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Accuracy of *International Classification of Diseases, Ninth Revision Codes* for Postpartum Hemorrhage Among Women undergoing Cesarean Delivery

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Abstract

Background—Determining the accuracy of *International Classification of Diseases, Ninth Revision Clinical Modification* (ICD-9) codes for postpartum hemorrhage (PPH) is vital for reaching valid conclusions about the epidemiology of PPH. Our primary objectives were to assess the performance characteristics of ICD-9 PPH codes against a reference standard using estimated blood loss (EBL) among a cohort undergoing cesarean delivery.

Study Design and Methods—We analyzed maternal discharge and EBL data from women who underwent cesarean delivery at Kaiser Permanente Northern California facilities between 2010 and 2013. We defined PPH as an EBL ≥1000 ml. In a secondary analysis, ICD-9 performance characteristics were assessed using an EBL ≥ 1500 ml to classify severe PPH.

Results—We identified 35,614 hospitalizations for cesarean delivery. Using EBL ≥ 1000 ml as the "gold standard", PPH codes had a sensitivity of 27.8%, specificity of 97%, positive predictive value of 74.5%, and a negative predictive value of 80.9%. The prevalence of a PPH code (9%) was lower than the prevalence using a blood loss≥1000 ml (24%). Using a reference standard of EBL ≥1500 ml, PPH codes had a sensitivity of 61.7%, specificity of 93.8%, positive predictive value of 34.2%, and negative predictive value of 97.9%.

Conclusion—PPH ICD-9 codes have high specificity, moderately high positive and negative predictive values, and low sensitivity. An EBL ≥1500 ml as a reference standard has higher sensitivity. Our findings suggest that, for women undergoing cesarean delivery, quality improvement efforts are needed to enhance PPH ICD-9 coding accuracy in administrative datasets.

Keywords

Classification; Hemorrhage; Postpartum; International Classification of Diseases

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Introduction

In the United States (US), postpartum hemorrhage (PPH) is a leading direct cause of maternal death and severe obstetric morbidity.[1,2] To add to this concern, the rate of PPH in the US has steadily increased, from 2.2% in 1994 to 2.9% in 2005 (a 26% increase over time).[3] Similar trends have been observed in other well-resourced countries. To better understand the causes, patterns, risk factors, and outcomes related to PPH, medical claims data have been used for large-scale evaluations of PPH epidemiology.[1,3-5] However, there has been limited examination of the accuracy of claims data generated from *International Classification of Diseases* (ICD) codes for PPH. Determining the accuracy of these codes is vital for reaching valid conclusions about the epidemiology of PPH and the use of key interventions for PPH management, including transfusion therapy.

Since October 2015, hospitals in the United States have transitioned to using ICD 10th Revision (ICD-10) diagnostic and procedure codes for hospital billing.[6] Since this transition is recent and US population-wide studies of PPH using ICD-10 codes are scarce, studies examining large administrative datasets must still rely on ICD 9th revision (ICD-9) diagnostic codes. However, to our knowledge, the accuracy of ICD-9 codes for PPH are poorly described. This is particularly surprising considering that national estimates of PPH burden and outcomes have relied on administrative data.[1,3-5] Furthermore, these data are also used to inform obstetric agencies, such as the National Partnership for Maternal Safety, who publish safety bundles for PPH prevention and management.[7]

Estimated blood loss (EBL) is central to the diagnosis of PPH.[8,9] International obstetric societies have provided EBL thresholds for classifying PPH.[8,10] The most commonly used definition is an EBL>500 ml post-vaginal delivery or an EBL>1000 ml post-cesarean delivery.[8] Of note, in the most recent PPH Practice Bulletin published by the American College of Obstetricians and Gynecologists in 2017,[9] PPH is defined as a cumulative blood loss ≥1,000 ml or blood loss accompanied by signs of symptoms of hypovolemia within 24 hrs of birth. Given that clinicians are most familiar with defining PPH using EBL thresholds and routinely document EBL volume at delivery into patients' medical records, and that EBL data can now be retrieved electronically, linking a clinical database containing EBL data with a discharge database containing ICD-9 codes provides an ideal opportunity to examine the accuracy of ICD-9 codes for PPH.

