View metadata, citation and similar papers at core.ac.uk

brought to you by CORE

provided by Carolina Digital Repository

NIH Public Access
Author Manuscript
Matern Child Health J. Author manuscript; available in PMC 2014 January 01.

Published in final edited form as:
Matern Child Health J. 2013 January ; 17(1): 33–41. doi:10.1007/s10995-012-0945-7.

Regional Variation in Late Preterm Births in North Carolina

Sofia R Aliaga, MD, MPH[1], **P. Brian Smith, MD, MPH, MHS**[2], **Wayne A Price, MD**[1], **Thomas S Ivester, MD, MPH**[3], **Kim Boggess, MD**[3], **Sue Tolleson-Rinehart, PhD**[1], **Martin J McCaffrey, MD**[1], and **Matthew M Laughon, MD, MPH**[1]

[1]Pediatrics, University of North Carolina, Chapel Hill, NC

[2]Pediatrics, Duke University Medical Center, Durham, NC

[3]Obstetrics and Gynecology, University of North Carolina, Chapel Hill, NC

Abstract

Objective—Late preterm (LPT) neonates (34 0/7th to 36 6/7th weeks' gestation) account for 70% of all premature births in the United States. LPT neonates have a higher morbidity and mortality risk than term neonates. LPT birth rates vary across geographic regions. Unwarranted variation is variation in medical care that cannot be explained by sociodemographic or medical risk factors; it represents differences in health system performance, including provider practice variation. The purpose of this study is to identify regional variation in LPT births in North Carolina that cannot be explained by sociodemographic or medical/obstetric risk factors.

Methods—We searched the NC State Center for Health Statistics linked birth-death certificate database for all singleton term and LPT neonates born between 1999 and 2006. We used multivariable logistic regression analysis to control for socio-demographic and medical/obstetric risk factors. The main outcome was the percent of late preterm birth in each of the six perinatal regions in North Carolina.

Results—We identified 884,304 neonates; 66,218 (7.5%) were LPT. After multivariable logistic regression, regions 2 (7.0%) and 6 (6.6%) had the highest adjusted percent of LPT birth.

Conclusions—Analysis of a statewide birth cohort demonstrates regional variation in the incidence of LPT births among NC's perinatal regions after adjustment for sociodemographic and medical risk factors. We speculate that provider practice variation might explain some of the remaining difference. This is an area where policy changes and quality improvement efforts can help reduce variation, and potentially decrease LPT births.

Keywords

late preterm; preterm birth; unwarranted variation; practice variation

Introduction

More than 70% of preterm births are late preterm (LPT) neonates, born between 34 0/7th and 36 6/7th weeks' gestation(1) and are at increased risk for morbidity and mortality compared to term neonates. (2) The incidence of LPT births in the US increased from 7.3% of births in 1990 to 9.2% in 2006 and accounts for 85% of the increase in the overall preterm birth rate. (3) LPT neonates experience longer initial hospitalizations, more frequent admissions to neonatal intensive care units, and higher rates of readmissions after discharge

Corresponding author: Sofia R Aliaga, MD, MPH Pediatrics CB#7596 101 Manning Drive Chapel Hill, NC 27599 Phone: 919-966-5063 Fax: 919-966-3034 saliaga@med.unc.edu.

NIH-PA Author Manuscript NIH-PA Author Manuscript NIH-PA Author Manuscript

NIH-PA Author Manuscript

NIH-PA Author Manuscript

NIH-PA Author Manuscript

from the birth hospitalization than do term neonates. (2, 4) LPT neonates also have an increased risk of adverse long-term neurodevelopmental outcomes, including cerebral palsy, developmental delay, and school-related problems than do term neonates. (5, 6)

Preterm births are not evenly distributed across the US. (7, 8) One explanation for this variation is underlying differences in the distribution of risk factors for preterm birth, including sociodemographic and medical/obstetric risk factors. (8) Recently, disparities in access to care and quality of care have been suggested as sources of the geographic variation in preterm births. (8) Practice variation of health care providers can affect quality of care and contribute to unwarranted variation (9, 10), and is a modifiable cause of preterm births. Variation in preterm births that cannot be explained by risk factors for preterm birth is unwarranted variation potentially amenable to intervention. (11)

Identifying and understanding variation in LPT births is an important step toward reducing the overall preterm birth rate and its associated morbidities and cost. Sources of unwarranted variation in LPT birth are targets for additional research and prevention as well as quality improvement efforts. The purpose of this study is to identify regional variation of LPT births in North Carolina that cannot be explained by sociodemographic or medical/obstetric risk factors.

Methods

We searched the North Carolina State Center for Health Statistics linked birth-death certificate database for all singleton live births between 1999 and 2006. We assigned one of two gestational age categories: 34 0/7th to 36 6/7th weeks' gestation (LPT) or ≥37 weeks' gestation (term) to each birth, and excluded neonates with major congenital anomalies, unknown gestational age, unknown birth weight, gestational age < 34 weeks, birth weight < 1000 g, and out of state births. Information on maternal Medicaid enrollment at time of birth was linked to this dataset with permission from the North Carolina Department of Health and Human Services' Division of Medical Assistance. Each birth was assigned to one of six perinatal care regions in North Carolina based on the county of birth hospital (Figure 1). The University of North Carolina Institutional Review Board approved this study.

