Published in final edited form as:

Paediatr Perinat Epidemiol. 2016 January ; 30(1): 67–75. doi:10.1111/ppe.12250.

Childhood Respiratory Morbidity after Late Preterm and Early Term Delivery: a Study of Medicaid Patients in South Carolina

Imelda N. Odibo^a, T. Mac Bird^b, Samantha S. McKelvey^a, Adam Sandlin^a, Curtis Lowery^a, and E. F. Magann^a

^aDepartment of Obstetrics and Gynecology, University of Arkansas for Medical Sciences, Little Rock, AR

^bCollege of Public Health, University of Arkansas for Medical Sciences, Little Rock, AR

Abstract

Background—There is a growing body of research documenting an increased risk of neonatal morbidity for late preterm infants (LPI, 34^{0/7} weeks to 36^{6/7} weeks) and early term infants (ETI, 37^{0/7} weeks to 38^{6/7} weeks) compared with term infants (TI, 39^{0/7} to 41^{6/7}); however, there has been little research on outcomes beyond the first year of life. In this study, we examined respiratory outcomes of LPI and ETI in early childhood.

Methods—South Carolina Medicaid claims data for maternal delivery and infant birth hospitalisations were linked to vital records data for the years 2000 through 2003. Medicaid claims for all infants were then followed until their fifth birthday or until a break in their eligibility. Infants born between 34^{0/7} and 41^{6/7} weeks were eligible. Infants with congenital anomaly, birthweight below 500 g or above 6000 g, and multiple births were excluded. We fit Cox proportional hazard models from which adjusted hazard ratio (HR) and 95% confidence interval (CI) were derived.

Results—A total of 3476 LPI, 12 398 ETI, and 25 975 term infants were included. Both LPI and ETI were associated with an increased risk for asthma (LPI: HR 1.24, 95% CI 1.10, 1.40; ETI: HR 1.12, 95% CI 1.06, 1.19), and bronchitis (LPI: HR 1.15, 95% CI 1.00, 1.34; ETI: HR 1.13, 95% CI 1.05, 1.2) at 3 to 5 years of age.

Conclusions—Late preterm infants and early term infants are at increased risk for asthma and bronchitis.

Keywords

late preterm; early term; long-term outcomes; respiratory morbidity; Medicaid

Late preterm infants (LPI) born between 34^{0/7} and 36^{6/7} weeks gestation make up over 70% of all preterm births and total over 300 000 births in the US each year.^{1,2} Early term infants

Correspondence: Imelda N. Odibo, Department of Obstetrics and Gynecology, University of Arkansas for Medical Sciences, 4301 W. Markham Street, Little Rock, AR 72205, USA. iodibo@yahoo.com.

Disclosure

The authors report no conflict of interest related to this manuscript.

(ETI) born between 37^{0/7} and 38^{6/7} weeks account for over 950 000 births each year.^{1,2} Most ETI and many LPI are of similar size to term infants, and therefore may be treated by caregivers and health care professionals as if they are developmentally similar to term infants.^{3,4} However, LPI and ETI are physiologically immature and are at greater risk of neonatal morbidity and mortality than term infants.³

Many obstetrical decisions during the final weeks of a pregnancy involve weighing the risks and benefits of delivering an infant prior to 39 weeks.^{5,6} In order to make fully informed decisions, an accurate understanding of the risks including long-term respiratory morbidity related to delivery prior to 39 weeks is necessary. However, most outcomes research on infants prior to 39 weeks has been focused on those infants born prior to 34 weeks gestation (WG).⁷⁻¹⁰ This is true even though, due to their large numbers, the public health impact of LPI and ETI is potentially as great as or greater than that of early and moderate preterm births.¹¹

There is a growing body of research documenting an increased risk of morbidity and mortality in the neonatal period for ETI and LPI compared with term infants. These include studies of complications during the birth hospitalisation,^{8,12-16} re-hospitalisation rates,^{13,17-19} risk factors for morbidity,^{3,16,18,20-22} and mortality rates.^{12,19,23} However, there has been comparatively little research on the health-related outcomes of ETI and LPI beyond the first year of age.^{9,10,24,25} Very few studies have looked at early delivery and respiratory morbidity at and beyond the first year of life, and results are mixed.²⁶⁻³¹

It remains difficult to isolate the outcomes that can be attributed solely to early delivery due to complication by many other variables including prenatal conditions, maternal risks, and clinical practices which may jointly influence early delivery and development of subsequent adverse outcomes. It will be useful to determine the extent to which gestational age is independently associated with adverse outcomes after accounting for these confounding factors. The goal of this study was to determine if ETI and LPI are at increased risk for long-term respiratory morbidity in comparison to their term counterparts. We addressed these questions by limiting our analysis to singleton births with no evidence of congenital anomalies while controlling for maternal complications and comorbidities.