We sought to evaluate the performance characteristics of ICD-9 diagnostic codes for PPH within an administrative discharge database by comparison to the recorded EBL from electronic medical records in a large sample of women who underwent cesarean delivery. For this study, we used data from Kaiser Permanente Northern California (KPNC), an integrated healthcare delivery system in the United States.

Materials and Methods

This study was approved by the Stanford University and KPNC Institutional Review Boards for the Protection of Human Subjects, and the Committee for the Protection of Human Subjects of the California Health and Human Services Agency.

We analyzed data from a cohort of women undergoing cesarean delivery at KPNC obstetric centers.[11] Maternal diagnoses were obtained from the KPNC Virtual Data Warehouse (VDW). The KPNC VDW contains electronic records of all patient encounters (inpatient and outpatient) at KPNC facilities, including patient unique identifiers, health plan enrollment dates, encounter dates and locations, dispositions, diagnostic and procedure codes, laboratory tests and their result.[12] Details of data cleaning, processing and the linkage electronic databases within KPNC have been previously described.[13-15] Our initial study cohort comprised women aged ≥15 yrs who underwent cesarean delivery at a KPNC center between January 1, 2010 and December 31, 2013.

EBL data were available from KPNC electronic medical records from 2010 onwards. Based on literature review,[10,16-18] we defined PPH as an EBL ≥1000 ml and severe PPH as an EBL ≥1500 ml. We excluded women with missing EBL data. Because of concern about the accuracy of very low EBL values, we also excluded women with an EBL<100 ml.

Information on PPH ICD-9 codes was obtained directly from KPNC VDW datasets. The following ICD-9 codes for PPH were identified: 666.0x (PPH from retained placenta); 666.1x (PPH from uterine atony); 666.2x (delayed or secondary PPH); the 'x' indicates all codes for 666.0, 666.1, and 666.2 down to the level of the fifth digit sub-classification. Coders typically review medical records in the maternal discharge record then apply relevant ICD-9 codes.

We abstracted data on a number of demographic, medical, obstetric, and peripartum co-variates. These characteristics were purposefully selected because they have been linked with PPH in prior studies.[4,16-22] Demographic characteristics included: maternal age, race, and ethnicity. Medical characteristics included: obesity, and chronic anemia. Obstetric characteristics included: gestational age at delivery, grand multiparity, number of prior cesarean deliveries, multiple gestation, fibroids, stillbirth, placenta previa, and preeclampsia. Peripartum characteristics included: induction of labor, labor, prolonged labor, chorioamnionitis, polyhydramnios, antepartum hemorrhage, placental abruption, and year of delivery. Relevant obstetric morbidities included: coagulopathy, uterine rupture, and hysterectomy. Data for race and ethnicity were obtained from the State of California Birth Certificate database. Maternal age, number of prior cesarean deliveries, gestational age, and year of delivery were obtained from linked KPNC databases. Other relevant diagnoses and procedures for each delivery hospitalization were identified using ICD-9 codes (see Appendix) and were obtained from a linked KPNC maternal discharge database.

Statistical Analyses

Using an EBL≥1000 ml as the 'reference standard', we examined the performance characteristics of ICD-9 codes for PPH. We calculated sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV), with exact binomial 95% confidence intervals (CI) for all women in the study cohort. We stratified results according to individual demographic, medical, obstetric, and peripartum characteristics. In a secondary analysis, we compared the performance characteristics of ICD-9 codes against a recorded EBL ≥1500 ml (severe PPH). Finally, we performed an exploratory analysis to examine the influence of selected maternal characteristics on the correct PPH assignment using our EBL

reference standard. We initially performed univariable logistic regression analysis to examine the associations between each variable and correct assignment of an ICD-9 PPH code. Factors with a *P*-value <0.1 on univariable analyses were then included into a multivariable regression model. All analyses were performed using Stata 12.0 (Stata Corp., College Station, TX).

