (5.8%) was highest at 34 weeks (Table 3), as was the frequency of antibiotics use (11%) and admissions to the neonatal intensive care unit (NICU) compared to greater gestational age subgroups (Table 3).

The association between GA and perinatal outcomes in late preterm births was further examined using multivariable logistic regression; in these analyses, the adjusted odds ratio approximates the relative risk as neonatal complications are often rare outcomes. Compared to deliveries that occurred between 37–40 weeks gestation, women who delivered at 34 weeks had a nearly two-fold increase in the risk of primary caesarean delivery (adjusted odds ratio [aOR]=1.86; 95% CI [1.80–1.93]). A subgroup analysis by parity indicated that this association was present for both nulliparas and multiparas, and the risk of primary caesarean delivery in multiparas was particularly higher at 34 weeks and 35 weeks GA (Table 4). Compared to deliveries between 37–40 weeks, neonates born at 34, 35, and 36 weeks were more likely to have fetal intolerance of labour as an indication for caesarean delivery (Table 4). In contrast, preterm deliveries at 34 through 36 weeks were protective against operative vaginal delivery for both nulliparas and multiparas (Table 4). Women were also more likely to receive antenatal corticosteroids at 34 weeks (aOR=25.5 [23.5–27.7]) than at 37 weeks; this risk decreased with increasing gestational age (Table 4).

Neonates delivered at 34 weeks had a more than 5-fold increased risk of having a low 5-minute Apgar score (aOR=5.51 [5.16–5.88] for 5-minute Apgar <7 and aOR=6.97 [6.11–7.95] for 5-minute Apgar<4) compared to those delivered between 37–40 weeks. The risk of low 5-minute Apgar score was also higher for neonates delivered at 35 and 36 weeks compared to 37 weeks GA (Table 4). Neonates born at 34 weeks had a much higher risk of having hyaline membrane disease (aOR=10.2 [9.44–10.9]), requiring assisted mechanical ventilation for >6 hours (aOR=9.78 [8.99–10.6]) and having neonatal seizures (aOR=2.08 [1.82–2.39]) than those delivered between 37–40 weeks. This increased risk of respiratory complication was also seen in neonates born at 35 and 36 weeks compared to those delivered at 37–40 weeks (Table 4).

Neonatal outcomes were further examined with stratification by mode of delivery (vaginal deliveries and caesarean deliveries). In neonates who were delivered vaginally, the risks of low 5-minte Apgar scores (<7 and <4), hyaline membrane disease, and need for mechanical ventilation use were all higher in neonates delivered late preterm compared to 37–40 weeks deliveries (Table 5). Similar associations were seen for neonates who were delivered by caesarean deliveries: neonates delivered late preterm had higher risks of morbidity compared to those delivered between 37–40 weeks gestation (Table 5). We further performed multivariable logistic regression analysis with stratification by gender to estimate the effect of gestational age on perinatal outcomes and observed similar directions and magnitudes of the associations as with the entire cohort (results not shown).

DISCUSSION AND CONCLUSION

In spite of being "near-term", neonates delivered between $34^{0/7}$ and $36^{6/7}$ weeks remained at increased risk of perinatal complications as compared to those delivered at 37–40 weeks. In particular, neonates delivered at 34 weeks had the highest risk of respiratory complications, low Apgar scores, neonatal seizures and requiring admission to the intensive care nursery. While these perinatal morbidities decreased with increasing gestational age, neonates born throughout the late preterm period had a higher risk of complications when compared to infants born at 37–40 weeks gestation.

Studies have demonstrated that caesarean delivery can be associated with increased risk of respiratory complications.(20,21) To examine the association of late preterm delivery and perinatal morbidity independent of mode of delivery, the study cohort was stratified by mode of delivery. Compared to deliveries at 37–40 weeks GA, neonates born late preterm consistently had higher risks of lower 5-minute Apgars, respiratory complications, and need for ventilatory support regardless of whether they were delivered vaginally or by caesarean, suggesting that in this cohort, this effect arises primarily from the gestational age at delivery rather than from the mode of delivery.

Several studies find long-term cognitive and developmental sequelae among infants born late preterm. Key neurological, behavioral, and cognitive conditions in childhood that appear more prevalent among late preterm births include cerebral palsy, antisocial behavior, attention problems, and sub-optimal academic performance (22,23,24,25). Talge and colleagues (26), for example, find that children age six years who were born late preterm exhibit an over two-fold increased risk of borderline intellectual functioning (IQ <85). In addition, the risk of developing cerebral palsy is 3-times more likely in children born late preterm than children born at term (27). These circumstances underscore the high social cost of late preterm well into childhood and adulthood.