Methods

Data

Data for this investigation came from linked vital records data and Medicaid claims data from the state of South Carolina. Vital records data were linked to maternal Medicaid delivery claims and newborn Medicaid claims. For the children, Medicaid claims were followed through their fifth birthday or until a break in eligibility. This linked data set was created by the South Carolina Budget and Control Board, Office of Research and Statistics in cooperation with South Carolina Department of Health and Human Services and the Department of Health and Environmental Control. During this period, Medicaid was the primary payer for 50% to 55% of the births in South Carolina. This study was approved by the institutional review board of the University of Arkansas for Medical Sciences.

Subjects

All South Carolina births with Medicaid as primary payer source and a gestational age between 34^{0/7} weeks and 41^{6/7} weeks that were born between January 2000 and December 2003 were eligible for inclusion ($n = 82\,862$). In an attempt to isolate the effect of gestational age on long-term morbidity, we excluded all infants greater than 6000 grams ($n = 8$), all infants less than 500 g ($n = 2$), all infants with any birth defect documented on either the birth certificate or the Medicaid claims files, International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes 740–758.9 ($n = 3497$), multiple births ($n = 1512$), and infants that died prior to their fifth birthday ($n = 21$). Because asthma is rarely diagnosed prior to 3 years of age, any infant with less than 36 months continuous eligibility, beginning at birth, were excluded from the analysis ($n = 35\,973$). All included infants were followed through their fifth birthday or until a break in their Medicaid eligibility. The number of subjects excluded from the study based on each exclusion criteria and the total number remaining is shown in Table 1.

Statistical analysis

Infants were categorised as either LPI, 34^{0/7} to 36^{6/7} weeks, ETI, 37^{0/7} to 38^{6/7} weeks TI, 39^{0/7} to 41^{6/7} weeks. Gestational age data came from birth certificates. The specific method used to determine the gestational age of individual newborns is not known; however, it is likely that a variety of methods were used within the population, with date of last menstrual period being the most frequent. Outcome measures are derived from Medicaid inpatient, outpatient, and emergency department claims files and are based on the presence of at least one ICD-9-CM diagnosis codes for a specific condition at any point between a child's first and fifth birthday. The specific conditions include asthma (493–493.9) and bronchitis (466–466.9), (774.0–774.3, 774.5–774.6, 782.4).

Control variables were derived from either birth certificate data, Medicaid claims data, or both. Variables such as preeclampsia and alcohol abuse which could possibly be found in either data source were searched for in both. Any indication in either data source was considered sufficient evidence of the condition. Birthweight, which would be expected to differ systematically by gestational age category and therefore bias the analysis if included, was accounted for by z-transformation of birthweight by each week of gestational age separately. Small for gestational age was defined as a birthweight z-score < -1.28 , and large for gestational age was defined as a birthweight z-score > 1.28 . This roughly demarks the upper and lower 10th percentile. Control variables included sociodemographic data, hospital level variables, delivery type, delivery complications, and maternal co-morbid medical condition.

Systematic differences could exist between those children that were excluded and included in the analysis based on length of Medicaid eligibility. To test for this possibility, a two stage Heckman-type selection model was employed. The first stage used a logit model to estimate the probability of being Medicaid eligible for 36 months or more. From this model, the inverse Mill's ratio was calculated and used as a regressor in the second stage of the analysis. Since subjects differ in the number of months of Medicaid eligibility, and are thus observed for varying durations in the data, the second stage of the analysis used a

multivariable Cox proportional hazard model. The inverse Mills ratio was not statistically significant in the second stage of the analysis, indicating no systematic differences between those with more or less than 36 months continuous eligibility; therefore, the two stage model was abandoned in favour of the more parsimonious single-stage Cox model. All analyses were conducted with Stata MP v12.0 statistical analysis software (Stata Corp., College Station, TX, USA).