We identified two categories of risk factors for LPT birth based on published literature and variables present in the birth certificate database: sociodemographic and medical/obstetric. The sociodemographic risk factors we identified are maternal race, age, education, marital status, parity, adequacy of prenatal care, tobacco use, alcohol use, Medicaid enrollment, infant sex, and birth year. Medicaid enrollment status and maternal education were used as a proxy for socioeconomic status. We omitted paternal sociodemographic information because of substantial amounts of missing data. The medical/obstetrical risk factors we identified in the data are previous small for gestational age/preterm birth, previous birth of a ≥ 4000 g neonate, maternal transfer prior to birth, placenta previa, placental abruption, premature rupture of membranes, pregnancy-associated hypertension, eclampsia, chronic hypertension, hydramnios/oligohydramnios, incompetent cervix, diabetes, cephalo-pelvic disproportion, uterine bleeding, maternal anemia, maternal cardiac disease, maternal renal disease, maternal fever during labor/delivery, malpresentation, maternal lung disease, genital herpes, maternal Rhesus sensitization, and maternal hemoglobinopathy. We did not include presence of meconium, precipitous labor, prolonged labor, dysfunctional labor, prolapsed cord, anesthetic complications, or fetal distress as risk factors because these factors are more likely to indicate intralabor and/or intrapartum complications. We defined mode of delivery as cesarean if primary cesarean or repeat cesarean was recorded as the method of delivery on the birth certificate. We determined that induction of labor occurred if it was recorded on the

NIH-PA Author Manuscript NIH-PA Author Manuscript NIH-PA Author Manuscript

birth certificate. We defined hospitals with more than 20 deliveries per year as a delivery hospital.

We determined gestational age by last menstrual period dating when available, as long as the difference between the last menstrual period estimate and the clinical estimate of gestational age was < 2 weeks. If the date of last menstrual period was missing or the difference between the last menstrual period estimate and clinical estimate was ≥ 2 weeks, we used the clinical estimate for gestational age. We considered prenatal care to be adequate if it was initiated within the first four months of pregnancy and the minimum number of expected visits was attended given the date of initiation of prenatal care using a modified Kotelchuck Adequacy of Prenatal Care Utilization Index. (12)

Statistical analysis

The main exposure variable was the region of birth and the primary outcome was LPT birth. We used chi-square analysis to compare the unadjusted incidence of LPT birth for each perinatal region, to compare regional rates of cesarean deliveries and labor inductions, and to examine the association between sociodemographic and medical/obstetric risk factors and LPT birth.

Multivariable forward stepwise logistic regression was used to calculate the unadjusted and adjusted odds ratio of LPT birth for each region, controlling for the sociodemographic and medical/obstetric risk factors described above. A p-value of 0.2 was chosen for entry and removal of variables in the regression model. Region 3, the region with the lowest incidence of LPT birth was chosen as the reference region for the logistic regression model. The unadjusted and adjusted percent (or probability) of LPT birth for each region was derived from a logistic regression model using the STATA 10.1 *predxcat* command. We accepted a p-value < 0.05 to indicate statistical significance. All data analyses were performed using STATA 10.1 statistical software package (College Station, Texas).

Results

We identified 926,915 singleton live births in North Carolina between 1999 and 2006; 42,611 (4.6%) births met exclusion criteria; 884,304 (95.4%) LPT and term neonates were included in the final dataset. Of these 66,218 (7.5%) were LPT births. LPT births increased during the study period, from 7.4% in 1999 to 7.5% in 2006 (p <0.001).

Region 3 had the lowest percent of LPT birth (7.0%). The percent of late preterm births for regions 1, 2, 5, and 6 were equal to or above the state's overall average, while for regions 3 and 4 were below the state's overall average (unadjusted values in Figure 2; p <0.001 to 0.02 when regions were compared to region 3, the reference region). The largest proportion of the state's births occurred in region 2 during the study period (n=202,002, 22.8%) and the fewest births occurred in region 1 (n=56,964, 6.4%). Region 2 had the lowest percent of labor inductions (12.8%) among LPT births and region 1 the highest (21.5%) (p<0.001, Table 1). Cesarean deliveries for LPT births ranged from 28.7% in region 6 to 30.3% in region 4 (p=0.13, Table 1). Regions 2 and 6 had the highest number of delivery hospitals during the study period (Figure 3). In regions 3 and 4, fewer than 5 delivery hospitals accounted for most LPT births.

The sociodemographic variables most frequently associated with an LPT birth were maternal age < 20 years and ≥ 35 years, non-Hispanic black race/ethnicity, < high school education, unmarried, inadequate prenatal care, alcohol use, tobacco use, maternal transfer prior to delivery, Medicaid recipient, multiparity, and male sex (Table 2). The medical/obstetric variables most associated with an LPT birth were preterm rupture of membranes,

NIH-PA Author Manuscript

NIH-PA Author Manuscript

NIH-PA Author Manuscript

placenta previa, placental abruption, previous SGA/preterm birth, pregnancy-associated hypertension, eclampsia, chronic hypertension, incompetent cervix, uterine bleeding, and hydramnios/oligohydramnios (Table 2).

