Validation of ICD-9 diagnostic codes for bronchopulmonary dysplasia in Quebec's provincial health care databases

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Abstract

Introduction: Bronchopulmonary dysplasia (BPD) is a chronic respiratory disease caused by neonatal lung injury. The aim of this study was to validate the use of ICD-9 diagnostic codes for BPD in administrative databases to allow for their use in health care utilization analyses.

Methods: The validation process used a retrospective cohort composed of preterm infants, with or without respiratory complications, admitted to the Montréal Children's Hospital, Montréal, Quebec, between 1983 and 1992. BPD subjects were identified using ICD-9 diagnostic codes in the provincial administrative databases (medical services and MED-ECHO) and then matched with subjects with confirmed BPD from the validation cohort. We examined concordance and estimated sensitivity and specificity associated with the use of these diagnostic codes for BPD.

Results: True positive and false negative BPD subjects did not differ significantly according to gestational age, birth weight and Apgar scores. False positive BPD subjects were found to have significantly lower gestational age than true negative subjects. The use of the ICD-9 diagnostic codes for BPD was associated with a specificity between 97.6% and 98.0%. The sensitivity was lower at 45.0% and 52.4% for the medical services and MED-ECHO databases, respectively. Milder cases of BPD tended to be missed more frequently than more severe cases.

Conclusion: The specificity of the use of ICD-9 diagnostic codes for BPD in the Quebec provincial health care databases is adequate to allow its routine use. Its lower sensitivity for milder cases will likely result in an underestimation of the impacts of BPD on the long-term health care utilization of preterm infants.

Keywords: *bronchopulmonary dysplasia, administrative databases, international classification of diseases*

Introduction

Bronchopulmonary dysplasia (BPD) is a chronic respiratory disease that develops as a result of neonatal lung injury. It is one of the most important sequelae of preterm birth,[1] and is most common in preterm infants who need mechanical ventilation and oxygen therapy for respiratory distress syndrome (RDS) of the newborn.[2]

BPD was first described four decades ago in children born slightly preterm with severe RDS who were then exposed to aggressive mechanical ventilation and high concentrations of inspired oxygen.[3] It has since been largely replaced by a new form of the condition occurring in more extreme preterm infants, often with less severe RDS as a result of administering pulmonary surfactant.[4]

Despite notable advances in prenatal and neonatal care, BPD remains a major complication, frequently resulting in mortality as well as short-term and long-term morbidities. With the high rate of preterm births worldwide[5] and the improved survival associated with preterm birth, numerous young adults who were born prematurely and suffered respiratory complications at birth manifest chronic obstructive pulmonary disease in late adolescence and/or early adulthood.[6]

Health administrative databases

In the Canadian province of Quebec, the costs of medical services and hospital care for all residents are covered by a universal health insurance program administered by the Régie de l'Assurance-Maladie du Québec (RAMQ). RAMQ holds a vast quantity of information useful for facilitating clinical and epidemiological research work and for assisting health professionals in decision making.

Since 1983, RAMQ has recorded the date of each delivered medical service claim and the relevant ICD-9 (*International Classification of Diseases, 9th revision)*[7] codes for clinical diagnoses. The medical service claims database includes all physician reimbursement claims for hospital and ambulatory medical services provided to Quebec residents.

Despite the potential advantages of administrative databases, the validity of the data, particularly the clinical diagnoses, may be uncertain. Studies have shown that clinical diagnoses were not reliable for common diseases such as asthma

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and chronic obstructive pulmonary disease.[8,9] As a result, despite that records such as these could prove extremely valuable in examining the history, prognosis and treatment of a condition, the ability of these databases to accurately identify patients with such conditions must be determined. The aim of this study was to validate the use of the Quebec provincial health administrative databases to identify patients who developed BPD as a complication of preterm birth and to observe potential differences in their health care utilization based on the presence or absence of BPD.