Results

A total of 7440 LPI, 24 210 ETI, and 51 212 term infants met the eligibility criteria. After exclusions 3476 LPI, 12 398 ET, and 25 975 term infants remained in the analysis. The average length of continuous Medicaid eligibility for the analytic cohort was 38.6 months, while 32.5% of the cohort had continuous Medicaid eligibility for at least 60 months. Number of infants remaining after each stage of the exclusion process is depicted in Table 1. Descriptive characteristics stratified by gestational age category, which were later used as control variables for multivariable analysis, are depicted in Table 2. There was a lower proportion of small for gestational age infants and a higher proportion of large for gestation infants in the LPI group, which would be expected due to the birthweight exclusion criteria. There was a greater proportion of white and Hispanic infants in the full-term group, while a greater proportion of late preterm infants were black. Primiparous mothers had a higher proportion of term deliveries, while deliveries to women of parity at or above 3 were more likely to be LPI.

Among deliveries to women over age 30, and those with no paternal data on the birth certificate, a higher proportion was in the LPI group. Among spontaneous vaginal deliveries and labour inductions, a higher proportion of infants were delivered at term. Among cesarean deliveries and emergency admissions, greater proportions were LPI. Women with fewer than five prenatal care visits were more likely to deliver LPI. Inter-pregnancy intervals less than 24 months were associated with earlier deliveries. With the exception of macrosomia, previous infants greater than 4000 grams and meconium staining, there was a general trend towards earlier deliveries with all other measured clinical factors complicating labour and delivery. There was a higher proportion of LPI deliveries in level 3 hospitals, Extracorporeal Membrane Oxygenation (ECMO) capable hospitals, and high-volume hospitals. Among maternal medical co-morbidities, there was a greater proportion of LPI deliveries for women with chronic diabetes, chronic hypertension, neurologic disorders, and coagulation disorders. No other measured medical co-morbidities were statistically different in terms of gestational age category.

Rates for asthma, bronchitis, and both outcomes –asthma and bronchitis by gestational age category and by individual week of gestational age are depicted in Table 3. Rates decreased with increasing gestational age for all outcomes; asthma (18.4%, 14.6%, and 12.8%); bronchitis (10.2%, 9.4%, and 8.3%), and asthma and bronchitis (4.1%, 3.7%, and 3.0%). A bivariate analysis of the association between neonatal respiratory morbidity and the study outcomes, stratified by gestational age category has been included in Appendix 1. For LPI, utilisation of oxygen therapy, respiratory syncytial virus (RSV) infection and apnoea increased the risk of development of asthma. Other variables with statistically significant

higher rates in neonates who developed asthma or bronchitis include respiratory distress, transitory tachypnoea, use of mechanical ventilation and sepsis. RSV infection was consistently higher in neonates who developed asthma and bronchitis regardless of gestational age. Maternal steroid injection did not seem to make a difference in the development of asthma and bronchitis regardless of gestational age.

Both crude and adjusted hazard ratios (HR) and 95% confidence intervals (CI) from comparisons of outcomes between LPI, ETI, and full-term infants are reported in Table 4. All variables in Table 2 were included as control variables in the multivariable models. Both LPI and ETI, when compared with full-term infants, have a greater risk of developing asthma (LPI: HR 1.24 95% CI 1.10, 1.40; ETI: HR 1.12 95% CI 1.06, 1.19), and bronchitis (LPI: HR 1.15 95% CI 1.00, 1.34; ETI: HR 1.13 95% CI 1.05, 1.22).

Comment

Studies evaluating the relationship between early delivery and development of long-term respiratory morbidities including asthma are few, and results are mixed. Even fewer studies have attempted to evaluate long-term respiratory morbidity up to school age. Vrijlandt *et al.*²⁶ reported increased hospitalisation for respiratory issues in the first year of life and increased respiratory symptoms such as nocturnal cough, cough or wheezing with or without a cold, dyspnoea, use of steroids, and antibiotics at preschool age. They also identified certain risk factors which were associated with respiratory symptoms by age 5 years including early respiratory problems, passive smoking, higher socio-economic status, and family history of asthma. Escobar *et al.*²⁷ reported increased risk for recurrent wheeze in the third year of life in preterm infants who were exposed to supplemental oxygen during the neonatal period and had respiratory syncytial virus infection during the first year of life. Goyal *et al.*²⁸ found that late preterm birth is a risk factor for development of asthma within the first 18 months of life. However, several studies have failed to find a link between late preterm birth and asthma.^{29–31} Proposed mechanisms by which preterm birth may affect risk of asthma in later life include genetic (reduced immunologic regulation needed for lung development and function), perinatal factors (loss of normal complexity and mature structural architecture of the lung due to prematurity or infection), or environmental factors (smoking).³²