We also found that the independent sociodemographic and medical/obstetric risk factors varied by region for all births in the dataset (Table 3). Region 1 had the lowest percent of non-Hispanic black births (5.2%) and region 6 the highest (34.4%). Births associated with inadequate prenatal care ranged from 11.9% to 20.4%. Region 4 had the lowest rate (8.0%) of tobacco exposure and region 1 the highest (19.1%). Region 1 had the highest percent of births associated with Medicaid enrollment at the time of delivery (54.3%); regions 3 and 4 had the lowest at 35.2% and 36.3%, respectively. Rates of pregnancy-associated hypertension ranged from 3.6% to 7.4%. Region 5 had the highest rate of eclampsia (0.6%), while the lowest rate was seen in region 3 (0.1%).

Controlling for sociodemographic and medical/obstetric risk factors, regions 2 and 6 had the highest adjusted percentage of LPT births: 7.0% ($p<0.001$ compared to other regions) and 6.6% respectively ($p= 0.003$ to $p<0.001$ compared to other regions). Regional differences in sociodemographic and medical/obstetric risk factors account for varying proportions of LPT births in each region (Figure 2). The absolute difference between the unadjusted and adjusted percent of LPT birth ranged from 0.8 percentage points in region 2 (or 10.3% of the region's unadjusted percent of LPT birth) to 1.6 percentage points in region 5 (or 20.5% of the region's unadjusted percent of LPT birth).

Controlling for sociodemographic and medical/obstetric risk factors resulted in the reordering of high-risk regions. For example, regions 2 and 5 had a similar unadjusted percent of LPT birth, and region 5's unadjusted percent of LPT birth was higher than that in region 4 (one of the lowest risk regions). After adjustment, the percent of LPT birth in region 2 was higher than for region 5 ($p<0.001$) and the difference between regions 4 and 5 was no longer statistically significant. We present odds ratios of the multivariate logistic regression results in Table 4.

Discussion

We observed variation in LPT births among North Carolina's perinatal regions. Controlling for known population differences in sociodemographic and medical/obstetric risk factors for LPT birth explained a portion of regional variation. Similar to previous studies, we also identified certain sociodemographic factors that appear to increase the risk for LPT birth, including the non-Hispanic black women, inadequate prenatal care, tobacco use and Medicaid enrollment. (5, 8) Medical/obstetric risk factors associated with LPT birth in our study, as in prior studies, included PROM, placental disorders, hypertensive disorders, previous SGA/preterm birth, incompetent cervix, uterine bleeding, hydramnios/oligohydramnios, and maternal diabetes. (2, 13–18) The remaining regional variation in LPT births is likely due to unwarranted variation, in which practice variation may play a role.

Previous research has demonstrated what we would consider to be unwarranted variation in LPT births. An analysis of US Birth Certificate data found that higher maternal age, non-Hispanic white ethnicity, a higher level of maternal education, delivery in the Midwest, South, and Western parts of the US, multiparity, and a history of a previous neonate with a birth weight > 4000 g are associated with LPT birth, in the absence of other medical/obstetrical indications for delivery.(17) Other researchers who have reviewed delivery indications for 514 LPT births at a tertiary care center classified 37.9% of the births as medically indicated, but 8.2% were classified as elective. (15) Potentially avoidable LPT births – those defined as associated with a stable, but high-risk condition - were 17% of the

NIH-PA Author Manuscript NIH-PA Author Manuscript NIH-PA Author Manuscript

cohort; these latter births were characterized as having been more likely to be attended by non-faculty private physicians, have private insurance payer status, and to have been scheduled cesarean deliveries. (15) Other investigators used data from a large multicenter birth cohort containing over 15,000 singleton LPT births to determine that 1 in 15 (or 6.9%) LPT deliveries were associated with “soft” or elective precursors, and 6.1% of LPT deliveries were for unknown indications. (18) Our study results, as do these earlier studies, support the speculation that physician practice patterns influence LPT birth rates.

Variation in both health care utilization and outcomes can result from many causes, and some of them may be non-modifiable or not readily modifiable risk factors such as disease incidence or socioeconomic status. Variation in care may be associated with misuse, underuse, and overuse of resources and services. Explanations for variation in care include the number of available physicians and hospital beds, sociodemographic composition of populations, access to health insurance, health status or illness severity, and provider practice variation. (10, 19) Variation resulting from differences in health care system performance, including practice variation, has been defined as unwarranted variation, and such unwarranted variation may drive differences in the quality, appropriateness, and efficiency of health care. (11) Variation in perinatal/neonatal medical care is associated with higher neonatal mortality, low birth weight, high use of intensive neonatal care, longer hospitalizations, more antenatal testing, more cesarean deliveries, and induction of labor, all of which persist after adjusting for risk factors. (7, 20–26) Some of this variation may be the result of differences in medical practice or the organization of care. (20)