Methods

Study design and selection of subjects

Validation cohort

The retrospective validation cohort included all preterm infants, that is, gestational age of less than 37 weeks (259 days),[10] with or without respiratory complications, who were admitted to the Montréal Children's Hospital (Montréal, Que.) between 1 January 1983 and 31 December 1992. The Montréal Children's Hospital is a tertiary pediatric hospital with specialized neonatal care that serves as a referral centre for the province of Quebec. It does not have a maternity unit, and all study subjects were transferred or admitted to the hospital following a premature birth. Data were abstracted from hospital records using a standardized data collection sheet. The subjects were identified using the ICD-9 codes listed on their medical discharge summary (prematurity: 765.*; BPD: 770.7; RDS: 769.*). Information collected included demographic characteristics as well as maternal, prenatal, delivery and main neonatal outcomes. Subjects' charts were carefully reviewed for evidence of BPD, as defined by the need for supplemental oxygen for at least 28 days[11] (see Table 1). Disease severity was assessed at 36 weeks postmenstrual age (or 56 days of life if born after 32 weeks) as mild BPD if breathing room air (fraction of inspired oxygen [FiO_2] = 0.21); moderate BPD (FiO_2 < 0.30); and severe BPD ($FiO_2 \geq 0.30$ or else positive pressure ventilation). Infants with BPD who died of respiratory causes before the assessment date were considered to have severe disease.[11] The validation cohort included only those subjects for whom gestational age and neonatal exposure to supplemental oxygen (timing, duration, FiO_2) were known.

Provincial databases cohort

We constructed a retrospective cohort of all subjects born in Quebec between 1983 and 1992 with respiratory complications of preterm birth using data from two RAMQ-administered provincial databases, the MED-ECHO database and the Medical services database. The MED-ECHO database[7] contains information on acute care hospitalizations and day surgeries performed in Quebec. Each record contains identifying demographic information along with the primary diagnosis on admission and 15 possible secondary diagnoses. This database was initiated 1 April 1987 and is complete for all subjects born thereafter.[12] The Medical services database includes data on diagnosis, medical billing (type of service performed, specialty of claimant, setting of the service (outpatient clinic, private clinic, emergency department, in-patient clinic) as well as the number of claims, the date on which the service was performed and the cost paid by RAMQ to the billing physician. This database is complete from 1 January 1983.

These two databases were used to identify all subjects with a preterm birth, defined as a gestational age of less than 37 weeks (using ICD-9 code 765.*and ICD-10 code P07.*) and diagnosed with associated respiratory complications, either BPD (ICD-9 code 770.7, ICD-10 code P27.1) or RDS (ICD-9 code 769.*, ICD-10 code P22.*).[7] Data were extracted from 1 January 1983 (or 1 April 1987 in the case of the MED-ECHO database) until 31 March 2008. ICD-9 codes were used in these databases from 1 April 1981 until 31 March 2006, and ICD-10 codes from 1 April 2006.[7]

Matching process

The validation cohort was matched with each of the provincial administrative databases using the subjects' unique

TABLE 1
Definition of bronchopulmonary dysplasia: diagnostic and severity criteria

	Diagnosis of BPD	
Gestational age, weeks	< 32	≥ 32
Time of assessment	36 weeks PMA or discharge home, whichever comes first	> 28 days but < 56 days postnatal age or discharge home, whichever comes first
	Treatment with oxygen	
Mild BPD	Breathing room air (FiO_2 = 0.21) at 36 weeks PMA or discharge, whichever comes first	Breathing room air by 56 days postnatal age or discharge, whichever comes first
Moderate BPD	Need for FiO_2 < 0.30 at 36 weeks PMA or discharge, whichever comes first	Need for FiO_2 < 0.30 at 56 days postnatal age or discharge, whichever comes first
Severe BPD	Need for $FiO_2 \geq 0.30$ and/or positive pressure (PPV or NCPAP) at 36 weeks PMA or discharge, whichever comes first	Need for $FiO_2 \geq 0.30$ and/or positive pressure (PPV or NCPAP) at 56 days postnatal age or discharge or discharge, whichever comes first

Source: Jobe & Bancalari, 2001[11]

Abbreviations: BPD, bronchopulmonary dysplasia; NCPAP, nasal continuous positive airway pressure; PMA, postmenstrual age; PPV, positive pressure ventilation; FiO_2, fraction of inspired oxygen.

RAMQ identification number. No nominal data were used. Access to the RAMQ database was approved by the Commission d'accès à l'information du Québec. This study was approved by the research ethics board of the McGill University Health Centre.