We examined the relationship between long-term respiratory morbidity, including asthma and bronchitis, and late preterm and early term births through the first five years of life. Results from our study suggest that late preterm infants and early term infants, when compared with term infants, are at increased risk for asthma and bronchitis up to school age even after excluding neonates with birth defects, multiple births, and controlling for obstetrical risk factors. These results support previous research studies by Vrijlandt, Escobar, and Goyal^{26–28} and further strengthen the evidence behind the American Congress of Obstetricians and Gynecologists (ACOG) practice guideline discouraging non-medically indicated deliveries prior to 39 weeks gestation.⁴ A recent publication also clearly enumerates timing of indicated late preterm and early term deliveries.³³ This study showed no difference in the rates for development of asthma or bronchitis with maternal steroid administration regardless of gestational age. Given the very low rates of documented

administration, we suspect that this may be under-reported although one has to consider the multifactorial nature of both disease conditions. Interestingly, RSV infection was consistently higher in neonates who later developed asthma or bronchitis regardless of gestational age and could be an area of focus in investigating preventive measures.

With the high rate of late preterm and early births in the US, decisions about the management of this group is a significant part of obstetric practice, and utilise a large portion of the nation's hospital resources. Accurate estimates of the risk of morbidity and mortality associated with these infants are needed to enable physicians and policymakers to make informed decisions concerning their care. Although the adjusted increase in risk for asthma and bronchitis for LPI and ETI is relatively modest (Table 4), considering the large number of infants in this cohort, any increased morbidity represented by this modest increase is substantial and could potentially have a very large public health impact, especially if effects of these morbidities persist beyond the birth hospitalisation and into early childhood.

An important strength of the study is the large sample size which allowed for the inclusion of a large number of control variables in the multivariable models. This study includes some limitations that should be addressed. Data are solely from Medicaid insurance records linked to birth certificates in a single state and may not be generalisable to uninsured or privately insured population. However, given that Medicaid was the primary payer for 50% to 55% of births in South Carolina during this period and up to 48% of deliveries in the US, it is fair to argue that these results are applicable to a broad spectrum of the population. Having Medicaid as the primary payer source is often associated with lower socio-economic status and generally poorer outcomes compared with having private insurance. At the same time, limiting the analysis to the Medicaid population reduces somewhat the bias expected from a population with more heterogeneous socio-economic status.

Data for this study came from administrative sources. Since much of the design of this study is based on the presence or absence of certain diagnosis and procedure codes in the administrative data, the limitations of using administrative data in a research study should be considered when interpreting the results. Administrative data sources are not necessarily designed for research and therefore may not include a number of potentially important variables. The exact criteria used to make clinical diagnoses, such as asthma or bronchitis, are also masked in administrative data sources. Administrative data, such as insurance claims data, are also known to under-report many clinical conditions and procedures to varying degrees.^{34,35} For instance, while maternal smoking is documented in the database, we do not have any specific information on maternal smoking habits or knowledge of the smoking habits of other household contacts. Gestational age for this study was retrieved from birth certificates. While we do not know exactly how it was determined, in general, last menstrual period, the first accurate ultrasound measurement or both are used to determine gestational age in obstetric practice.

While most of the effort should be aimed at prevention of preterm birth and reduction of non-medically indicated preterm and early term births, future studies should be directed at identifying modifiable factors that make these preterm infants especially vulnerable to long-

term morbid conditions including asthma and bronchitis. Knowledge of these factors would help identify possible targets for prevention and help determine the therapeutic interventions that need to be developed to prevent these long-term morbidities.

Acknowledgments

We would like to thank Donna Eastham, BA for her editing skills on this manuscript.

Grant sponsor: Funding for this study was provided in part by the Arkansas Children's Hospital Research Institute and through the Translational Research Institute of the University of Arkansas for Medical Sciences awards UL1TR000039 and KL2TR000063.