Approximately 50% of preterm births are spontaneous; the remaining births are considered medically indicated or iatrogenic. (8, 27) Providers' practice style is a critical determinant of health care utilization. (28, 29) Practice variation frequently results from the presence of uncertainty about the appropriateness or effectiveness of health care services. Unwarranted variation will occur when providers disagree about the “safest” or ”best” choice. Because obstetric practice has traditionally considered 34 weeks gestation a marker of maturity, management of many pregnancy complications changes at this point, with fewer attempts made to prolong the pregnancy. (8, 13) The rise in LPT births paralleled rising rates of cesarean deliveries and labor inductions among LPT pregnancies. (30, 31) Evidence suggests that this change in obstetrical practice, particularly among non-emergent indications for delivery, partly explains the rise in LPT births. (13, 31) The potential for practice variation in the management of LPT pregnancies comes in part from the uncertainty regarding the optimal timing of delivery for LPT pregnancies complicated by obstetric or medical co-morbidities.

In this study, sociodemographic risk factors and medical/obstetric risk factors did not explain regional differences in LPT births. Regional differences in rates of labor inductions and cesarean deliveries do not follow a pattern that would further explain regional variation in LPT births; however differences in obstetrical decision-making for non-spontaneous LPT deliveries might further characterize underlying practice variation. Birth certificate data does not allow for the determination of the clinical intent surrounding a labor induction or cesarean delivery. Perinatal regionalization was established in North Carolina in the 1970s to organize access and availability of prenatal services, referrals for neonatal services, and outreach and education. At that time, the boundaries of the regions were primarily determined by geographic characteristics. The regions were defined so that at least one tertiary neonatal center was present in each region. We found that more than 35% of LPT births occurred outside the top 5 birth hospitals within regions 2 and 6, the regions with the highest percent of adjusted LPT birth. This observation may suggest a role for center variation (practice style differences between centers) as an explanation for unwarranted variation in LPT births in these regions.

NIH-PA Author Manuscript NIH-PA Author Manuscript NIH-PA Author Manuscript

The strengths of this study are its use of a large comprehensive population dataset that is generalizable to the population of North Carolina, limiting the risk of selection bias that might result from using a study population taken from one particular health care setting. Since variation in care is influenced by the performance of the local health care system and characteristics of the population in a given geographic area, studies on variation should be population based. We might expect other areas of the country with similar health care systems and populations to experience a similar degree of variation. This study is also one of the first that attempts to uncover practice variation as an underlying driver of LPT birth, a less common approach to the study of preterm birth prevention.

Our study is constrained by the limitations of both completeness and accuracy of birth certificate data, which do not permit determinations of clinical intent surrounding a birth. (32) Limitations in the use of birth certificate data include inaccurate estimates of gestational age, as well as the underreporting of obstetric procedures, complications of labor and delivery, and maternal and fetal medical conditions. (33–37) The random and non-random nature of the underreporting might have led us to overestimate the variation of LPT birth across regions, particularly if underreporting of associated medical/obstetric conditions occurred unevenly. It is possible that the regional differences in LPT births found in this analysis are attributable to risk factors that vital statistics data do not capture, including other associated medical co-morbidities requiring delivery and patient preferences. Linking of birth certificate data to more accurate medical record information on medical risk factors would help address underreporting of these conditions. In addition, an analysis including regional characteristics of the health care system (e.g. number of obstetricians or maternal-fetal medicine physicians, access to health insurance) might help further characterize unwarranted variation in LPT births.

Gestational age estimated from birth certificate data is not always reliable. (32) Various data editing methods attempt to improve the estimation. (33, 34) A common approach relies on last menstrual period dating, and incorporates birth weight as a proxy for gestational age during data editing. Other methods include applying the clinical estimate when last menstrual period dating is unavailable or creating a composite estimate. We used a composite approach that incorporates both last menstrual period and clinical estimate information. We did not incorporate birth weight for gestational age editing since LPT birth weights overlap significantly with that of term births. Our approach resulted in a more conservative estimate of LPT births, with potentially more LPT births classified as term, although our observations of the trend in rates of LPT births are similar to those made from National Center for Health Statistics data over the 8-year period. (38) Our incidence of singleton LPT births in the final cohort is lower than that reported by the National Center for Health Statistics (7.5% vs. 8.3%) likely due to differences in estimation of gestational age and processes for excluding those born with congenital anomalies and very premature neonates.

In conclusion, we have identified regional variation in LPT births in North Carolina that, after adjustment for known sociodemographic or medical/obstetric risk factors for preterm delivery are examples of unwarranted variation. Practice variation in the management of LPT deliveries might explain this variation. Understanding patterns of unwarranted variation and practice variation in LPT births will help researchers and public health officials customize the implementation and dissemination of best practices and quality improvement activities aimed at decreasing variation and, it is to be hoped, the LPT birth rate. Even small improvements in LPT birth rates will improve public health because of the large annual number of LPT births in the US.

NIH-PA Author Manuscript

NIH-PA Author Manuscript

NIH-PA Author Manuscript

Acknowledgments

Dr. Smith received support from NICHD 1K23HD060040-01 and DHHS-1R18AE000028-01.

