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Varying Patterns of Home Oxygen Use in Infants at 23-43 Weeks' Gestation Discharged from United States Neonatal Intensive Care Units

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Objectives To compare proportions of infants at different gestational ages discharged from the neonatal intensive care unit (NICU) on home oxygen, to determine how many were classified with chronic lung disease based on timing of discharge on home oxygen, and to determine the percentage discharged on home oxygen who received mechanical ventilation.

Study design We evaluated a retrospective cohort of infants of 23-43 weeks' gestational age discharged from 228 NICUs in 2009, using the Pediatrix Clinical Data Warehouse. Multilevel logistic regression analysis identified predictors of home oxygen use among extremely preterm, early-moderate preterm, late preterm, and term infants. Duration of mechanical ventilation and median length of stay were calculated for infants discharged on home oxygen.

Results For the 48 877 infants studied, the rate of home oxygen use ranged from 28% (722 of 2621) in extremely preterm infants to 0.7% (246 of 34 934) in late preterm and term infants. Extremely preterm infants composed 56% (722 of 1286) of the infants discharged on home oxygen; late preterm and term infants, 19% (246 of 1286). After gestational age, mechanical ventilation was the main predictor of home oxygen use; however, 61% of the late preterm and term infants discharged on home oxygen did not receive ventilation. The median length of hospital stay was 95 days (IQR, 76-114 days) for extremely preterm infants discharged on home oxygen, but only 15 days (IQR, 10-22 days) for late preterm and term ventilated infants discharged on home oxygen.

Conclusion Although home oxygen use is uncommon in later-gestation infants, the greater overall numbers of later-gestation infants contribute significantly to the increased need for home oxygen for infants at NICU discharge. Neither respiratory failure nor lengthy hospitalization is a prerequisite for home oxygen use at later gestational age. *(J Pediatr 2013;163:976-82)*.

Infants discharged from the neonatal intensive care unit (NICU) have high rates of morbidities requiring extensive resource utilization postdischarge, as has been well studied in the extremely preterm population.[1,2] Later-gestation infants that require NICU care also have increased use of medical resources after discharge.[3-6] Although later-gestation infants have lower rates of medical complications compared with extremely preterm infants, they compose a substantial proportion of the infants who need specialized services after NICU discharge.[6-8]

A common medical need after NICU discharge is home oxygen therapy for bronchopulmonary dysplasia (BPD). We recently reported on the prevalence and predictors of home oxygen use for infants at 23-31 weeks' gestation with BPD, as well as the significant intercenter variation in home oxygen use.[9] There are other reasons besides BPD for the use of home oxygen therapy.[10] Respiratory failure in late preterm and term infants can lead to chronic lung disease (CLD) and home oxygen use. Clinical trials for respiratory failure reported CLD in 3%-20% of late preterm and term infants and home oxygen use in 5%-11% of these infants.[11-15] To date, there are no published data comparing proportions of infants discharged with home oxygen therapy across gestational ages.

Studies of late preterm and term infants with respiratory failure have reported average NICU lengths of stay of 17-29 days. Because CLD is defined as an oxygen requirement at 28 days of life or discharge, whichever comes first, we hypothesized that some infants in this age group would be discharged on home oxygen therapy before 28 days of life.[12,14,15] These later-gestation infants would be classified with CLD according to the proposed National Institutes of Health consensus definition, based on the initiation of home oxygen therapy.[16] This difference in timing of discharge on home oxygen therapy could have significant effects on reported rates of CLD outside of the extremely preterm population; however, there is no information about this practice.

AUC	Area under the curve
BPD	Bronchopulmonary dysplasia
CLD	Chronic lung disease
MAS	Meconium aspiration syndrome
NICU	Neonatal intensive care unit
PPHN	Persistent pulmonary hypertension of the newborn
ROC	Receiver operating characteristic

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Home oxygen therapy also may be used in infants without respiratory failure. In modern neonatal care, many extremely preterm infants do not require significant initial oxygen or mechanical ventilation support, yet develop BPD owing to arrest of lung development. These infants are at risk for use of home oxygen therapy despite not having a severe initial respiratory course.[17,18] At later gestational ages, home oxygen also may be used in infants without respiratory failure as a means toward discharge for infants who have achieved other discharge readiness milestones. There are no data on the use of home oxygen therapy in infants who did not receive mechanical ventilation.