References

1. Martin JA, Hamilton BE, Osterman MJ, Curtin SC, Matthews TJ. Births: final data or 2013. National Vital Statistics Reports: From the Centers for Disease Control and Prevention, National Center for Health Statistics, National Vital Statistics System. 2015; 64:1–65.
2. Davidoff MJ, Dias T, Damus K, Russel R, Bettegowda VR, Dolan S, et al. Changes in the gestational age distribution among U.S. singleton births: impact on rates of late preterm birth, 1992 to 2002. *Seminars in Perinatology*. 2006; 30:8–15. [PubMed: 16549207]
3. Engle WA, Tomashek KM, Wallman C. Late-preterm' infants: a population at risk. *Pediatrics*. 2007; 120:1390–1401. [PubMed: 18055691]
4. ACOG Committee Opinion No. 404 April 2008. Late-preterm infants. *Obstetrics and Gynecology*. 2008; 111:1029–1032. [PubMed: 18378769]
5. Fuchs K, Gyamfi C. The influence of obstetric practices on late prematurity. *Clinics in Perinatology*. 2008; 35:343–360. vi. [PubMed: 18456073]
6. Ecker JL, Frigoletto FD Jr. Cesarean delivery and the risk-benefit calculus. *The New England Journal of Medicine*. 2007; 356:885–888. [PubMed: 17329693]
7. Eichenwald EC, Stark AR. Management and outcomes of very low birth weight. *The New England Journal of Medicine*. 2008; 358:1700–1711. [PubMed: 18420502]
8. Clapp DW. Developmental regulation of the immune system. *Seminars in Perinatology*. 2006; 30:69–72. [PubMed: 16731279]
9. Schendel DE, Stockbauer JW, Hoffman HJ, Herman AA, Berg CJ, Schramm WF. Relation between very low birth weight and developmental delay among preschool children without disabilities. *American Journal of Epidemiology*. 1997; 146:740–749. [PubMed: 9366622]
10. Saigal S, Feeny D, Rosenbaum P, Furlong W, Burrows E, Stoskopf B. Self-perceived health status and health-related quality of life of extremely low-birth-weight infants at adolescence. *The Journal of the American Medical Association*. 1996; 276:453–459. [PubMed: 8691552]
11. Gilbert WM, Nesbitt TS, Danielsen B. The cost of prematurity: quantification by gestational age and birth weight. *Obstetrics and Gynecology*. 2003; 102:488–492. [PubMed: 12962929]
12. Khashu M, Narayanan M, Bhargava S, Osiovi H. Perinatal outcomes associated with preterm birth at 33 to 36 weeks' gestation: a population-based cohort study. *Pediatrics*. 2009; 123:109–113. [PubMed: 19117868]
13. Escobar GJ, Clark RH, Greene JD. Short-term outcomes of infants born at 35 and 36 weeks gestation: we need to ask more questions. *Seminars in Perinatology*. 2006; 30:28–33. [PubMed: 16549211]
14. Wang ML, Dorer DJ, Fleming MP, Catlin EA. Clinical outcomes of near-term infants. *Pediatrics*. 2004; 114:372–376. [PubMed: 15286219]
15. Seubert DE, Stetzer BP, Wolfe HM, Treadwell MC. Delivery of the marginally preterm infant: what are the minor morbidities? *American Journal of Obstetrics and Gynecology*. 1999; 181(5 Pt 1):1087–1091. [PubMed: 10561623]
16. Melamed N, Klinger G, Tenenbaum-Gavish K, Hercovici T, Linder N, Hod M, et al. Short-term neonatal outcome in low-risk, spontaneous, singleton, late preterm deliveries. *Obstetrics and Gynecology*. 2009; 114(2 Pt 1):253–260. [PubMed: 19622985]