Dr. Laughon receives support from the U.S. government for his work in pediatric and neonatal clinical pharmacology (Government Contract HHSN267200700051C, PI: Benjamin) and from NICHD (1K23HL092225-01).

We would like to thank the North Carolina State Center for Health Statistics and the Division of Medical Assistance at the North Carolina Department of Health and Human Services for providing access to the data used for this study.

References

1. Martin JA, Hamilton BE, Sutton PD, et al. Births: final data for 2007. Natl Vital Stat Rep. 2010; 58(24):1–85. [PubMed: 21254725]
2. Raju TN, Higgins RD, Stark AR, et al. Optimizing care and outcome 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(3):1207–14. [PubMed: 16951017]
3. Martin, JA.; Hamilton, BE.; Sutton, PD., et al. Births: Final Data for 2006. National Center for Health Statistics; Hyattsville, MD: 2009. Contract No.: 7
4. Engle WA, Tomashek KM, Wallman C. “Late-preterm” infants: a population at risk. Pediatrics. 2007; 120(6):1390–401. [PubMed: 18055691]
5. Morse SB, Zheng H, Tang Y, et al. Early school-age outcomes of late preterm infants. Pediatrics. 2009; 123(4):e622–9. [PubMed: 19336353]
6. Petrini JR, Dias T, McCormick MC, et al. Increased risk of adverse neurological development for late preterm infants. J Pediatr. 2009; 154(2):169–76. [PubMed: 19081113]
7. Thompson LA, Goodman DC, Chang CH, et al. Regional variation in rates of low birth weight. Pediatrics. 2005; 116(5):1114–21. [PubMed: 16263997]
8. Behrman, RE.; Butler, AS., editors. Preterm Birth: Causes, Consequences, and Prevention. Institute of Medicine of the National Academies Press; Washington, DC: 2006.
9. Brook RH, Lohr KN. Efficacy, effectiveness, variations, and quality. Boundary-crossing research. Med Care. 1985; 23(5):710–22. [PubMed: 3892183]
10. Wennberg J, Gittelsohn A. Variations in medical care among small areas. Sci Am. 1982; 246(4): 120–34. [PubMed: 7079718]
11. Goodman DC. Unwarranted variation in pediatric medical care. Pediatr Clin North Am. 2009; 56(4):745–55. [PubMed: 19660625]
12. Kotelchuck M. An evaluation of the Kessner Adequacy of Prenatal Care Index and a proposed Adequacy of Prenatal Care Utilization Index. Am J Public Health. 1994; 84(9):1414–20. [PubMed: 8092364]
13. Fuchs K, Gyamfi C. The influence of obstetric practices on late prematurity. Clin Perinatol. 2008; 35(2):343–60. [PubMed: 18456073]
14. McIntire DD, Leveno KJ. Neonatal mortality and morbidity rates in late preterm births compared with births at term. Obstet Gynecol. 2008; 111(1):35–41. [PubMed: 18165390]
15. Holland MG, Refuerzo JS, Ramin SM, et al. Late preterm birth: how often is it avoidable? Am J Obstet Gynecol. 2009; 201(4):404, e1–4. [PubMed: 19716546]
16. Slattery MM, Geary M, Morrison JJ. Obstetric antecedents for preterm delivery. J Perinat Med. 2008; 36(4):306–9. [PubMed: 18598119]
17. Reddy UM, Ko CW, Raju TN, et al. Delivery indications at late-preterm gestations and infant mortality rates in the United States. Pediatrics. 2009; 124(1):234–40. [PubMed: 19564305]
18. Laughon SK, Reddy UM, Sun L, et al. Precursors for late preterm birth in singleton gestations. Obstet Gynecol. 2010; 116(5):1047–55. [PubMed: 20966688]
19. Chassin MR, Kosecoff J, Park RE, et al. Does inappropriate use explain geographic variations in the use of health care services? A study of three procedures. JAMA. 1987; 258(18):2533–7. [PubMed: 3312655]

NIH-PA Author Manuscript NIH-PA Author Manuscript NIH-PA Author Manuscript

20. Roblin DW, Richardson DK, Thomas E, et al. Variation in the use of alternative levels of hospital care for newborns in a managed care organization. Health Serv Res. 2000; 34(7):1535–53. [PubMed: 10737452]

21. Jason CJ, Samuhel ME, Glick BJ, et al. Geographic distribution of unexplained low birth weight. J Occup Med. 1986; 28(8):728–40. [PubMed: 3746498]

22. Helfand M, Zimmer-Gembeck MJ. Practice variation and the risk of low birth weight in a public prenatal care program. Med Care. 1997; 35(1):16–31. [PubMed: 8998200]

23. Glantz JC. Labor induction rate variation in upstate New York: what is the difference? Birth. 2003; 30(3):168–74. [PubMed: 12911799]

24. Baicker K, Buckles KS, Chandra A. Geographic variation in the appropriate use of cesarean delivery. Health Aff (Millwood). 2006; 25(5):w355–67. [PubMed: 16895942]