Results

Our initial study cohort comprised 38,086 women who underwent cesarean delivery at a KPNC obstetric center between 2010 and 2013. After excluding women with missing EBL data (n=2,217) and women with EBL values less than 100 ml (n=345), our final analytic sample comprised 35,614 women.

Characteristics of women in the final analytic sample as well as those with an ICD-9 code for PPH are presented in Table 1. A total of 3,194 (9%) women had any ICD-9 code for PPH; of these, 86 (0.2%) women had an ICD-9 code for PPH from retained placenta, 3,032 (8.5%) had an ICD-9 code for PPH from uterine atony, and 104 (0.3%) had an ICD-9 code for delayed or secondary PPH. Based on available EBL data, the mean (95% CI) EBL among all women was 800 ml (250 – 1490 ml). Based on our *a priori* EBL thresholds for PPH and severe PPH, 8,557 (24%) women experienced an EBL ≥1000 ml and 1,771 (5%) women experienced an EBL ≥1500 ml. The prevalence of an ICD-9 code for transfusion was 3.1%.

For all women in the analytic sample, performance characteristics for any ICD-9 code for PPH were: sensitivity=27.8%, specificity=97%, PPV=74.5%, and NPV=80.9%. Table 2 presents the performance characteristics according to each maternal characteristic. In our stratified analyses, the specificity, PPV, and NPV values remained fairly consistent across all maternal characteristics. Sensitivities remained low for the majority of the characteristics, except for coagulopathy (62.6%) and hysterectomy (85.2%). In the secondary analysis, the performance characteristics of the PPH ICD-9 codes were compared against an EBL≥1500 ml (Appendix). The specificity (93.8%) and NPV (97.9%) remained high, with an improvement in the sensitivity (61.7%). However, there was a moderate decrease in PPV to 34.2%. These indices remained fairly consistent across all maternal characteristics.

Findings from our univariable and multivariable analysis examining characteristics associated with correct assignment of PPH codes are presented in Table 3. In the multivariable analysis, women who delivered <37 weeks' gestational age were more likely to be coded correctly (aOR=1.25; 95% CI=1.14-1.36) than those delivering between 37-41 weeks. Characteristics of women who were less likely to be correctly assigned a PPH code, included: maternal age ≥35 years, Black race, obesity, chronic anemia, gestational age at delivery >41 weeks, multiple gestation, placenta previa, preeclampsia, induction of labor, labor, prolonged labor, chorioamnionitis, polyhydramnios, antepartum hemorrhage, and uterine rupture.

Discussion

Administrative datasets containing ICD-9 codes are vital data sources for US population-wide studies of PPH. However, the accuracy of these codes has been poorly examined. In this validation study of ICD-9 codes for PPH within a population of women undergoing cesarean delivery, the sensitivity was poor (28%), but the specificity and NPV were high (97% and 81%, respectively), and the PPV was moderately high (75%). These findings suggest that ICD-9 codes may underestimate the prevalence of PPH among women undergoing cesarean delivery.

Few studies have assessed the accuracy of ICD-9 codes for PPH. Lyndon-Rochelle et al. compared hospital discharge data with information documented in the medical records of 4,541 women who underwent delivery hospitalization in Washington State in 2000.[23] Although the reported PPV (71.9%) for ICD-9 codes for PPH was similar to that observed in our study, there was a lower prevalence of PPH (4.7%). In a separate study of 1,611 deliveries in 52 hospitals in California between 1992-1993 linking hospital records with hospital discharge data, the sensitivity (21%) was similar to our study but the PPV was substantially higher (98%).[24] In a systematic review of validation studies of maternal data in hospital discharge datasets, Lain et al. pooled data to report the PPV, sensitivity and sensitivity of specific obstetric complications, including PPH.[25] Compared to our findings, PPV values were higher (ranging from 83.9% to 98%) and the specificity values were similar (ranging from 98.2% to 99.8%). Comparisons of sensitivity are more difficult because a wide range of reported sensitivity values was reported (21% to 90.2%) in the review. None of these studies described the reference standard for defining PPH or reported performance characteristics of ICD-9 codes using EBL values as reference standards. This may account for some of the variability in the performance characteristics of PPH ICD-9 codes across these studies.

