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ORIGINAL PAPER

Birth Certificate Validity and the Impact on Primary Cesarean Section Quality Measure in New York State

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Abstract
In New York (NY), birth certificate data are routinely used for assessing quality of care and health outcomes such as primary cesarean section (PCS) rates. However rare events are often underreported. This study compared birth certificates to medical records, and examined the impact of underreporting on risk adjustment variables for PCS. We conducted an internal validation study using a random sample of 702 NY births in 2009. Sensitivity and positive predictive value (PPV) of rare events reported on birth certificates were determined using abstracted and matched medical records as the gold standard. To assess the impact, we calculated PCS odds ratios for variables in the risk-adjustment model before and after correcting for measurement error. The sensitivity and PPV of birth certificate data elements including those in the PCS risk model varied from 0 to 100. After correction for measurement error, PCS odds ratios increased for most variables. For example, the PCS odds ratio for those with no prior live births was 3.03 (95% CI 2.94, 3.13), but after correction of measurement error increased to 3.46 (95% CI 3.22, 3.67). A composite negative event variable including abruptio placenta, eclampsia, or infection was the only variable that decreased after correction and was no longer significant (uncorrected OR 3.06, 95% CI 2.86, 3.29; corrected OR 1.42, 95% CI 0.79, 2.59). Underreporting on birth certificates remains concerning and impacts the risk adjustment for quality measures. Without improved data validity, health plans' quality metrics do not fully account for patient case-mix.

Keywords Birth certificates · Health care quality indicators · Cesarean section · Data accuracy

Introduction

Administrative datasets are regularly used for quality reporting, research efforts, and quality improvement. Vital statistics birth certificate data are used by researchers and state policymakers in assessing the quality of prenatal care and perinatal outcomes in New York State (NYS). In 2003, a New York State Department of Health (NYSDOH) study assessing the validity and accuracy of 1999 birth data showed very low sensitivity for rare conditions, indicating a failure to accurately report conditions present on the medical record [1]. Since 1999, The National Center for Health Statistics has implemented changes to birth certificate variables and in 2009 NYS released the Medicaid prenatal care standards for care, warranting an analogous study [2, 3]. In 2010, NYS initiated a study using 2009 birth certificate data examining data validity and the impact on quality measures.

Multiple studies over the past 30 years have shown that reporting of rare conditions on birth certificates continues to be poor. A 2005 review of 24 studies concluded that there was poor accuracy on birth certificates that compromises research results, public reporting, and maternal and infant health improvement efforts [4]. Since then, studies assessing data from Washington, Indiana, New Jersey, Florida, New York, Vermont, California, and Missouri, as well as nationwide studies have identified underreporting of risk factors and delivery characteristics [5–12]. Despite thorough documentation of underreporting, the limited progress on increasing reporting accuracy necessitates providing further incentives for improving birth certificate data quality [4].

Birth certificate data are used for many purposes within the NYSDOH. A report of all vital statistics information is published annually, which includes details on prenatal care and birth outcomes for NYS and individual counties [13]. In managed care, birth certificate data are used to assess differences in birth outcomes across plans, such as risk-adjusted

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primary cesarean section and risk-adjusted low birthweight [14]. Therefore, to adequately adjust for potential risk factors it is critical that information in the medical record be reported on the birth certificate. Bundled payment, where providers receive a lump sum for all medical care in an episode instead of being paid per service, is gaining popularity as payers try to realign incentives in maternity care. This approach awards providers financially who perform under their expected costs. A bundled-payment budget methodology can provide financial incentives to reduce unwarranted primary cesarean section. However, it is imperative that accurate reporting of risk-adjusted primary cesarean section take into account the level of risk in their population so as not to undercalculate their expected budgets. The underreporting of critical risk factors limits the ability to statistically adjust for known risk factors, potentially hindering the accuracy of quality reports, research efforts, and payment models.

The objective of this paper is to examine the impact of inaccurate reporting on primary cesarean section risk adjustment by documenting the sensitivity and positive predictive value (PPV) of risk factors and delivery characteristics reported on birth certificate data and correcting odds ratios for risk factors in the primary cesarean section model.

Methods

Data Sources

The NYSDOH collects birth certificate data from the 57 NYS counties, excluding the five boroughs of New York City, where the New York City Department of Health and Mental Hygiene (NYCDOHMH) maintain a vital records registry. We requested maternal hospital medical and prenatal care records from Medicaid managed care (MMC) plans and Medicaid fee for service (FFS) providers for 2009 births. We used the Medicaid Prenatal Care Standards sample, created to determine baseline compliance rates with the new 2010 standards. To ensure the sample would provide meaningful results for our analysis, we estimated a sample size using a prevalence of 10% and an expected sensitivity of 75% based on the ranges of prevalence and sensitivity in prior analyses of NYS data. We required 721 births in the sample using Buderer's sample size estimation methods [15]. We oversampled our random selection of births to account for medical records that hospitals submit with incomplete or inadequate submission.