Women who deliver between 34 and 36 weeks gestation are at increased risk of primary caesarean delivery compared to women delivered at 37–40 weeks gestation. This increased risk applies to both nulliparas and multiparas and is even more pronounced in multiparas, with the indication for caesarean likely less frequently due to labour dystocia and more likely attributable to fetal intolerance of labour, since women undergoing caesarean for malpresentation and praevia were excluded from the cohort in this study. Women undergoing caesarean delivery incur higher risks of maternal and neonatal complications both in the index pregnancy as well as in future pregnancies.(28,29) In an era of declining trial of labour after caesarean, once the first caesarean is performed, women are likely to face the increased morbidity from repeat caesareans in the future.(30)

In addition to the increase in perinatal morbidity during the late preterm period observed in this study, previous studies have shown that infants born between 34–36 weeks are at increased risk of grade 1–2 intraventricular hemorrhage, temperature instability, hypoglycemia, hyperbilirubinemia, feeding difficulty, and longer hospital stay.(10,11,12,31,32) Recent studies also report that beyond the immediate neonatal period, infant mortality (death from 28 day of life to 1 year of life) of infants born in the late preterm period is twice that of full term births (31).

The healthcare costs required to care for neonates born at 33 weeks GA are estimated as 10 times that for term neonates: the average spending per case was $7,200 for 34 weeks GA,

$2,600 for 36 weeks GA, and $1,100 for term births in California in 1996.(33) In a recent study of the financial costs associated with clinical problems and extended hospital stays among late preterm births, Wang and colleagues (34) estimated a mean excess of $2,630 ($3,081 in 2010 dollars) in total health care costs for each late preterm, relative to term, birth. If we apply this value to the total number of late preterm births in the U.S. in 2005 (i.e., 173,819), the excess hospital costs for late preterm births sum to approximately $535 million per year. Given that Wang and colleagues followed late preterm births only to age one, this estimate represents a lower bound of the total health care costs incurred over the life course. As healthcare expenditures continue to skyrocket and financial and social resources are finite, strategies to prevent preterm birth should not only focus on curtailing preterm delivery between 24 and 34 weeks but should also include strategies for prevention of late preterm births.

The emerging evidence of significant perinatal, neonatal, and postnatal morbidity and mortality associated with late preterm births is particularly alarming given the 25% increase in the incidence rate of late preterm births between 1990 and 2006 in the U.S. Most obstetric interventions to reduce perinatal morbidity and mortality associated with preterm birth are tertiary prevention (intervention initiated after the parturition process has begun), as it is difficult to identify women at risk (secondary prevention) or institute population-level interventions for women before or during pregnancy (primary prevention).(35) As the majority of late preterm births result from spontaneous preterm labour,(5,6) obstetricians/ clinicians are in a key position to provide preventative care, including: preconception counseling, public education, nutritional supplementation, smoking cessation, prenatal care, screening for at-risk women, treatment for high-risk women, and early diagnosis and treatment of preterm labour.(27) For women who have an obstetric or fetal indication for delivery, the benefits and risks of intervention and the resulting iatrogenic late preterm delivery with its associated immediate neonatal effects as well long-term ramifications should be carefully considered. For example, in the setting of preterm premature rupture of the membranes (PROM), the American College of Obstetricians and Gynecologists (ACOG) Practice Bulletin states that “delivery is recommended with PROM occurs at or beyond 34 weeks of gestation.”(36) Perhaps, in the absence of clinical or subclinical infection, the benefit of expectant management may be cautiously weighed against potential morbidity associated with late preterm delivery to optimize perinatal outcome. Thus, this topic deserves further investigation.