In our study, using an EBL threshold of 1000 ml to define PPH, the sensitivity of ICD-9 codes for PPH was low (27.8%). The sensitivity only improved moderately (62%) using a threshold of 1500 ml. There are several possible explanations for these findings. Firstly, obstetric diagnoses tend to be less accurately reported than obstetric procedures, such as mode of delivery.[25] Secondly, documentation of PPH in medical records may not depend on EBL or specific EBL thresholds. Thirdly, it is possible that some patients may have experienced PPH in the postoperative period. Because EBL is typically recorded at the end of surgery, some late PPH events with codes for PPH would not have been identified using EBL data. Finally, for patients with hemorrhage-related morbidities, PPH episodes may be more accurately documented and coded. Our findings support this assertion in that we observed higher sensitivity and PPV values among women with coagulopathy (63% and 88%, respectively) and hysterectomy (85% and 93%, respectively).

In our regression analysis, we identified a number of maternal and obstetric characteristics (such as maternal age ≥35 years, Black race, obesity, chronic anemia) that were associated with a reduced likelihood of correct assignment of PPH codes. As no clear patterns can be elucidated, it is unclear if these associations are spurious or chance findings. Further studies are needed to validate these findings and to investigate whether other unaccounted for

factors influence coding accuracy, such as, coder training and experience, and facility quality-control efforts.

Our main findings suggest that ICD-9 codes for PPH may substantially underestimate the disease burden of PPH. The low sensitivity of ICD-9 codes for PPH indicates that there is a need to improve current coding practices for PPH. As clinicians are prone to underestimating blood loss, especially when large volumes of blood are lost,[26,27] these sensitivities may be overestimated. With the majority of nonfederal acute care US hospitals (83% in 2015) implementing electronic health records (EHRs),[28] a new source of health care data for epidemiological studies is becoming available. Data recorded in EHR systems provide an opportunity to improve medical documentation of PPH, which may secondarily improve the accuracy of PPH coding. Alert systems could be developed to prompt clinicians to enter a diagnosis of PPH into the EHR based on pre-specified criteria, especially for women at-risk for PPH. To account for potential EBL underestimation, the presence of other morbidities strongly associated with severe PPH, such as severe postpartum anemia[11] and transfusion[29], could be also be built into alert systems for enhancing PPH documentation in medical records. Alert systems would need to be carefully designed to limit the lack of physician response due to alert fatigue.

The main strengths of our analysis are the large study population and the ability to compare EBL data with ICD-9 codes for PPH by linkage of KPNC clinical and hospital discharge databases. We acknowledge that our study has several limitations. Because KPNC hospitals are located in Northern California, we are uncertain how generalizable our findings are to other US obstetric centers, especially if there are notable differences in coding practices for PPH. We cannot ascertain whether obstetricians or coders use EBL values or other clinical indices as the reference standard. Further studies are needed to determine what information in the medical records is used to code for PPH. Although blood loss cutoffs are somewhat arbitrary, the use of a blood loss cutoff of 1000 ml is supported by The Women's Health Registry Alliance (an initiative that comprises members from over 80 stakeholder obstetric and maternal health organizations in the United States)[30], the Brighton Collaboration Primary Postpartum Haemorrhage Working Group (a panel of experts formed to develop definition and guidelines for data collection and analysis for PPH),[31] and in the latest PPH guidelines from the American College of Obstetricians and Gynecologists.[9] We applied our EBL threshold using definitions for PPH that were current for our study period (2010-2013).[10] We acknowledge that the latest ACOG PPH definition is either blood loss accompanied by clinical features of hypovolemia or a cumulative blood loss ≥ 1,000 ml.[9] This new definition may further complicate how future cases of PPH are coded. Plus, due to a lack of international consensus for defining PPH,[10,32] variation in ICD-9 coding accuracy may exist in other developed countries. We classified ICD-9 codes 666.3x as coagulopathy and did not use these codes to identify women with PPH. Although misclassification is a potential concern, our estimates of coding accuracy are unlikely to be biased because, among 8,557 women with an EBL≥1000 ml, only 52 (0.8%) women had a 666.3x ICD-9 code without an accompanying PPH code (666.0x, 666.1x, or 666.2x). The classification systems used by medical coders to identify episodes of PPH may be highly specific or complicated, resulting in inconsistencies in how PPH is coded. Similarly, we did not assess coding accuracy for other diagnoses and procedures identified using ICD-9 codes. As standardization of coding

