# Risk Factors and Costs of Hospital Admissions in First Year of Life: A Population-Based Study

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**Objective** To identify the maternal and infant risk factors associated with hospital admission in the first year and estimate the associated costs of infant hospitalization.

**Study design** Data from the Perinatal Data Collection for 599 753 liveborn infants born in New South Wales, Australia, 2001-2007 were linked to hospital admission data. Logistic regression models were used to investigate the association between maternal and infant characteristics and admission to hospital once, and more than once in the first year; and average costs for total hospital admissions were calculated.

**Results** Almost 15% of infants were admitted to hospital once and 4.6% had multiple admissions. Gestational age <37 weeks was most strongly associated with admission to hospital once, and severe neonatal morbidity was most strongly associated with multiple admissions (aOR 2.60; 95% CI 2.47-2.75). Infants born <39 weeks gestational age, to adolescent mothers, mothers who smoke, are not married, or had a planned delivery also have an increased risk of multiple admissions. Infants with severe neonatal morbidity contributed 27% of total infant hospital costs. With each increasing week of gestational age the mean annual cost decreased on average 10% and 27% for infants with and without neonatal morbidity respectively.

**Conclusions** Infants born with severe neonatal morbidity have increased hospitalizations in the first year; however, the majority of burden on health system is by infants without severe neonatal morbidity. Hospitalizations, and associated costs, increased with decreasing gestational age, even for infants born at 37-38 weeks. Targeted public health strategies may reduce the burden of infant hospitalizations. *(J Pediatr 2013;163:1014-9)*.

Admission to hospital in the first year of life places an economic burden on both the infant's family and the health system. Over one-quarter of pediatric hospital admissions (up to 18 years of age) in Australia occur in the first year[1] with many admissions relating to conditions originating in the perinatal period. Infants born with severe neonatal morbidity are more likely to be readmitted to hospital after initial discharge.[2] Other factors have also been identified as risk factors for hospital admission in the first 4-6 weeks after birth including preterm birth,[3-6] low birthweight,[3,6] primiparity,[7,8] insurance status,[3,7] maternal age,[9] maternal smoking,[8] and socioeconomic status of the family.[5,10] However, no population-based study has assessed risk factors for admissions up to the end of the first year of life.

A review of literature on economic costs of preterm birth performed by Petrou et al[11] highlighted a common theme (ie, the inverse relationship between gestational age at birth and costs associated with hospital admissions). Although preterm and low birthweight infants have a high incidence of morbidity, severe neonatal morbidity in term infants potentially also has large economic consequences on the health system. The proportion of term infants with neonatal morbidity ranges from almost 4%[2] to around 10%[12] depending upon how morbidity is defined.

The utilization and cost of health services by infants of all gestations has been examined in a number of studies,[13-16] however, the complete burden on the health system of all infant admissions during the first year of life, and specifically, the economic impact of infants born with severe neonatal morbidity, has not been investigated. Identification of important risk factors for infant hospitalization can help identify strategies that may reduce infant hospital use and reduce the economic burden of infant hospital admissions on the health system. We aimed to identify maternal and infant risk factors associated with hospital admission and estimate the cost of hospitalization for infants in the first year of life.

## Methods

All live births to women residing in New South Wales (NSW), Australia from January 2001 through December 2007 who survived to discharge from hospital after birth were included in the study population. NSW is the most populous

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| A$ | Australian dollars |
| APDC | Admitted Patient Data Collection |
| NSW | New South Wales |
| PDC | Perinatal Data Collection |

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state in Australia, with around 95 000 births per year, comprising 34% of all Australian births. Infants born in this period were followed up to 1 year of age.

Data were obtained from the NSW Perinatal Data Collection (PDC) and the Admitted Patient Data Collection (APDC). The PDC is a legislated population-based surveillance system of all births in NSW, including home births, of ≥20 weeks gestation or a baby ≥400 g birth weight collected by the attending midwife or doctor. The APDC is an administrative database of all hospital admissions in NSW and is based on information from hospital discharge summaries, coded according to the 10th revision of the *International Classification of Diseases*. From diagnosis and procedure information, each admission is coded using the Australian Refined Diagnoses Related Groups classification system. The average cost per Australian Refined Diagnoses Related Group for public and private hospitals for 2007/2008, published by the Commonwealth Department of Health and Ageing, were applied to each admission.[17] This study had approval from the NSW Population and Health Services Research Ethics Committee.