17. Escobar GJ, Greene JD, Hulac P, Kincannon E, Bischoff K, Gardner MN, et al. Rehospitalisation after birth hospitalisation: patterns among infants of all gestations. *Archives of Disease in Childhood*. 2005; 90:125–131. [PubMed: 15665162]
18. Shapiro-Mendoza CK, Tomashek KM, Kotelchuck M, Barfield W, Weiss J, Evans S. Risk factors for neonatal morbidity and mortality among 'healthy,' late preterm newborns. *Seminars in Perinatology*. 2006; 30:54–60. [PubMed: 16731277]
19. Tomashek KM, Shapiro-Mendoza CK, Weiss J, Kotelchuck M, Barfield W, Evans S, et al. Early discharge among late preterm and term newborns and risk of neonatal morbidity. *Seminars in Perinatology*. 2006; 30:61–68. [PubMed: 16731278]
20. Sibai BM. Preeclampsia as a cause of preterm and late preterm (near-term) births. *Seminars in Perinatology*. 2006; 30:16–19. [PubMed: 16549208]
21. Blair E, Watson L. Epidemiology of cerebral palsy. *Seminars in fetal & neonatal medicine*. 2006; 11:117–125. [PubMed: 16338186]
22. Hansen AK, Wisborg K, Uldbjerg N, Henriksen TB. Elective caesarean section and respiratory morbidity in the term and near-term neonate. *Acta Obstetrica et Gynecologica Scandinavica*. 2007; 86:389–394. [PubMed: 17486457]
23. Tomashek KM, Shapiro-Mendoza CK, Davidoff MJ, Petrini JR. Differences in mortality between late-preterm and term singleton infants in the United States, 1995–2002. *The Journal of Pediatrics*. 2007; 151:450–456. 456.e451. [PubMed: 17961684]
24. Boyce TG, Mellen BG, Mitchel EF Jr, Wright PF, Griffin MR. Rates of hospitalization for respiratory syncytial virus infection among children in Medicaid. *The Journal of Pediatrics*. 2000; 137:865–870. [PubMed: 11113845]
25. Petrini JR, Dias T, McCormick MC, Massolo ML, Green NS, Escobar GJ. Increased risk of adverse neurological development for late preterm infants. *The Journal of Pediatrics*. 2009; 154:169–176. [PubMed: 19081113]
26. Vrijlandt EJ, Kerstjens JM, Duiverman EJ, Bos AF, Reijneveld SA. Moderately preterm children have more respiratory problems during their first 5 years of life than children born full term. *American Journal of Respiratory and Critical Care Medicine*. 2013; 187:1234–1240. [PubMed: 23525931]
27. Escobar GJ, Ragins A, Li SX, Prager L, Masaquel AS, Kipnis P. Recurrent wheezing in the third year of life among children born at 32 weeks' gestation or later: relationship to laboratory-confirmed, medically attended infection with respiratory syncytial virus during the first year of life. *Archives of pediatrics & adolescent medicine*. 2010; 164:915–922. [PubMed: 20921348]
28. Goyal NK, Fiks AG, Lorch SA. Association of late-preterm birth with asthma in young children: practice-based study. *Pediatrics*. 2011; 128:e830–e838. [PubMed: 21911345]
29. Kugelman A, Colin AA. Late preterm infants: near term but still in a critical developmental time period. *Pediatrics*. 2013; 132:741–751. [PubMed: 24062372]
30. Crump C, Winkleby MA, Sundquist J, Sundquist K. Risk of asthma in young adults who were born preterm: a Swedish national cohort study. *Pediatrics*. 2011; 127:e913–e920. [PubMed: 21422091]
31. Abe K, Shapiro-Mendoza CK, Hall LR, Satten GA. Late preterm birth and risk of developing asthma. *The Journal of Pediatrics*. 2010; 157:74–78. [PubMed: 20338577]
32. Baraldi E, Filippone M. Chronic lung disease after premature birth. *The New England Journal of Medicine*. 2007; 357:1946–1955. [PubMed: 17989387]
33. Spong CY, Berghella V, Wenstrom KD, Mercer BM, Saade GR. Preventing the first cesarean delivery: summary of a joint Eunice Kennedy Shriver National Institute of Child Health and Human Development, Society for Maternal-Fetal Medicine, and American College of Obstetricians and Gynecologists Workshop. *Obstetrics and Gynecology*. 2012; 120:1181–1193. [PubMed: 23090537]
34. DiGiuseppe DL, Aron DC, Ranbom L, Harper DL, Rosenthal GE. Reliability of birth certificate data: a multi-hospital comparison to medical records information. *Maternal and Child Health Journal*. 2002; 6:169–179. [PubMed: 12236664]
35. Roohan PJ, Josberger RE, Acar J, Dabir P, Feder HM, Gagliano PJ. Validation of birth certificate data in New York State. *Journal of Community Health*. 2003; 28:335–346. [PubMed: 14535599]

Appendix 1. Bivariate comparison of neonatal and early childhood respiratory morbidity to early childhood diagnosis of asthma and bronchitis by gestational age category