Statistical analyses

Subjects were divided into four categories: (1) true positive BPD subjects who had been diagnosed with BPD during their initial admission following preterm birth and were labelled as having BPD in the administrative databases; (2) false positive BPD subjects who did not have BPD during their initial admission or subsequent re-admissions but had been labelled as such in the administrative databases; (3) false negative BPD subjects who were in the reverse situation, having been diagnosed with BPD but not labelled as such in the databases; and (4) true negative subjects who had neither respiratory complications nor RDS following a preterm birth and were not labelled as having BPD in the administrative databases. We examined the overall characteristics associated with correctly classified and misclassified cases of BPD and used a subject-years approach to analyze health care utilization. Analysis of variance (ANOVA) or *t*-tests were used to compare means of continuous variables, and Mantel–Haenszel chi-square tests to compare ordinal variables. Concordances were examined, resulting in overall and yearly estimates of sensitivity and specificity associated with the use of diagnostic codes for BPD in each of the administrative databases. For multivariable analysis, variables that were significantly associated with the outcome in univariate analyses were initially included, and a multivariate Poisson regression model[12] was used to determine the association of clinical factors with the number of admissions and outpatient and emergency department visits. Significance was set at $p \leq .05$. Statistical analyses were conducted using statistical package SAS version 9.2 (SAS Institute Inc., Cary, NC, United States).

Results

Subjects' characteristics

The validation cohort consisted of 894 preterm subjects admitted to the Montréal Children's Hospital between 1983 and 1992. From the RAMQ records, 3442 preterm subjects were identified (773 with BPD and 2669 with RDS). Of these, 876 were successfully matched with the validation cohort.

Table 2 shows the characteristics of the matched subjects. Gestational age differed significantly between the true negative and false positive groups, with false positive BPD subjects being on average more premature than the subjects correctly classified as not suffering from BPD (31 and 34 weeks of gestation, respectively).

The use of the diagnostic codes for BPD was associated with a specificity of 97.6% for the medical services database and 98.0% for the MED-ECHO database.

TABLE 2
Characteristics of the correctly classified and misclassified preterm bronchopulmonary dysplasia subjects in the RAMQ databases, 1983–1992, Quebec, Canada

	RAMQ classification category					
	True positive[a]	False negative[b]	*p*	True negative[c]	False positive[d]	*p*
Preterm subjects, n	104	137	—	623	12	—
Male, n (%)	59 (56.7)	84 (61.3)	.47	384 (61.6)	8 (66.7)	.72
Birth weight, mean (SD) kg	1.15 (0.6)	1.05 (0.3)	.12	2.17 (0.7)	1.79 (0.7)	.12
Gestational age, mean (SD) weeks	28.0 (3.3)	27.7 (3.1)	.45	34.0 (2.9)	31.2 (3.8)	.004
1-minute Apgar score, mean (SD)	3.7 (2.4)	4.2 (2.4)	.13	6.5 (2.4)	6.1 (2.1)	.81
5-minute Apgar score, mean (SD)	6.2 (2.2)	6.4 (2.1)	.40	8.2 (1.9)	7.8 (1.3)	.78
BPD severity, (n, %)						
None	0	0	—	623 (100)	12 (100)	—
Mild	16 (15.4)	36 (26.5)	—	0	0	—
Moderate	52 (50.0)	52 (38.2)	—	0	0	—
Severe	36 (34.6)	48 (35.3)	—	0	0	—
Mortality						
Number, n (%)	5 (4.8)	0	—	0	1 (8.3)	—
Age, mean (SD) years	0.9 (0.64)	—	—	—	17.9 (—)	—

Abbreviations: BPD, bronchopulmonary dysplasia; RAMQ, Régie de l'Assurance-Maladie du Québec.

[a] True positive subjects were diagnosed with BPD following a preterm birth and labelled as diagnosed with BPD in the administrative databases.

[b] False negative subjects were not diagnosed with BPD but were labelled as such in the administrative databases.

[c] True negative subjects were neither diagnosed with BPD nor labelled as such in the administrative databases.

[d] False positive subjects were not diagnosed with BPD during their initial admission or subsequent re-admissions but were labelled as having BPD in the administrative databases.

Sensitivity was somewhat lower, a value of 45.0% and 52.4% respectively. Milder cases of BPD tended to be missed more frequently when comparing the proportion of false negative and true positive cases (Table 2). The misclassification of BPD subjects also varied over the years, with the sensitivity improving after the introduction of MED-ECHO in 1987 (see Figure 1).