While this population-based study reflects obstetric and neonatal outcomes of low-risk births between 34 and 36 weeks gestation in the United States in 2005, it has limitations. As this study examines perinatal outcomes associated with late preterm deliveries, the accuracy of gestational age dating is essential. The issue of gestational age dating in the Natality data by menstrual or obstetric/clinical estimates has been examined in depth (15,16). Obstetric/ clinical estimates reportedly provide a close approximation to the menstrual dating. While we chose to use obstetric/clinical dating for this analysis to minimize such error in estimation, some women may have been misclassified such that they were assigned a higher gestational age than they should have been. Although misclassification bias is usually unidirectional, the bias affects all groups so the comparisons of each week sub-strata to the others are still valuable. The advantage of using the Vital Statistics natality data is the representation of all live births in the United States, which truly reflects the obstetric care in this country. Although maternal and neonatal outcomes were reported with detailed definitions and routinely verified by the Federal and State maternal and child health personnel for quality control checks to ensure accuracy and completeness, missing data and reporting error may still exist; however, this typically represent a very small proportion (<1%) of the population and they were excluded from analysis. We assumed that censorship occurred in a random fashion and likely would not have biased study findings given the small number. One exception was the examination of 5-minute Apgar scores, which the state of California did not report and represented 15% of the births.

We report one of the largest cohorts in the literature that examines perinatal outcomes associated with late preterm births. Consistent with prior studies, we found that deliveries at 34 weeks gestation remain at risk of perinatal morbidity compared to deliveries at 37–40 weeks. This risk decreases with increasing gestational age but is still significant at 34, 35, or 36 weeks gestation. This evidence suggests that since neonates born late preterm are not physiologically as mature as term infants, they should not be considered "functionally term." As late preterm births continue to rise, there is an urgent need for clinical and research efforts to focus on the prevention of preterm delivery even at 34 weeks and beyond. In the meantime, the findings of our large population-based study may aid clinicians in the management of late preterm labour and in counseling women at risk for late preterm births.

Acknowledgments

The authors would like to acknowledge Sanae Nakagawa for statistical programming assistance.

Funding

Dr. Yvonne Cheng is supported by the UCSF Women's Reproductive Health Research Career Development Award, NIH, the *Eunice Kennedy Shriver* National Institute of Child Health and Human Development (K12 HD001262)

Dr. Donna Halloron is supported by the Washington University CTSA (KL2RR024994-01)

References

1. Raju TNK, Higgins RD, Stark AR, Leveno KJ. Optimizing care and outcomes for late-preterm (near-term) infants: A summary of the workshop sponsored by the National Institute of Child Health and Human Development. Pediatrics. 2006; 118:1207–14. [PubMed: 16951017]
2. Hamilton BE, Martin JA, Ventura SJ. Centers for Disease Control and Prevention National Center for Health Statistics National Vital Statistics System. Births: Preliminary data for 2006. Natl Vital Stat Rep. 2007; 56:1–18. [PubMed: 18277471]
3. Mathews TJ, MacDorman MF. Infant mortality statistics from the 2006 period linked birth/infant death data set. National Vital Statistics Reports. 2010; 58:1–32.
4. Martin JA, Osterman MJK, Sutton PD. Are preterm births on the decline in the United States? Recent data from the National Vital Statistics System. NCHS Data Brief. 2010; 39:1–8. [PubMed: 20604990]
5. Martin JA, Hamilton BE, Sutton PD, Ventura SJ, Menacker F, Kirmeyer S, et al. Centers for Disease Control and Prevention National Center for Health Statistics National Vital Statistics System. Births: Final data for 2005. Natl Vital Stat Rep. 2007; 56:1–103. [PubMed: 18277471]
6. Villar J, Abalos E, Carroli G, Giordano D, Wojdyla D, Piaggio G, et al. World Health Organization Antenatal Care Trial Research Group. Heterogeneity of perinatal outcomes in the preterm delivery syndrome. Obstet Gynecol. 2004; 104:78–87. [PubMed: 15229004]
7. Barros FC, Valez Mdel P. Temporal trends of preterm birth subtypes and neonatal outcomes. Obstet Gynecol. 2006; 107:1035–41. [PubMed: 16648408]
8. The American College of Obstetricians and Gynecologists. ACOG Practice Bulletin. Management of preterm labor. Clinical management guidelines for Obstetrician-Gynecologists. No 43, May 2003. Obstet Gynecol. 2003; 101:1039–47. [PubMed: 12738177]
9. Report of the Consensus Development Conference on the Effect of Corticosteroids for Fetal Maturation on Perinatal Outcomes. National Institute of Child Health and Human Development. November 1994. NIH Publication No. 95–3784.
10. Committee on Obstetric Practice. ACOG Committee Opinion No. 404 April 2008. Late-preterm infants. Obstet Gynecol. 2008; 111:1029–32. [PubMed: 18378769]