Condition	LPI			ETI			TI	
	No asthma %	Asthma %	P-value	No asthma %	Asthma %	P-value	No asthma %	Asthma %
Respiratory distress	4.5	5.5	0.292	0.4	1.3	<0.001	0.2	0.4
Transitory tachypnea	8.9	8.7	0.869	2.9	3.3	0.419	2.2	2.3
Apnoea	7.5	10.4	0.013	1.8	2.5	0.035	1.2	1.5
Mechanical ventilation	4.1	5.0	0.334	0.6	1.8	<0.001	0.6	1.0
Oxygen therapy	0.6	1.7	0.004	0.1	0.3	0.084	0.1	0.3
Sepsis	4.3	5.0	0.475	0.9	1.6	0.002	0.7	0.6
Maternal steroid injection	0.5	0.2	0.207	0.4	0.2	0.143	0.2	0.4
Respiratory syncytial virus	0.6	2.7	<0.001	0.3	1.3	<0.001	0.4	1.7
Condition	No bronchitis %			Bronchitis %			P-value	
	No bronchitis %	Bronchitis %	P-value	No bronchitis %	Bronchitis %	P-value	No bronchitis %	Bronchitis %
Respiratory distress	4.5	6.0	0.226	0.4	1.2	<0.001	0.2	0.4
Transitory tachypnea	8.9	9.1	0.903	2.8	4.3	0.005	2.2	3.0
Apnoea	8.0	7.9	0.945	1.9	1.9	0.877	1.2	1.0
Mechanical ventilation	4.2	4.8	0.604	0.8	1.1	0.177	0.6	1.0
Oxygen therapy	0.7	1.4	0.176	0.1	0.2	0.740	0.1	0.2
Sepsis	4.6	3.7	0.456	0.9	1.8	0.002	0.6	1.2
Maternal steroid injection	0.5	0.0	0.178	0.4	0.2	0.268	0.3	0.2
Respiratory syncytial virus	0.5	4.5	<0.001	0.3	2.5	<0.001	0.4	2.0

Table 1

Number of subjects excluded from the study based on exclusion criteria

Exclusion Criteria	n – excluded				n – remaining			
	LPI	ETI	TI	Total	LPI	ETI	TI	Total
Gestational age 34–41 weeks	–	–	–	–	7440	24 210	51 212	82 862
Birthweight >6000 g	1	3	4	8	7439	24 207	51 208	82 854
Birthweight <500 g	0	1	1	2	7439	24 206	51 207	82 852
Any birth defect	418	1 020	2 059	3 497	7021	23 186	49 148	79 355
Multiple births	776	578	158	1 512	6245	22 608	48 990	77 843
Died prior to 60 months	3	5	13	21	6242	22 603	48 977	77 842
36 months of continuous Medicaid eligibility	2766	10 205	23 002	35 973	3476	12 398	25 975	41 849
Total	3964	11 812	25 237	41 013	3476	12 398	25 975	41,849

ETI, early term infants; LPI, late preterm infants; TI, term infants.

Table 2

Demographic and delivery-related characteristics of late preterm, early term, and term infants with 36 to 60 months of continuous Medicaid eligibility

	Late preterm	Early term	Term	P-value
Infant characteristics				
<i>n</i>	3476	12 398	25 975	–
Mean birthweight (Grams)	2582	3070	3368	–
Small for gestational age	7.0	7.9	8.8	<0.001
Large for gestational age	9.8	8.9	9.8	0.008
Intrauterine growth restriction	3.4	2.0	0.6	<0.001
Respiratory distress syndrome	4.7	0.5	0.2	<0.001
Transitory tachypnoea	8.9	3.0	2.3	<0.001
Apnoea	8.0	1.9	1.2	<0.001
Mechanical ventilation	4.3	0.8	0.6	<0.001
Oxygen therapy	0.8	0.1	0.1	<0.001
Sepsis	4.5	1.0	0.7	<0.001
Respiratory syncytial virus	1.0	0.5	0.6	0.005
Male	50.6	49.6	51.4	0.005
White	37.4	37.3	39.9	<0.001
Black	58.5	37.3	39.9	<0.001
Hispanic	3.0	4.8	6.0	<0.001
Other/unknown	1.0	0.9	1.2	0.097
Maternal characteristics				
Parity = 1	41.0	37.0	44.2	<0.001
Parity = 2	28.9	32.7	29.8	<0.001
Parity = 3	17.5	18.5	16.5	<0.001
Parity ≥ 4	12.6	11.8	9.5	<0.001
Maternal tobacco use	22.2	18.8	18.2	<0.001
Maternal alcohol use/abuse	7.4	5.2	4.7	<0.001
Maternal drug use/abuse	2.6	1.1	0.8	<0.001
Married	25.1	27.2	26.6	0.038
No paternal data on birth certificate	53.7	51.3	50.4	0.001
Maternal age				
15 to 19 Years	25.5	24.1	26.2	0.001
20 to 24 Years	40.4	40.3	41.0	0.374
25 to 29 Years	18.1	20.6	19.5	0.002
30 to 34 Years	9.6	9.4	8.8	0.097
35 to 39 Years	4.4	4.0	3.2	<0.001
40 to 44 Years	1.0	1.0	0.7	0.001
Maternal education				
Less than 9th grade	5.0	4.9	5.6	0.010
10th through 12th grade	77.1	76.1	75.4	0.054