The goals of the present study were: (1) to compare the proportion of infants discharged from the NICU with home oxygen therapy who were born at extreme preterm, early-moderate preterm, late preterm, or term gestation; (2) to determine how many infants in each gestational age group were classified with CLD based on the timing of discharge on home oxygen therapy; (3) to identify clinical predictors of home oxygen use for each gestational age group; and (4) to determine the percentage of infants discharged on home oxygen who had received mechanical ventilation. This information could serve as a starting point to identify potential best practices for neonates of all gestational age groups with respiratory disease.

Methods

The data for this analysis were acquired from the Pediatrix Clinical Data Warehouse, a deidentified electronic medical records database containing information on all patients cared for by the Pediatrix Medical Group. This group oversees 15%-20% of NICU admissions in the US across a range of sizes and types of hospitals.[19] We conducted a retrospective cohort analysis of all infants at 23-43 weeks' gestational age discharged to home from a Pediatrix center in 2009. We excluded infants with major congenital anomalies, as identified by listed diagnoses. We also excluded infants who died or were transferred before discharge, along with infants reported from centers >4000 feet above sea level, because of differences in use of home oxygen therapy in those areas.[20,21]

The primary outcome was home oxygen use. For infants of 23-31 weeks' gestation, we used the consensus definition of moderate-severe BPD as supplemental oxygen at 36 weeks' corrected age as our primary designation of BPD, because this better captures the subset of infants with the primary outcome of home oxygen use.[9,16] The use of physiologic testing to diagnose BPD was not recorded in this data set.[22] CLD (proposed) was defined as receipt of supplemental oxygen at 28 days of life or at discharge, whichever came first.[16] Infants receiving mechanical ventilation at 36 weeks' corrected age or 28 days of life were classified with CLD, regardless of their supplemental oxygen requirement.

Gestational age was recorded as completed weeks of gestation based on obstetric estimate, and was divided into 4 groups: extreme preterm (23-28 weeks), early-moderate preterm (29-33 weeks), late preterm (34-36 weeks), and term (37-43 weeks). Birth weight was recorded as a continuous variable; small birth weight for gestational age was defined as below the 10th percentile for age based on published growth charts.[23]

We collected information on sex, multiple birth versus singleton birth status, receipt of antenatal steroids, and race/ethnicity. To describe respiratory support, we recorded the days of mechanical ventilation, use of surfactant, and use of nitric oxide. Respiratory diagnoses were recorded as documented in the medical record, including pneumonia or sepsis, pneumothorax, persistent pulmonary hypertension of the newborn (PPHN), and meconium aspiration syndrome (MAS). Sepsis and pneumonia were considered a single diagnosis, as were PPHN and MAS owing to the overlap between these disorders.[14] Because detailed reports, such as chest radiography findings, were not available, more granular categorizations were not considered. Length of stay was recorded as a continuous variable. Hospitals were assigned a random identification number to maintain deidentification. The altitude of each hospital's location was recorded as a continuous variable.

We compared demographics, respiratory diagnoses, and respiratory support requirements by gestational age, assessing differences in proportions by gestational age using the χ^2 test for differences in proportions and the Kruskal-Wallis test for differences in median values. Rates of missing data were assessed; infants with missing data were retained in the dataset. We calculated rates of home oxygen use for each gestational age group, as well as the gestational age distribution for the subset of infants discharged on home oxygen therapy. For infants with BPD or CLD, we calculated the proportion in each gestational age group who were discharged to home before 36 weeks' corrected age or 28 days of life, comparing differences using the χ^2 test.

To determine clinical characteristics predicting home oxygen use across varying gestational ages, we fit 4 separate multilevel logistic regression models, 1 for each gestational age group studied. Each model was adjusted for hospital altitude, with hospitals as random intercepts. We included all variables in each model, with exceptions based on clinical relevance; antenatal steroids and patent ductus arteriosus were included only in models for infants <34 weeks' gestational age, whereas PPHN and MAS were included only in models for infants ≥34 weeks' gestational age. Variables, or categories within variables, were included only if they were present in at least 50 infants. Each model's fit was assessed with receiver operating characteristic (ROC) curves, including the full model and a reduced model that included only variables with $P < .05$. Differences between the area under the receiver operating characteristic curve (AUC) of the full and reduced models were compared using the χ^2 test. To assess the fit of clinical risk factors alone versus a model including hospital-level variation, we also calculated the AUC of corresponding full and reduced logistic regression models. Finally, for the infants discharged on home oxygen therapy, we compared the distribution of duration of mechanical ventilation