practices is lacking, improvements are needed to enhance the value of administrative databases for epidemiological studies of PPH. Because hospitals transitioned to ICD-10 coding in October 2015,[6] the long-term impact of our findings is uncertain. Given that this transition is very recent, epidemiological studies assessing temporal trends in PPH incidence will likely rely on identifying PPH events using both ICD-9 and ICD-10 codes. Moreover, coding inaccuracies may persist or even increase because the number of ICD-10 diagnostic codes (69,823) is far greater than that of ICD-9 diagnostic codes (14,025).[33]

In conclusion, our findings indicate that ICD-9 codes for PPH may underestimate the true prevalence of PPH using an EBL threshold ≥1000 ml as a reference standard. These findings may serve as a useful benchmark for future studies that examine PPH rates using ICD codes.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Source of work: Secondary analyses of data sourced from databases based at the Division of Research at Kaiser Permanente Northern California, Oakland, California.

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References

1. Callaghan WM, Creanga AA, Kuklina EV. Severe maternal morbidity among delivery and postpartum hospitalizations in the United States. Obstet Gynecol. 2012; 120:1029–36. [PubMed: 23090519]
2. Creanga AA, Syverson C, Seed K, Callaghan WM. Pregnancy-Related Mortality in the United States, 2011–2013. Obstet Gynecol. 2017; 130:366–73. [PubMed: 28697109]
3. Callaghan WM, Kuklina EV, Berg CJ. Trends in postpartum hemorrhage: United States, 1994–2006. Am J Obstet Gynecol. 2010; 202:353.e1–6. [PubMed: 20350642]
4. Bateman BT, Berman MF, Riley LE, Leffert LR. The epidemiology of postpartum hemorrhage in a large, nationwide sample of deliveries. Anesth Analg. 2010; 110:1368–73. [PubMed: 20237047]
5. Kramer MS, Berg C, Abenhaim H, Dahhou M, Rouleau J, Mehrabadi A, Joseph KS. Incidence, risk factors, and temporal trends in severe postpartum hemorrhage. Am J Obstet Gynecol. 2013; 209:449.e1–7. [PubMed: 23871950]
6. Office of the Federal Register. 45 CFR Part 162. US Government. Federal Register. 2014:45128–34. [PubMed: 25122944]
7. D'Alton ME, Main EK, Menard MK, Levy BS. The National Partnership for Maternal Safety. Obstet Gynecol. 2014; 123:973–7. [PubMed: 24785848]
8. Rath WH. Postpartum hemorrhage--update on problems of definitions and diagnosis. Acta Obstet Gynecol Scand. 2011; 90:421–8. [PubMed: 21332452]
9. American College of Obstetricians and Gynecologists. ACOG Practice Bulletin No. 183: Postpartum Hemorrhage Obstet Gynecol. 2017; 130:e168–e186. [PubMed: 28937571]
10. Dahlke JD, Mendez-Figueroa H, Maggio L, Hauspurg AK, Sperling JD, Chauhan SP, Rouse DJ. Prevention and management of postpartum hemorrhage: a comparison of 4 national guidelines. Am J Obstet Gynecol. 2015; 213:76.e1–10. [PubMed: 25731692]