25. Clark SL, Belfort MA, Hankins GD, et al. Variation in the rates of operative delivery in the United States. Am J Obstet Gynecol. 2007; 196(6):526, e1–5. [PubMed: 17547880]

26. Tromp M, Eskes M, Reitsma JB, et al. Regional perinatal mortality differences in the Netherlands; care is the question. BMC Public Health. 2009; 9:102. [PubMed: 19366460]

27. Ananth CV, Vintzileos AM. Epidemiology of preterm birth and its clinical subtypes. J Matern Fetal Neonatal Med. 2006; 19(12):773–82. [PubMed: 17190687]

28. Wennberg JE. Dealing with medical practice variations: a proposal for action. Health Aff (Millwood). 1984; 3(2):6–32. [PubMed: 6432667]

29. Eddy DM. Variations in physician practice: the role of uncertainty. Health Aff (Millwood). 1984; 3(2):74–89. [PubMed: 6469198]

30. Davidoff MJ, Dias T, Damus K, et al. Changes in the gestational age distribution among U.S. singleton births: impact on rates of late preterm birth, 1992 to 2002. Semin Perinatol. 2006; 30(1): 8–15. [PubMed: 16549207]

31. MacDorman MF, Declercq E, Zhang J. Obstetrical intervention and the singleton preterm birth rate in the United States from 1991–2006. Am J Public Health. 2010; 100(11):2241–7. [PubMed: 20864720]

32. Schoendorf KC, Branum AM. The use of United States vital statistics in perinatal and obstetric research. Am J Obstet Gynecol. 2006; 194(4):911–5. [PubMed: 16580275]

33. Parker JD, Schoendorf KC. Implications of cleaning gestational age data. Paediatr Perinat Epidemiol. 2002; 16(2):181–7. [PubMed: 12064271]

34. Qin C, Dietz PM, England LJ, et al. Effects of different data-editing methods on trends in race-specific preterm delivery rates, United States, 1990–2002. Paediatr Perinat Epidemiol. 2007; 21(Suppl 2):41–9. [PubMed: 17803617]

35. Mustafa G, David RJ. Comparative accuracy of clinical estimate versus menstrual gestational age in computerized birth certificates. Public Health Rep. 2001; 116(1):15–21. [PubMed: 11571404]

36. Qin C, Hsia J, Berg CJ. Variation between last-menstrual-period and clinical estimates of gestational age in vital records. Am J Epidemiol. 2008; 167(6):646–52. [PubMed: 18182378]

37. Wingate MS, Alexander GR, Buekens P, et al. Comparison of gestational age classifications: date of last menstrual period vs. clinical estimate. Ann Epidemiol. 2007; 17(6):425–30. [PubMed: 17395481]

38. National Center for Health Statistics. Retrieved September 26th, 2010 from www.marchofdimes.com/peristats

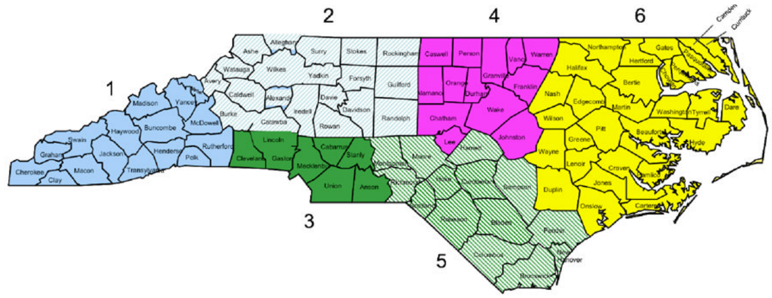


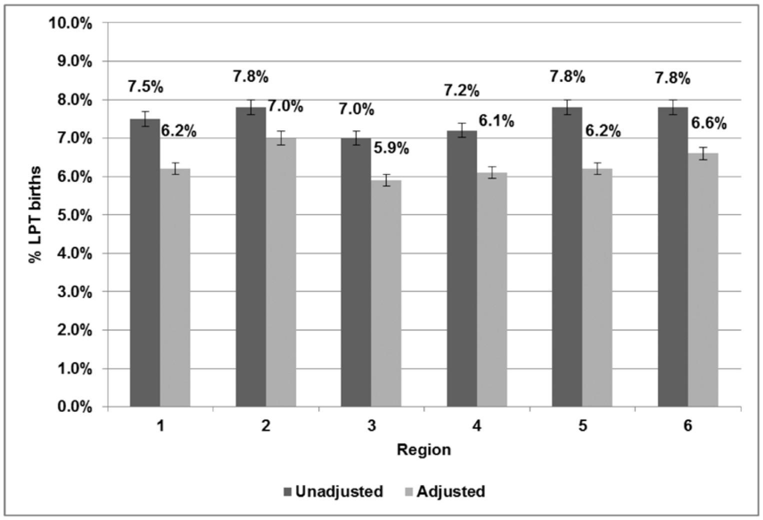
Figure 1.
Perinatal Regions in North Carolina

NIH-PA Author Manuscript NIH-PA Author Manuscript NIH-PA Author Manuscript

NIH-PA Author Manuscript

NIH-PA Author Manuscript

NIH-PA Author Manuscript



The vertical bars are the 95% confidence intervals of both adjusted and unadjusted percents.