11. Shapiro-Mendoza CK, Tomashek KM, Kotelchuck M, Barfield W, Nannini A, Weiss J, et al. Effect of late-preterm births and maternal medical conditions on new born morbidity risk. Pediatrics. 2008; 121:e223–32. [PubMed: 18245397]
12. Wang ML, Dorer DJ, Fleming MP, Catlin EA. Clinical outcomes of near-term infants. Pediatrics. 2004; 114:372–6. [PubMed: 15286219]
13. Sarici, Su; Serdar, MA.; Korkmaz, A.; Erdem, G.; Oran, O.; Tekinalp, G., et al. Incidence, course, and prediction of hyperbilirubinemia in near-term and term newborns. Pediatrics. 2004; 113:775–80. [PubMed: 15060227]
14. Martin JA, Hamilton BE, Sutton PD, Ventura SJ, Menacker F, Kirmeyer S, et al. Center for Disease Control and Prevention National Center for Health Statistics National Vital Statistics System. Births: Final data for 2005. Natl Vital Stat Rep. 2007; 56(6):1–103. [PubMed: 18277471]
15. Ananth CV. Menstrual versus clinical estimate of gestational age dating in the United States: Temporal trends and variability in indices of perinatal outcomes. Paediatr Perinat Epidemiol. 2007; 21(Supp 2):22–30. [PubMed: 17803615]
16. Wier ML, Pearl M, Kharrazi M. Gestational age estimation on United States live birth certificates: A historical overview. Paediatr Perinat Epidemiol. 2007; 21(Supp 2):4–12. [PubMed: 17803613]
17. National Center for Health Statistics. Guide to completing the facility worksheets for the Certificate of Live Birth and Report of Fetal Death. Hyattsville, Maryland: National Center for Health Statistics; 2003 revisionAvailable on the internet at: http://www.cdc.gov/nchs/data/dvs/GuidetoCompleteFacilityWks.pdf
18. Martin, JA.; Hamilton, BE.; Sutton, PD.; Ventura, SJ.; Menacker, F.; Munson, ML. Births: Final data for 2003. National vital statistics reports. Vol. 54. Hyattsville, Maryland: National Center for Health Statistics; 2005.
19. Cheng YW, Nicholson JM, Nakagawa S, Bruckner TA, Washington AE, Caughey AB. Perinatal outcomes in low-risk term pregnancies: Do they differ by weeks of gestation? Am J Obstet Gynecol. 2008; 199:370.e1–7. [PubMed: 18928977]
20. Gerten KA, Coonrod DV, Bay RC, Chambliss LR. Cesarean delivery and respiratory distress syndrome: does labor make a difference? Am J Obstet Gynecol. 2005; 193:1061–4. [PubMed: 16157112]
21. Hansen, Ak; Wisborg, K.; Uldbjerg, N.; Henriksen, TB. Risk of respiratory morbidity in term infant delivered by elective caesarean section: cohort study. BMJ. 2008; 336:85–7. [PubMed: 18077440]
22. Nomura Y, Rajendran K, Brooks-Gunn J, Newcorn JH. Roles of perinatal problems on adolescent antisocial behaviors among children born after 33 completed weeks: a prospective investigation. J Child Psychol Psychiatry. 2008; 49:1108–17. [PubMed: 18673404]
23. Nomura Y, Halperin JM, Newcorn JH, et al. The risk for impaired learning-related abilities in childhood and educational attainment among adults born near-term. J Pediatr Psychol. 2009; 34:406–18. [PubMed: 18794190]
24. Petrini JR, Dias T, McCormick MC, Massolo ML, Green NS, Escobar GJ. Increased risk of adverse neurological development for late preterm infants. J Pediatr. 2009; 154:169–76. [PubMed: 19081113]
25. Morse SB, Zheng H, Tang Y, Roth J. Early school-age outcomes of late preterm infants. Pediatrics. 2009; 123:e622–29. [PubMed: 19336353]
26. Talge NM, Holzman C, Wang J, Lucia V, Gardiner J, Breslau N. Late-Preterm Birth and Its Association With Cognitive and Socioemotional Outcomes at 6 Years of Age. Pediatrics. 2010; 126:1124–31. [PubMed: 21098151]
27. Khashu M, Narayanan M, Bhargava S, Osiovich H. Perinatal outcomes associated with preterm birth at 33 to 36 weeks' gestation: A population-based cohort study. Pediatrics. 2009; 123:109–13. [PubMed: 19117868]
28. Silver RM, Landon MB, Rouse DJ, Leveno KJ, Spong CY, Thom EA, et al. National Institute of Child Health and Human Development Maternal-Fetal Medicine Unites Network. Maternal morbidity associated with multiple repeat cesarean deliveries. Obstet Gynecol. 2006; 107:1226–32. [PubMed: 16738145]
29. Smith GC, Fretts RC. Stillbirth. Lancet. 2007 Nov 17.370:1715–25. [PubMed: 18022035]