We generated a random sample of 33 births (30 births with 10% oversample) from the NYS Quality Assurance Reporting Requirements 2009 birth files for each of the 18 MMC plans. For FFS records, we generated a random sample of 220 births (200 births with 10% oversample) from 2009 Medicaid claims. We used a random sampling method that uses an equal probability weight for each birth within each MMC plan and FFS claims. The sampling method uses a uniform random number function starting from a seed selects births without replacement using a simple random sampling algorithm. In total, 715 hospital records were abstracted, but due to incomplete hospital record submission, the final sample was 702 records. The final sample included 26% FFS records and 74% MMC records.

Registered nurses trained in medical record abstraction reviewed the medical records according to the NYSDOH/NYCDOHMH guidelines for birth certificate data collection, and abstracted data elements relevant to this study. Inter-rater reliability testing was performed during abstractor training and internal quality control monitoring occurred throughout data collection to ensure consistency of reviews. Validity of the review was assured via supervisory overreads throughout the review, with a resultant accuracy rate of greater than 95%. Nurse reviewers did not have access to the birth certificate at any point during their review. The NYSDOH Institutional Review Board approved this study.

Sensitivity and Positive Predictive Value

This analysis reports the sensitivity and PPV of data elements in the birth certificate from 2009 using the medical record as the "gold standard" similar to other studies [6, 9]. Sensitivity is the likelihood that the birth certificate will accurately indicate a risk factor among individuals that have the risk factor identified in their medical record (true positives divided by the sum of true positives and false negatives). The PPV is the probability that the medical record will indicate a risk factor as accurate among those with the risk factor identified on the birth certificate (true positives divided by the sum of true positives and false positives). The accuracy of continuous variables is shown as a percent of birth certificates that had an exact match with the medical record.

Primary Cesarean Section Risk Factor Correction

The primary cesarean section rate is used in health insurance performance evaluations, statewide monitoring efforts, and is publicly reported on the NYSDOH department website as part of the annual Health Plan Comparison [14, 16]. To assess the impact of underreporting on quality measure risk adjustment, we corrected primary cesarean section birth certificate statistics using the internal validation study. The cesarean model, outlined in Table 1, was developed to risk adjust the primary cesarean section rate using vital statistics data [17].

We determined model variables at risk of measurement error based on sensitivity calculations performed earlier in

Table 1 Primary cesarean section risk adjustment 2009 model variables

Variable	Values
Maternal risk factors	
Maternal education	Less than high school High school Any college
Maternal age	< 18 years 18–19 years 20–29 years ≥ 30 years
Medicaid aid eligibility	SSI MA/ADC/safety net Family Health Plus
Chronic diabetes	Yes/no
Gestational diabetes	Yes/no
Chronic hypertension	Yes/no
Pregnancy induced hypertension	Yes/no
No previous live births	Yes/no
Race/ethnicity	Black Hispanic Other White
Body mass index	< 18.5 18.5–25.0 25.1+
Labor and delivery characteristics	
Birthweight	500–1500 g 1501–3999 g > 4000 g
Gestation weeks at delivery	< 33 weeks 33–35 weeks 36–38 weeks > 38 weeks
Negative events (abruptio placenta, eclampsia, or infection)	Yes/no
Breech presentation	Yes/no

SSI supplemental security income, *MA/ADC* medicaid aid or aid to dependent children

the study and prior literature. Maternal demographics, usually reported by the mother, are unlikely to have measurement error so we did not perform statistical corrections for the variables: maternal education, maternal age, Medicaid eligibility, race/ethnicity, or body mass index [1, 5, 18]. For the remaining variables we estimated a corrected odds ratio of primary cesarean section. We used weighted log odds ratio estimators to incorporate information from the medical record and correct for measurement error in the birth certificate for each variable. This followed the computational strategy Lyles described for correcting exposure misclassification using validation data [19]. The medical record was considered the "gold standard". We assumed non-differential measurement error for birth certificates variables, as the error is caused by underreporting due to system factors such as access to prenatal records rather than a result of the characteristics themselves. We used a Wald test to compare the uncorrected OR and corrected OR.