Implications on health care utilization analyses

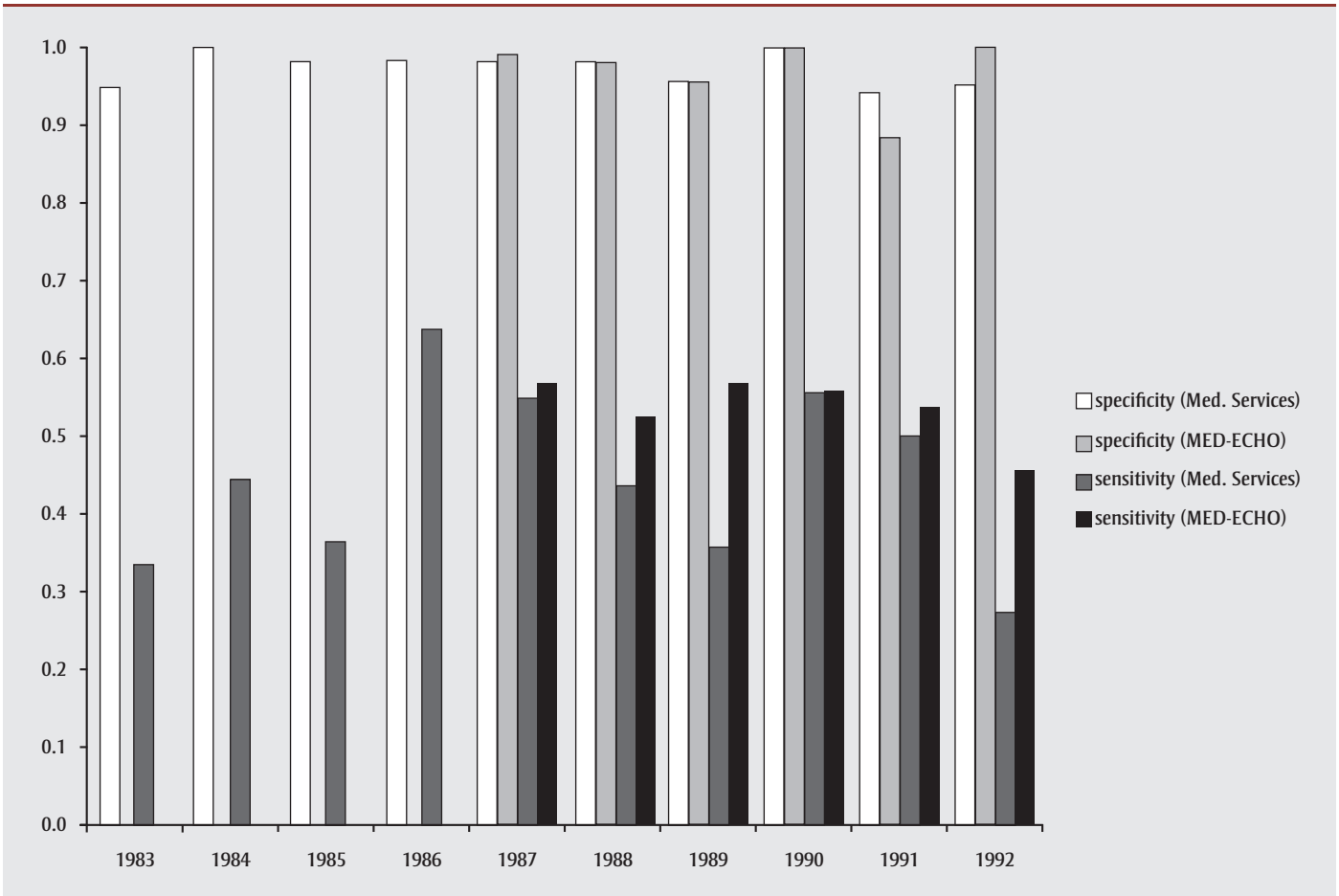
Table 3 shows the hospital readmissions rate per person-year across the four categories for the entire duration of the follow-up (mean follow-up duration: 19 years) as well as outpatient and emergency department visits. A diagnosis of BPD in the validation cohort was associated with adjusted rate ratios of 9.3 (95% confidence interval [CI]: 6.9–12.5) for hospital readmissions, 8.1 (95% CI: 7.6–8.6) for outpatient visits and 4.4 (95% CI: 3.6–5.3) for emergency department visits when adjusted for gestational age, birth weight, 1-minute Apgar score, maternal age and the initial severity of BPD according to the National Institutes of Health (NIH)-consensus definition.[11]

Discussion

The specificity for using ICD-9 diagnostic codes for BPD in the Quebec provincial health care databases was excellent, the sensitivity less so, especially before the introduction of the MED-ECHO database in 1987. The tendency was to miss milder cases of BPD. Since 2006, ICD-10 diagnostic codes have replaced ICD-9 codes in Quebec's administrative databases, but the relevance of documenting the predictive values associated with the ICD-9 code for BPD remains, particularly when looking at long-term health care utilization of preterm subjects older than 6 years of age.