*Adjusted OR from multivariate logistic regression adjusted for maternal age, race, education, marital status, parity, adequacy of prenatal care, tobacco use, alcohol use, Medicaid enrollment, infant sex, maternal transfer prior to birth, birth year, previous small for gestational age/preterm birth, previous birth of a ≥ 4000 g neonate, placenta previa, placental abruption, premature rupture of membranes, pregnancy-associated hypertension, eclampsia, chronic hypertension, hydramnios/oligohydramnios, incompetent cervix, diabetes, cephalo-pelvic disproportion, uterine bleeding, maternal anemia, maternal cardiac disease, maternal renal disease, maternal fever during labor/delivery, malpresentation, maternal lung disease, genital herpes, maternal Rhesus sensitization, and maternal hemoglobinopathy

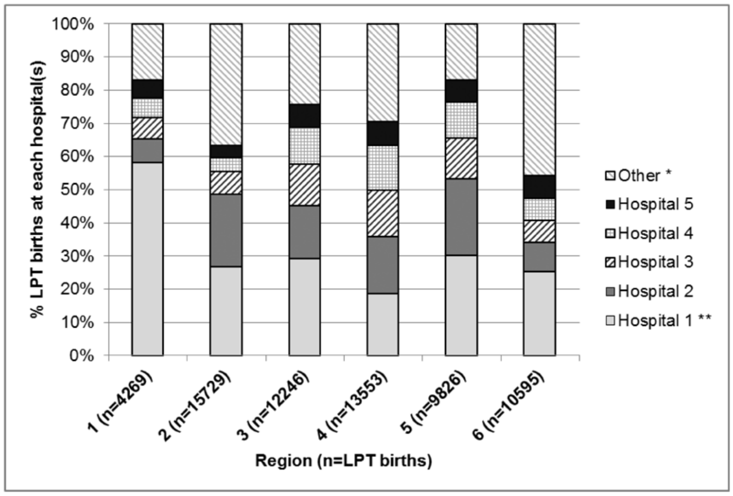
Figure 2.

Unadjusted and adjusted* percents of late preterm birth by perinatal region in North Carolina, 1999–2006

NIH-PA Author Manuscript

NIH-PA Author Manuscript

NIH-PA Author Manuscript



Maximum possible delivery hospitals per region (1999-2006): 13 in region 1, 26 in region 2, 13 in region 3, 15 in region 4, 14 in region 5, 19 in region 6

* * Hospital 1 – 5: top 5 delivery hospitals for LPT births (%) in each region

* Other: remaining delivery hospitals in each region

Figure 3.

Regional Distribution of Late Preterm Births by Birth Hospital in North Carolina, 1999 – 2006

NIH-PA Author Manuscript

NIH-PA Author Manuscript

NIH-PA Author Manuscript

Table 1

Regional differences in labor inductions and cesarean deliveries for late preterm and term births in North Carolina, 1999–2006 (%), n=884,304

	Labor induction		Cesarean	
Region	**LPT***	**Term***	**LPT^**	**Term***
1	21.5	25.5	29.2	23.9
2	12.8	19.2	29.1	24.3
3	15.1	19.6	29.4	25.1
4	15	16.3	30.3	25.1
5	19.1	23.6	29	25.5
6	18.3	21.4	28.7	24.7

* $p<0.001$

^ $p=0.13$

NIH-PA Author Manuscript NIH-PA Author Manuscript NIH-PA Author Manuscript

Table 2

Sociodemographic and medical/obstetric risk factors for LPT and term, births in North Carolina, 1999–2006 (n=884,304)

Variable	% Late Preterm (n=66,218)	% Term (n=818,086)	Adjusted OR* (95%CI)
Maternal age (years)			
<20	13.6	12.1	1.08 (1.05 – 1.12)
20 – 24	27.1	27.3	1
25 – 29	25.8	27.2	1.02 (0.99 – 1.05)
30 – 34	20.5	22.1	1.03 (1.00 – 1.06)
35 – 39	10.6	9.5	1.17 (1.14 – 1.21)
≥ 40	2.4	1.8	1.34 (1.26 – 1.42)
Maternal race/ethnicity			
Non-hispanic white	56.3	59.8	1
Non-hispanic black	29.4	22.4	1.31 (1.28 – 1.34)
Hispanic	10.7	13.7	0.80 (0.78 – 0.83)
Other	3.7	4.2	0.96 (0.92 – 1.01)
Unmarried	40.7	35.2	1.07 (1.04 – 1.09)
Maternal education			
< High School	6.3	6.9	1.04 (0.99 – 1.08)
High School	50.2	45.5	1
>High School	43.3	47.6	0.91 (0.90 – 0.93)
Parity			
Multiparous	66.8	65.7	1.06 (1.04 – 1.08)
Inadequate prenatal care	20.3	16.7	1.22 (1.19 – 1.24)
Tobacco use	16.9	12.5	1.26 (1.23 – 1.29)
Alcohol use	0.9	0.5	1.27 (1.15 – 1.39)
Medicaid at time of birth	47.9	42.6	1.05 (1.03 – 1.07)
Gender			
Male	53.5	50.8	1.12 (1.10 – 1.14)
Maternal transfer prior to delivery	1.4	0.1	7.92 (7.18 – 8.74)
PROM	8.8	1.6	6.78 (6.55 – 7.01)
Placental abruption	2.1	0.3	6.05 (5.63 – 6.50)
Placenta previa	1.4	0.3	5.64 (5.20 – 6.12)
Previous SGA/preterm birth	3.6	0.7	4.51 (4.30 – 4.76)
Eclampsia	1.4	0.2	4.37 (4.00 – 4.77)
Incompetent cervix	0.9	0.2	3.35 (3.03 – 3.70)
Pregnancy related hypertension	12.1	4.4	3.16 (3.07 – 3.25)
Chronic hypertension	2.4	0.9	2.36 (2.23 – 2.51)
Uterine bleeding	1.1	0.3	2.37 (2.16 – 2.60)
Hydramnios/olygohydramnios	3	1.4	2.07 (1.96 – 2.18)