Results

Sensitivity and Positive Predictive Value

The sensitivity and PPV of NYS birth certificate data is shown for risk factors in Table 2, and delivery characteristics in Table 3. Most risk factors had low sensitivity, most notably pre-labor high risk referral (9%), eclampsia (0%), and gonorrhea (0%). The risk factors with the highest sensitivity were hepatitis B (100%), syphilis (100%), and previous cesarean section (85%). The PPV of maternal risk factors varied from 9% for bacterial vaginosis to 100% for hepatitis C, chronic diabetes, previous preterm delivery and syphilis.

Labor and delivery characteristics, displayed in Table 3, tended to have slightly higher sensitivity compared to maternal risk factors on the birth certificate. However, there was still low sensitivity for prolonged labor (7%), and refused vaginal birth after cesarean (11%). PPV again varied widely from 13% for both general inhalation of anesthesia and steroids during labor and delivery, to 100% for abruptio placenta.

The percent exact match between the birth certificate and the medical record are shown in Table 4 for continuous data elements. The lowest rate of matching was for number of prenatal care visits, where only 29% of birth certificates exactly matched medical records. The number of prenatal care visits recorded on the birth certificate was within 3 visits 76% of the time. However, 91% of birth certificates exactly matched the medical record for number of previous live births, and 99% of birth certificates were within 2 of the number of previous live births.

Primary Cesarean Section Risk Factor Correction

Table 5 shows the odds ratios for individual variables in the primary cesarean section risk adjustment model before and after correction for measurement error. There was variation in the change in odds ratios between uncorrected and corrected odds ratios. The odds of primary cesarean section for those delivered less than 33 weeks compared to those delivered after 33 weeks was similar between the uncorrected (OR 3.94; 95% CI 3.56, 4.31) and the corrected model (OR 4.06; 95% CI 3.63, 4.53). For those that experienced a negative event including abruptio placenta, eclampsia, or infection, the uncorrected odds ratio for primary cesarean section was 3.06 (95% CI 2.86, 3.29). The corrected odds ratio for those that experienced a negative event was no longer statistically significant after decreasing to 1.42 (95%

Table 2 The sensitivity and positive predictive value (PPV) for maternal risk factors reported in birth certificate data in 2009 using medical records as a gold standard

Data element	Sensitivity	(95% CI)	PPV	(95% CI)
Maternal medical risk factors				
Hepatitis B	100	(3, 100)	20	(0, 72)
Hepatitis C	25	(1, 81)	100	(3, 100)
Genital herpes	61	(39, 80)	70	(46, 88)
Chronic diabetes	38	(9, 76)	100	(29, 100)
Chronic hypertension	32	(13, 57)	75	(35, 97)
Previous preterm delivery	24	(12, 39)	100	(59, 100)
Previous low birthweight	12	(3, 27)	67	(14, 79)
Previous poor pregnancy outcome	11	(5, 22)	23	(8, 37)
Prelabor high risk referral	9	(2, 21)	25	(5, 42)
Previous cesarean delivery	85	(77, 91)	95	(86, 97)
Risk factors related to pregnancy				
Gestational diabetes	64	(49, 78)	76	(60, 89)
Pregnancy induced hypertension	16	(6, 32)	46	(19, 75)
Other serious chronic diseases	21	(14, 29)	65	(47, 80)
Bacterial vaginosis	12	(1, 36)	9	(1, 29)
Chlamydia	40	(16, 68)	67	(30, 93)
Eclampsia	0		NR	
Gonorrhea	0		NR	
Rubella	NR		NR	
Syphilis	100	(3, 100)	100	(3, 100)
Vaginal bleeding	10	(1, 32)	20	(3, 56)
Lifestyle risk factors				
Tobacco use	48	(40, 56)	76	(67, 84)
Alcohol use	2	(0, 7)	33	(4, 78)
Illegal drug use	12	(6, 19)	63	(34, 78)

PPV positive predictive value, *NR* no cases reported on either birth certificate or medical record

CI 0.79, 2.59). The corrected odds ratios for negative events and no previous live births were significantly different from the uncorrected odds ratios.

Discussion

We found underreporting substantially impacted the risk adjustment process. Odds ratios for primary cesarean section changed for several risk factors when using corrected data and regression compared to uncorrected birth certificate data. The corrected odds ratio was outside of or at the uncorrected 95% confidence interval for birthweight greater than 4000 g, negative events, no previous live births, and gestational diabetes. Every odds ratio increased after correction except for the variable negative events. Risk adjustment is crucial to monitoring quality without penalizing plans for patient factors that affect outcomes but cannot be controlled by the health plans [17]. The distribution of patient factors that affect the primary cesarean section rate vary across health plans. When a patient characteristic is underreported, health plans with higher prevalence of that characteristic receive less benefit from risk adjustment than health plans with a lower prevalence of that characteristic. The current risk adjusted primary cesarean section rates could better reflect health plan's quality if birth certificate data was more complete and accurate.