The two databases, PDC and APDC, were linked by the Center for Health Record Linkage using probabilistic linkage. This process enables each infant's PDC birth data to be linked cross-sectionally to their own and their mother's hospital birth admission and then longitudinally linked to subsequent hospital admissions in the first year of life. Once linked by Center for Health Record Linkage, de-identified data is available for analysis. Over 98% of birth records linked to both a mother and infant hospital record. The proportion of missing data was small; maternal age 0.02%, gestational age 0.04%, and marital status 0.06%.

The 2 primary outcomes of the study were whether infants had been admitted to hospital once after discharge home from the birth admission or more than once in the first year of life. Inter-hospital transfers were included as part of the admission in which they occurred and not counted as a new admission.

The Neonatal Adverse Outcome Indicator was used to identify infants born with severe neonatal morbidity.[2] This tool uses reliably reported information from the PDC and diagnosis and procedure codes from the APDC to identify infants who have a severe adverse birth outcome in the first 28 days of life. The adverse outcome indicator comprises a range of conditions (gestational age less than 32 weeks, birthweight less than 1500 g, a diagnosis of respiratory distress syndrome, seizure, cerebral infarction, birth trauma, periventricular leukomalacia, hypoxic ischemic encephalopathy, necrotizing enterocilitis, bronchopulmonary dysplasia, pneumonia, respiratory failure, sepsis, or >grade 2 intraventricular hemorrhage) and procedures (infants who have received ventilatory support, cardiopulmonary resuscitation, a central venous or arterial catheter, a pneumothorax requiring an intercostal catheter, a body cavity surgical procedure, any intravenous fluids, or a transfusion).[2] A composite outcome overcomes the under-ascertainment associated with using individual diagnoses and procedures in population health databases and increases the chance of capturing all sick infants as severely ill infants are more likely to have more than 1 condition or procedure.

Other explanatory variables included were known risk factors for hospital admission in the short term as reported in the literature.[3-9] Covariates available for analysis obtained from the PDC included gestational age, birth order, maternal age, delivery with or without labor, public or private hospital care, maternal smoking during pregnancy, and residential postcode; maternal marital status was obtained from the APDC. Socioeconomic status was derived based on scores from the Index of Relative Disadvantage from the Socio-Economic Indexes for Areas[18] produced by the Australian Bureau of Statistics. An Index of Relative Disadvantage was assigned to each postcode and infants were classified into three socioeconomic status groups: (1) "disadvantaged" (0-20th percentile); (2) "average" (21st-80th percentile); and (3) "advantaged" (81st-100th percentile). Urban/rural status was derived from the Accessibility/Remoteness Index of Australia,[19] whereby a mean Accessibility/Remoteness Index of Australia score was attributed to each postcode and then dichotomized. Planned births were defined as births where the onset of labor was not spontaneous (labor induction or pre-labor cesarean delivery).

Validation studies comparing data in the PDC with medical records found information collected about gestational age, number of previous pregnancies, smoking status, and onset of labor had kappa values over 0.8 indicating excellent agreement,[20] and only conditions and procedures reliably reported in the APDC are included in the morbidity indicator.[2]

## Statistical Analyses

To examine the association between maternal and infant risk factors and admission to hospital, univariate analysis was performed on all explanatory variables that are known to be associated with short term hospital admission. All variables associated ($P < .20$) with infant admission to hospital were included in the multivariable logistic regression models. The final model fit was tested using the Hosmer-Lemeshow test. Because the risks and outcomes are different for singleton vs multiple births (twins and triplets), the analyses were stratified by plurality.

The average length of stay and average cost of the birth admission and subsequent admissions for all infants were calculated. Total average costs per year were calculated for all infants, including costs for the birth admission and for all subsequent admissions. Because of the difference in risks between infants with and without severe neonatal morbidity, average costs were also calculated separately for these groups. Although costs are displayed in Australian dollars (A$), the relative difference in cost between groups rather than the absolute cost is more important. However, for comparison in 2007 the purchasing power parities index (for gross domestic product) for US dollars to A$ dollars was 1.43.[21]