30. Landon MB, Hauth JC, Leveno KJ, Spong CY, Leindecker S, Varner MW, et al. National Institute of Child Health and Human Development Maternal-Fetal Medicine Unites Network. Maternal and perinatal outcomes associated with a trial of labor after prior cesarean delivery. N Engl J Med. 2004 Dec 16.351:2581–9. [PubMed: 15598960]

31. McIntire DD, Leveno JK. Neonatal mortality and morbidity rates in late preterm births compared with births at term. Obstet Gynecol. 2008; 111:35–41. [PubMed: 18165390]

32. Darcy AE. Complications of the late preterm infant. J Perinat Neonatal Nurs. 2009; 23:78–86. [PubMed: 19209064]

33. Gilbert WM, Nesbitt TS, Daneilsen B. The cost of prematurity: Quantification by gestational age and birth weight. Obstet Gynecol. 2003; 102:488–92. [PubMed: 12962929]

34. Wang ML, Dorer DJ, Fleming MP, Catlin E. Clinical Outcomes of Near-Term Infants. Pediatrics. 2004; 114:372–6. [PubMed: 15286219]

35. Iams JD, Romero R, Culhane JF, Goldenberg RL. Primary, secondary, and tertiary interventions to reduce the morbidity and mortality of preterm birth. Lancet. 2008; 371:164–75. [PubMed: 18191687]

36. American College of Obstetricians and Gynecologists Practice Bulletin. Clinical Management Guidelines for Obstetrician-Gynecologists. Premature rupture of membranes. No 80, April 2007. Obstet Gynecol. 2007; 109:1007–9. [PubMed: 17400872]

Table 1

Maternal characteristics associated with gestational age at delivery*

	34 weeks (n=23,574)	35 weeks (n=44,705)	36 weeks (n=106,833)	37–40 weeks (n=2,992,503)
Age				
≤ 19 years (n=327,026)	1.00 %	1.82 %	3.92 %	93.26 %
20–34 years (n=2,410,494)	0.71 %	1.37 %	3.31 %	94.61 %
35–40 years (n=382,813)	0.72 %	1.33 %	3.25 %	94.70 %
≥ 41 years (n=47,282)	0.97 %	1.51 %	3.66 %	93.87 %
Parity				
Nulliparas (n=1,200,976)	0.82 %	1.48 %	3.34 %	94.46 %
Multipara (n=1,949,268)	0.68 %	1.35 %	3.37 %	94.60 %
Race/Ethnicity				
Non-Hispanic White (n=1,654,044)	0.69 %	1.38 %	3.43 %	94.50 %
African American (n=491,124)	1.22 %	2.09 %	4.59 %	92.10 %
Latina/Hispanic (n=717,254)	0.61 %	1.15 %	2.66 %	95.57 %
Asian (n=149,945)	0.49 %	0.93 %	2.38 %	96.20 %
Other (n=66,644)	0.75 %	1.41 %	3.51 %	94.33 %
Education				
0–8 years (n=679,484)	0.89 %	1.62 %	3.57 %	93.92 %
9–11 years (n=902,617)	0.79 %	1.51 %	3.61 %	94.10 %
12 years (n=647,963)	0.72 %	1.40 %	3.43 %	94.45 %
13–16+ years (n=896,308)	0.57 %	1.13 %	2.90 %	95.39 %
Not stated/unknown (n=36,449)	0.82%	1.42 %	3.16 %	94.59 %
Prenatal care visits				
≤ 6 visits (n=283,863)	1.86 %	3.00 %	5.70 %	89.44 %
7 to 14 visits (n=2,310,368)	0.62 %	1.25 %	3.14 %	94.99 %
≥ 15 visits (n=472,469)	0.48 %	1.03 %	2.77 %	95.72 %

Source: National Center for Health Statistics (2005)

*p<0.0001 for all comparisons using chi-square test

Table 2

Maternal outcomes by gestational age at delivery *
(CD: caesarean delivery; VD: vaginal delivery)