Subjects classified as true negative had the fewest hospital readmissions and a shorter length of stay, whereas true positive BPD cases were associated with more outpatient and emergency department visits for the duration of the 19-year follow-up. False positive BPD subjects, who had been more premature at birth than those of their counterparts not diagnosed with BPD, had more hospital readmissions and a longer length of stay in hospital. The presence of BPD as a complication of a preterm birth was found to have a great impact on health care utilization, an effect that remained significant

FIGURE 1
Specificity and sensitivity of the medical services and MED-ECHO databases for the diagnostic codes of bronchopulmonary dysplasia, 1983–1992, Quebec, Canada



Abbreviation: Med, Medical.

TABLE 3
Health care utilization across correctly classified and misclassified preterm bronchopulmonary dysplasia subjects[a]

	RAMQ classification category					
	True positive[b]	False negative[c]	*p*	True negative[d]	False positive[e]	*p*
Hospital admissions[f]/person-year, n	1.6	1.3	.023	1.1	1.7	.004
Length of stay, mean (SD) days	11.6 (26.4)	18.3 (32.6)	.22	4.2 (7.8)	6.4 (15.8)	.01
Outpatient visits/person-year, n	6.7	3.2	<.0001	3.7	5.4	.45
ED visits/person-year, n	3.0	1.7	.0001	2.8	2.7	.33

Abbreviations: BPD, bronchopulmonary dysplasia; ED, emergency department; RAMQ, Régie de l'Assurance-Maladie du Québec.

[a] Mean follow-up duration of BPD subjects was 19 years.

[b] True positive subjects were diagnosed with BPD following a preterm birth and labelled as having BPD in the administrative databases.

[c] False negative subjects were not diagnosed with BPD but were labelled as such in the administrative databases.

[d] True negative subjects were neither diagnosed with BPD nor labelled as such in the administrative databases.

[e] False positive subjects were not diagnosed with BPD during their initial admission or subsequent re-admissions but were labelled as having BPD in the administrative databases.

[f] Hospital re-admission following initial hospital discharge after birth.

when corrected for birth weight, gestational age, Apgar score and maternal age.

Limitations

The main limitation of this study is the evolving definition of BPD in clinical practice over the duration of the study period. Until the consensus definition for BPD was reached in 2000,[11] there was a striking lack of uniformity in the diagnostic criteria for BPD among clinicians and in the medical literature.[13] The criteria proposed to define BPD (suggested in an NIH-sponsored workshop in 1979) included continued oxygen dependency during the first 28 days in addition to compatible clinical and radiological changes.[3] These criteria were considered appropriate for the classic presentation of BPD, but less so for identifying ''new'' BPD cases identified after the early 1990s. Accordingly, the following definition was proposed: the need for supplemental oxygen at 36 weeks post-menstrual age (PMA).[14] This stricter definition was considered better for identifying infants with more severe lung disease and therefore at predicting long-term outcome.[15] This definition was further refined at an NIH workshop in 2000 to include the need for 28 days or more of supplemental oxygen as well as a severity assessment date at 36 weeks PMA.[11] A repeat validation study using subjects born after 2000 will address this limitation.

A minor limitation was the incomplete matching process (2%) between the validation cohort and the provincial databases cohort. Missing unique RAMQ identification numbers at the time of admission, a frequent occurrence in infants since they are admitted at birth under their maternal RAMQ identification number, accounted for the discrepancy of the matching process between the two cohorts.

A third limitation was the incompleteness of the MED-ECHO database over the first 4 years of the study period, likely resulting in an incomplete capture of the BPD cases during this time and an underestimation of the health care utilization with regard to the number of hospitalizations.

Conclusion

The specificity of the use of ICD-9 diagnostic codes for BPD in the Quebec provincial health care databases is adequate to allow its routine use. Its lower sensitivity for milder cases will likely result in an underestimation of the impacts of BPD on the long-term health care utilization of those born preterm.

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