NIH-PA Author Manuscript
NIH-PA Author Manuscript
NIH-PA Author Manuscript

*Adjusted OR from multivariate logistic regression adjusted for maternal age, race, education, marital status, parity, adequacy of prenatal care, tobacco use, alcohol use, Medicaid enrollment, infant sex, maternal transfer prior to birth, birth year, previous small for gestational age/preterm birth, previous birth of a ≥ 4000 g neonate, placenta previa, placental abruption, premature rupture of membranes, pregnancy-associated hypertension, eclampsia, chronic hypertension, hydramnios/oligohydramnios, incompetent cervix, diabetes, cephalo-pelvic disproportion, uterine bleeding, maternal anemia, maternal cardiac disease, maternal renal disease, maternal fever during labor/delivery, malpresentation, maternal lung disease, genital herpes, maternal Rhesus sensitization, and maternal hemoglobinopathy

NIH-PA Author Manuscript

NIH-PA Author Manuscript

NIH-PA Author Manuscript

Table 3

Regional distribution of sociodemographic and medical/obstetric risk factors for LPT and term births in North Carolina, 1999–2006 (%), n= 884,304

Region	1	2	3	4	5	6
Maternal age ≥ 40 years	1.8	1.7	2	2.4	1.4	1.4
< HS education	5.6	7.1	6.5	8	6.3	6.2
Non-Hispanic black	5.2	17.2	22.5	23.6	27.1	34.4
Unmarried	32.7	34.8	33.9	32.1	40.3	40.8
Multiparous	62.8	67	65.8	65.8	66	64.9
Inadequate prenatal care	11.9	13.2	17.5	20.3	18.9	17.5
Tobacco	19.1	16	10.6	8	15.1	13.3
Medicaid	54.3	45.4	35.2	36.3	48.1	49.2
Male	51.3	50.9	51.1	51.0	50.9	51.1
PROM	2.2	1.3	2.6	3	2.3	1.4
Placental abruption	0.5	0.4	0.5	0.4	0.6	0.3
Placenta previa	0.3	0.4	0.3	0.3	0.4	0.3
Eclampsia	0.3	0.2	0.1	0.2	0.6	0.5
Pregnancy related hypertension	7.4	5.7	5.2	3.6	5.1	4
Chronic hypertension	1	0.8	1.1	1	1.4	1.1
Diabetes	2.4	2	3.8	2.2	3.5	2.5

$p<0.001$ for all except infant sex ($p=0.39$)

HS: high school

PROM: premature rupture of membranes

NIH-PA Author Manuscript NIH-PA Author Manuscript NIH-PA Author Manuscript

Table 4

Unadjusted and Adjusted OR of Late Preterm Birth by North Carolina Perinatal Region, 1999–2006

Region	Unadjusted OR (95% CI)	Adjusted OR (95% CI)*
3	Reference	Reference
4	1.03 (1.00, 1.06)	1.04 (1.01, 1.07)
5	1.13 (1.09, 1.16)	1.06 (1.03, 1.09)
1	1.08 (1.04, 1.12)	1.07 (1.03, 1.11)
6	1.13 (1.10, 1.16)	1.13 (1.09, 1.16)
2	1.13 (1.09, 1.15)	1.20 (1.17, 1.24)

*Adjusted OR from multivariate logistic regression adjusted for maternal age, race, education, marital status, parity, adequacy of prenatal care, tobacco use, alcohol use, Medicaid enrollment, infant sex, maternal transfer prior to birth, birth year, previous small for gestational age/preterm birth, previous birth of a ≥ 4000 g neonate, placenta previa, placental abruption, premature rupture of membranes, pregnancy-associated hypertension, eclampsia, chronic hypertension, hydramnios/oligohydramnios, incompetent cervix, diabetes, cephalo-pelvic disproportion, uterine bleeding, maternal anemia, maternal cardiac disease, maternal renal disease, maternal fever during labor/delivery, malpresentation, maternal lung disease, genital herpes, maternal Rhesus sensitization, and maternal hemoglobinopathy