	34 weeks (n=23,574)	35 weeks (n=44,705)	36 weeks (n=100,833)	37–40 weeks (n=2992,503)
Primary CD (n=459,688)	24.6 %	19.9 %	17.0 %	14.3 %
Nulliparas (n=249,649)	32.8 %	28.1 %	26.1 %	24.8 %
Multiparas (n=207,177)	20.3 %	15.9 %	12.8 %	9.43 %
CD for fetal intolerance of labour (n=46,709)	11.9 %	11.0 %	8.67 %	7.64 %
Operative VD (n=144,806)	2.16 %	3.01 %	3.55 %	4.67 %
Nulliparas (n=82,795)	3.57 %	5.29 %	6.52 %	8.42 %
Multiparas (n=61,439)	1.42 %	1.91 %	2.23 %	2.93 %
Tocolysis (n=10,438)	5.20 %	3.76 %	2.60 %	0.92 %
Antenatal corticosteroids (n=2,732)	6.42 %	2.81 %	1.22 %	0.14 %
Labour induction (n=658,576)	12.3 %	13.1 %	15.0 %	21.2 %
Nulliparas (n=230,398)	14.8 %	16.3 %	18.8 %	23.3 %
Multiparas (n=425,481)	11.0 %	11.5 %	13.4 %	20.3 %
Febrile morbidity (n=27,541)	1.01 %	0.87 %	1.00 %	1.28 %

Source: National Center for Health Statistics (2005)

* $p<0.0001$ for all outcomes by Cochran-Armitage test for trend

Table 3

Neonatal outcomes by gestational age at delivery.* (NICU: neonatal intensive care unit)

	34 weeks (n=23,574)	35 weeks (n=44,705)	36 weeks (n=106,833)	37 weeks (n=2,992,503)
5-minute Apgar <7† (n=19,408)	3.42 %	2.20 %	1.54 %	0.65 %
5-minute Apgar <4† (n=1,712)	1.47 %	0.92 %	0.51 %	0.18 %
Hyaline membrane disease (n=5,708)	3.93 %	2.53 %	1.26 %	0.17 %
Mechanical ventilation >30 minutes (n=6,966)	3.93 %	2.42 %	1.17 %	0.24 %
Mechanical ventilation > 6 hours (n=4,324)	5.76 %	3.14 %	1.49 %	0.31 %
Surfactant administration (n=848)	1.98 %	0.96 %	0.34 %	0.04 %
Antibiotics administration (n=11,980)	10.8 %	6.36 %	3.22 %	0.97 %
Neonatal seizures (n=1,107)	0.09 %	0.08 %	0.06 %	0.03 %
NICU admission (n=34,604)	47.0 %	24.3 %	11.0 %	2.49 %

Source: National Center for Health Statistics (2005)

* p<0.0001 for all outcomes by Cochran-Armitage test for trend

† available in 3,237,630 (86.0%) birth records (excluding California)

NIH-PA Author Manuscript
NIH-PA Author Manuscript

Table 4

Adjusted odds ratios of perinatal outcomes using multivariable logistic regression analyses*

	34 weeks		35 weeks		36 weeks	
	aOR	**95% CI**	**aOR**	**95% CI**	**aOR**	**95% CI**
Maternal Outcomes						
1° Caesarean delivery	1.86	1.80–1.93	1.43	1.39–1.46	1.19	1.17–1.21
1° *CD nulliparas*	1.47	1.42–1.53	1.17	1.13–1.21	1.04	1.02–1.07
1° *CD multiparas*	2.60	2.48–2.73	1.90	1.83–1.98	1.44	1.40–1.48
CD-fetal intolerance of labour	1.75	1.65–1.86	1.55	1.48–1.62	1.25	1.20–1.29
Operative vaginal delivery	0.51	0.47–0.55	0.68	0.64–0.72	0.79	0.76–0.82
OpVD nulliparas	0.48	0.43–0.53	0.66	0.62–0.71	0.79	0.76–0.82
OpVD multiparas	0.58	0.49–0.68	0.72	0.65–0.78	0.82	0.76–0.85
Antenatal Corticosteroids	25.5	23.5–27.7	10.7	9.80–11.6	4.63	4.26–5.04
Labor induction	0.56	0.54–0.58	0.61	0.59–0.62	0.70	0.69–0.71
Febrile morbidity	0.88	0.77–1.01	0.76	0.69–0.85	0.89	0.84–0.95
Neonatal Outcomes						
5-minute Apgar <7†	5.51	5.16–5.88	3.42	3.23–3.63	2.34	2.24–2.46
5-minute Apgar <4†	6.97	6.11–7.95	4.08	3.61–4.63	2.41	2.16–2.68
Hyaline membrane disease	10.2	9.44–10.9	6.49	6.08–6.93	3.61	3.41–3.82
Mechanical ventilation >30 minutes	9.09	8.46–9.77	5.46	5.11–5.83	3.03	2.87–3.21
Mechanical ventilation >6 hours	9.78	8.99–10.6	5.53	5.11–5.99	2.94	2.74–3.15
Surfactant	6.31	5.55–7.18	3.74	3.21–4.22	1.88	1.68–2.10
Antibiotics	9.00	8.43–9.60	5.24	4.93–5.55	2.84	2.70–2.99
Seizure	2.08	1.82–2.39	1.59	1.42–1.79	1.47	1.36–1.59
NICU admission	32.3	30.9–33.6	11.3	11.0–11.7	4.43	4.29–4.57