	Late preterm	Early term	Term	P-value
Greater than high school	18.0	19.0	19.0	0.312
Delivery characteristics				
Labour induction	22.9	26.0	31.2	<0.001
Cesarean delivery	26.8	25.0	31.2	<0.001
Emergency admission	17.2	14.3	12.4	<0.001
Prenatal care				
0 to 4 visits	10.6	5.2	4.3	<0.001
5 to 9 visits	32.3	24.8	21.4	<0.001
10 or more visits	57.1	70.0	74.6	<0.001
Inter-pregnancy interval				
12 months or less	7.8	4.9	3.4	<0.001
13 to 24 months	18.3	19.6	16.6	<0.001
Greater than 24 months	35.2	40.1	38.2	<0.001
Clinical factors complicating labour and delivery				
Gestational diabetes	4.3	4.4	2.8	<0.001
Pre/Eclampsia	2.0	0.7	0.3	<0.001
Placental abruption/previa	5.7	1.9	1.1	<0.001
PROM	17.2	3.4	2.0	<0.001
Premature labour	58.0	3.2	0.6	<0.001
Prenatal steroid	0.5	0.4	0.3	0.041
Malpresentation/breech	4.6	3.1	1.9	<0.001
Maternal soft tissue disorder	2.8	2.3	1.6	<0.001
Macrosomia	0.3	1.1	1.7	<0.001
Previous infant > 4000 g	0.3	0.8	1.1	<0.001
Previous preterm delivery	4.3	1.7	0.8	<0.001
Oligohydramnios	3.5	2.1	1.8	<0.001
Polyhydramnios	0.9	0.6	0.4	<0.001
Maternal fever	1.1	1.1	1.4	0.034
Meconium staining	2.8	4.1	8.3	<0.001
Hospital characteristics				
Hospital top 20% in volume	48.3	42.9	43.1	<0.001
Hospital bottom 20% in volume	3.6	4.5	4.2	0.065
Urban hospital	57.4	57.7	58.8	0.068
Maternal medical comorbidities				
Chronic diabetes	2.2	1.4	0.4	<0.001
Chronic hypertension	14.3	10.3	6.4	<0.001
Anemia	12.6	12.9	12.9	0.920
Chronic lung disease	3.3	2.8	2.7	0.111
Herpes	1.8	1.7	1.4	0.090
Neurologic disorder	0.7	0.4	0.4	0.054
Coagulation disorder	0.7	0.5	0.4	0.021
Obesity	1.3	1.5	1.5	0.502

	Late preterm	Early term	Term	P-value
Depression	0.8	0.7	0.5	0.067

Other than birth weight, other variables presented as percentages.

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

Table 3

Rates of respiratory morbidity diagnosed between the third and fifth year of life by gestational age category and by single week of gestational age

Gestational age	Asthma (%)	Bronchitis (%)	Asthma and bronchitis (%)
Late preterm gestation (weeks)	18.4	10.2	4.1
34	21.5	11.4	5.5
35	19.6	10.3	4.7
36	17.0	9.8	3.3
Early term gestation (weeks)	14.6	9.4	3.7
37	15.6	10.0	4.2
38	14.1	9.1	3.5
Term gestation (weeks)	12.8	8.3	3.0
39	13.4	8.2	3.0
40	12.5	8.6	3.0
41	11.5	7.6	2.6

Table 4

Respiratory morbidity between late preterm infants and early term infants to term infants between their third and fifth year

Outcomes	Late preterm		Early term	
	Unadjusted HR (95% CI)	Adjusted HR (95% CI)	Unadjusted HR (95% CI)	Adjusted HR (95% CI)
Asthma	1.44 (1.33, 1.57)	1.24 (1.10, 1.40)	1.13 (1.07, 1.20)	1.12 (1.06, 1.19)
Bronchitis	1.24 (1.11, 1.38)	1.15 (1.00, 1.34)	1.13 (1.05, 1.21)	1.13 (1.05, 1.22)

Hazard ratios (HR) were adjusted for variables shown in Table 2.