This study demonstrates that risk factors and delivery characteristics continue to be underreported on birth certificates when compared to medical records. We found large variation in the sensitivity and PPV of data elements collected on the birth certificate. By 2009, the reporting of most data elements had not increased and in some cases, was even lower than those reported in 1999 [1]. These results underscore the lack of improvement in birth certificate reporting despite copious documentation of the problem in the literature. Particularly concerning was the poor validity of data elements used as variables to adjust health plan quality measures such as primary cesarean section rate. For example, sensitivity was low for chronic diabetes (38%), chronic hypertension (32%), and pregnancy induced hypertension (16%). Only 83% had an exact match of the gestation weeks at delivery.

Table 3 The sensitivity and positive predictive value (PPV) for labor and delivery characteristics reported in birth certificate data using medical records as a gold standard

Data element	Sensitivity	(95% CI)	PPV	(95% CI)
Method of delivery/presentation				
Vaginal	98	(96, 99)	98	(97, 99)
Cesarean	98	(94, 99)	99	(97, 100)
Vaginal forceps	50	(1, 99)	33	(0, 91)
Vaginal vacuum	87	(60, 98)	76	(50, 93)
Cephalic presentation	99	(98, 100)	92	(89, 94)
Breech presentation	68	(47, 85)	85	(62, 97)
Trial labor for cesarean delivery	71	(42, 92)	17	(8, 29)
Indications for cesarean delivery				
Failure to progress	71	(54, 84)	67	(51, 81)
Malpresentation	58	(37, 78)	58	(37, 78)
Previous cesarean	83	(73, 91)	68	(57, 78)
Fetus at risk	71	(55, 84)	73	(57, 86)
Maternal condition, not pregnancy related	25	(3, 65)	67	(9, 99)
Maternal condition, pregnancy related	32	(13, 57)	60	(26, 88)
Refused vaginal birth after cesarean	11	(0, 48)	17	(0, 46)
Elective	34	(20, 51)	37	(22, 54)
Other indication	14	(3, 35)	17	(4, 41)
Anesthesia				
Analgesia	61	(52, 70)	52	(44, 60)
Epidural	83	(79, 87)	87	(82, 90)
General inhalation	14	(0, 58)	13	(0, 53)
General intravenous	50	(23, 77)	39	(17, 64)
Spinal	76	(68, 83)	71	(64, 78)
Local	51	(39, 63)	40	(30, 51)
Obstetrical procedures during labor and delivery				
Antibiotics	35	(29, 42)	62	(53, 71)
Augmentation of labor	45	(37, 52)	55	(46, 63)
Episiotomy and repair	70	(57, 80)	70	(57, 80)
External electronic fetal monitoring	89	(86, 92)	79	(76, 82)
Internal electronic fetal monitoring	57	(43, 70)	41	(30, 52)
Induction of labor, AROM	27	(18, 38)	29	(19, 40)
Induction, medicinal	51	(43, 60)	56	(47, 65)
Steroids	33	(1, 91)	13	(0, 53)
Sterilization	56	(38, 73)	68	(48, 84)
Complications of labor and delivery				
Abruptio placenta	20	(1, 72)	100	(3, 100)
Chorioamnionitis	80	(28, 99)	50	(16, 84)
Fetal intolerance	38	(9, 76)	17	(4, 41)
Meconium staining	55	(43, 67)	60	(46, 72)
Precipitous labor	30	(19, 43)	49	(32, 66)
Prolonged labor	7	(2, 18)	44	(14, 79)
Premature rupture of membranes	35	(21, 50)	44	(28, 62)
Prolonged rupture of membranes	33	(7, 70)	16	(3, 40)
Birthweight > 4000 g	100	(92, 100)	80	(67, 90)
No reported characteristics	93	(90, 95)	63	(59, 67)

PPV positive predictive value, *AROM* artificial rupture of membranes

Table 4 Percent match between birth certificate and medical records for continuous data elements

Data element	% Match
Date of first prenatal care visit	
Exact	65
± 1 day	67
± 2 days	68
± 1 week	71
Number of prenatal care visits	
Exact	29
± 1 visit	51
± 2 visits	66
± 3 visits	76
Date of last menses	
Exact	71
± 1 week	82
Number of previous live births	
Exact	91
± 1	98
± 2	99
Infant's birthweight	
Exact	73
± 100 g	96
± 200 g	97
Infant's estimated gestation	
Exact	83
± 1 week	96
± 2 weeks	99