Source: National Center for Health Statistics (2005)

*Adjusting for maternal age, parity, race/ethnicity, maternal education, gestational weight gain, prenatal visits and cigarette smoking during pregnancy

Reference comparison group: women who delivered between 37–40 weeks of gestation

† available in 3,237,630 (86.0%) birth records (excluding California)

Table 5

Stratification by mode of delivery: Adjusted odds ratios of neonatal outcomes using multivariable logistic regression analyses*

Vaginal Delivery	34 weeks (n=16,019)		35 weeks (n=32,777)		,36 weeks (n=81101)	
	aOR	95% CI	aOR	95% CI	aOR	95% CI
5-min Apgar <7†	4.27	3.88–4.70	2.91	2.67–3.16	2.14	2.01–2.27
5-min Apgar <4†	5.32	4.36–6.50	3.21	2.68–3.85	2.11	1.82–2.44
Hyaline membrane disease	9.87	8.94–10.9	6.13	5.62–6.69	3.32	3.08–3.58
Mechanical ventilation >30 m	9.20	8.35–10.1	4.88	4.46–5.35	2.67	2.48–2.89
Mechanical ventilation >6 hrs	8.85	7.80–10.0	4.21	3.73–4.76	2.53	2.29–2.80
Surfactant	4.95	4.07–6.03	2.56	2.13–3.09	1.47	1.26–1.72
Antibiotics	9.40	8.60–10.3	4.71	4.34–5.11	2.55	2.37–2.73
Neonatal seizure	2.28	1.91–2.72	1.41	1.20–1.64	1.37	1.24–1.51
NICU admission	33.7	31.9–35.6	10.7	10.2–11.3	4.14	3.97–4.33
Caesarean Delivery	**34 weeks (n=10,268)**		**35 weeks (n=17,126)**		**36 weeks (n=37,074)**	
	aOR	**95% CI**	**aOR**	**95% CI**	**aOR**	**95% CI**
5-min Apgar <7†	6.74	6.16–7.37	4.09	3.74–4.46	2.66	2.47–2.87
5-min Apgar <4†	8.04	6.74–9.59	5.06	4.25–6.01	2.78	2.36–3.26
Hyaline membrane disease	10.8	9.68–12.1	7.46	6.74–8.26	4.34	3.98–4.75
Mechanical ventilation >30 m	9.05	8.10–10.1	6.58	5.95–7.27	3.79	3.47–4.13
Mechanical ventilation >6 hrs	9.91	8.82–11.1	6.78	6.09–7.54	3.39	3.06–3.75
Surfactant	8.32	6.98–9.91	5.77	4.90–6.78	2.63	2.23–3.09
Antibiotics	7.99	7.25–8.79	5.69	5.22–6.20	3.20	2.96–3.46
Neonatal seizure	1.86	1.46–2.37	2.10	1.76–2.50	1.72	1.50–1.97
NICU admission	27.7	26.0–29.5	11.3	10.7–11.9	4.56	4.46–4.76

Source: National Center for Health Statistics (2005)

*Adjusting for maternal age, parity, race/ethnicity, maternal education, gestational weight gain, prenatal visits and cigarette smoking during pregnancy

Reference comparison group: women who delivered between 37–40 weeks of gestation

†available in 3,237,630 (86.0%) birth records (excluding California)