Many studies have demonstrated similar discrepancies in data elements when comparing birth certificates to medical records or another gold standard. However, the degree to which birth certificate validity impacts the results of quality measure reports or research investigations is less explored. Jurek and Greenland examined how birth certificate misclassification changed the association between maternal smoking during pregnancy and clefting [10]. After accounting for both maternal smoking and clefting misclassification, odds ratios varied widely and many fell outside of the 95% confidence intervals determined before considering reporting error. This study showed how associations described in research or reporting could be largely impacted by underreporting in the birth certificate data [10]. Using data from West Virginia, Li and colleagues demonstrated that misclassification of neonatal conditions as congenital anomalies on birth certificate data resulted in an inappropriately high state rate of congenital anomalies reported [20]. Furthermore, misclassification had produced a false temporal and geographic pattern of congenital anomalies, which would have been concerning and could theoretically result in unnecessary monitoring or intervention [20].

Studies examining the cause of underreporting will be useful to health plans and providers that want quality metrics or payments to be accurately adjusted for case mix. A survey of birth registrars in NYS determined data elements for the birth certificate come from an average of four sources [21]. One important source is clinical notes and charts, yet 46% of birth registrars reported clinical staff did not provide complete information, and 30% reported prenatal records were unavailable. Opportunities to train staff are limited to 36% of registrars and 46% of clinicians [4, 21]. Health plans that want their rates to most accurately reflect care quality, should support improvements to data collection, such as training birth registrars and clinicians, and ensuring medical record systems are compatible and accessible.

This study is subject to limitations that should be considered while interpreting these findings. We assumed non-differential measurement error in birth certificate data elements. While it is possible there is some systematic variation in the reporting, assuming non-differential measurement error allowed us to maintain that the error all occurred in a similar direction due to systematic underreporting, rather than misclassification. The sample size is restricted to 702 due to the time and effort required to abstract and review medical records. For some characteristics, the small sample size resulted in wide confidence intervals when estimating sensitivity and PPV due to the rarity of certain poor outcomes and extremely small proportion of events in the

Table 5 Uncorrected and corrected odds ratios of primary cesarean section for risk factors with measurement error

Data element	Uncorrected		Corrected	
	Odds ratio	(95% CI)	Odds ratio	(95% CI)
Delivered less than 33 weeks	3.94	(3.56, 4.31)	4.06	(3.63, 4.53)
Gestational diabetes	1.68	(1.57, 1.80)	1.80	(1.62, 1.99)
Chronic hypertension	2.86	(2.53, 3.22)	3.16	(1.97, 5.00)
Birth weight greater than 4000 g	2.12	(2.03, 2.27)	2.34	(2.10, 2.64)
Negative events[a]	3.06	(2.86, 3.29)	1.42	(0.79, 2.59)*
No previous live births	3.03	(2.94, 3.13)	3.46	(3.22, 3.67)*

*There is a significant difference in the uncorrected and corrected odds ratios using a Wald test

[a]Negative events include: abruptio placenta, eclampsia, or infection

validation sample. The small sample size prevented our data from fitting a full model with all corrected variables included. Additionally, the small sample size made it impossible to calculate corrected values for rare characteristics such as chronic diabetes and pregnancy induced hypertension. Medical records are considered the gold standard; however, some data elements may not be complete due to limited access to full prenatal care records. Additionally, self-reported lifestyle risk factors, such as smoking during pregnancy, may be underreported on the medical record as well as the birth certificate. Finally, we acknowledge the data used in this analysis are less recent than ideal. However, the impact of data accuracy on the risk adjustment process is relevant regardless of when the data was collected. Since birth certificate data accuracy has not improved since the 1990s, the downstream effects of data accuracy persist in contemporary use of the data, and should be recognized.

These results demonstrate data validity is crucial for adequate risk adjustment of quality measures yet underreporting on birth certificate data continues in NYS. Because of the differences in the distribution of patient characteristic across plans, underreporting impacts health plans differently according to the prevalence in each health plan. Although risk adjustment with birth certificate data provides a significant impact by considering patient case-mix, improvements in reporting on the birth certificate would ensure health plans are receiving the full benefit of risk adjustment [17]. Furthermore, reporting improvements would facilitate the interpretation of rates for quality monitoring at the health center, health plan, and state level. Health plans should encourage hospitals to implement methods to improve data accuracy and provide feedback on data inconsistencies. With more accurate data, healthcare providers and policy makers can be better informed and the health plans can fully benefit from risk adjustment of quality measures.

Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

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