11. Butwick AJ, Walsh EM, Kuzniewicz M, Li SX, Escobar GJ. Patterns and predictors of severe postpartum anemia after Cesarean section. Transfusion. 2017; 57:36–44. [PubMed: 27618767]
12. Chimmula S, Dhuru R, Folck B, Gul J, Lee M, Ng D, Tao W, Yurkevicj S. PS2–44: VDW data sources: Kaiser Permanente Northern California. Clin Med Res. 2012; 10:193.
13. Escobar GJ, Greene JD, Hulac P, Kincannon E, Bischoff K, Gardner MN, Armstrong MA, France EK. Rehospitalisation after birth hospitalisation: patterns among infants of all gestations. Arch Dis Child. 2005; 90:125–31. [PubMed: 15665162]
14. Escobar GJ, Greene JD, Scheirer P, Gardner MN, Draper D, Kipnis P. Risk-adjusting hospital inpatient mortality using automated inpatient, outpatient, and laboratory databases. Med Care. 2008; 46:232–9. [PubMed: 18388836]
15. Selby JV. Linking automated databases for research in managed care settings. Ann Intern Med. 1997; 127:719–24. [PubMed: 9382386]
16. Magann EF, Evans S, Hutchinson M, Collins R, Lanneau G, Morrison JC. Postpartum hemorrhage after cesarean delivery: an analysis of risk factors. South Med J. 2005; 98:681–5. [PubMed: 16108235]
17. Al-Zirqi I, Vangen S, Forsen L, Stray-Pedersen B. Prevalence and risk factors of severe obstetric haemorrhage. BJOG. 2008; 115:1265–72. [PubMed: 18715412]
18. Skjeldestad FE, Oian P. Blood loss after cesarean delivery: a registry-based study in Norway, 1999–2008. Am J Obstet Gynecol. 2012; 206:76.e1–7. [PubMed: 21963102]
19. Kolas T, Oian P, Skjeldestad FE. Risks for peroperative excessive blood loss in cesarean delivery. Acta Obstet Gynecol Scand. 2010; 89:658–63. [PubMed: 20218934]
20. Combs CA, Murphy EL, Laros RK Jr. Factors associated with hemorrhage in cesarean deliveries. Obstet Gynecol. 1991; 77:77–82. [PubMed: 1984231]
21. Naef RW 3rd, Washburne JF, Martin RW, Magann EF, Scanlon PH Jr, Morrison JC. Hemorrhage associated with cesarean delivery: when is transfusion needed? J Perinatol. 1995; 15:32–5. [PubMed: 7650550]
22. Belghiti J, Kayem G, Dupont C, Rudigoz RC, Bouvier-Colle MH, Deneux-Tharaux C. Oxytocin during labour and risk of severe postpartum haemorrhage: a population-based, cohort-nested case-control study. BMJ Open. 2011; 1:e000514.
23. Lydon-Rochelle MT, Holt VL, Nelson JC, Cardenas V, Gardella C, Easterling TR, Callaghan WM. Accuracy of reporting maternal in-hospital diagnoses and intrapartum procedures in Washington State linked birth records. Paediatr Perinat Epidemiol. 2005; 19:460–71. [PubMed: 16269074]
24. Romano PS, Yasmeen S, Schembri ME, Keyzer JM, Gilbert WM. Coding of perineal lacerations and other complications of obstetric care in hospital discharge data. Obstet Gynecol. 2005; 106:717–25. [PubMed: 16199627]
25. Lain SJ, Roberts CL, Hadfield RM, Bell JC, Morris JM. How accurate is the reporting of obstetric haemorrhage in hospital discharge data? A validation study. Aust N Z J Obstet Gynaecol. 2008; 48:481–4. [PubMed: 19032664]
26. Stafford I, Dildy GA, Clark SL, Belfort MA. Visually estimated and calculated blood loss in vaginal and cesarean delivery. Am J Obstet Gynecol. 2008; 199:519.e1–7. [PubMed: 18639209]
27. Toledo P, McCarthy RJ, Hewlett BJ, Fitzgerald PC, Wong CA. The accuracy of blood loss estimation after simulated vaginal delivery. Anesth Analg. 2007; 105:1736–40. [PubMed: 18042876]
28. Henry, J., Pylypchuk, Y., Searcy, T., Patel, V. Adoption of Electronic Health Record Systems among U.S. Non-Federal Acute Care Hospitals: 2008–2015; Office of the National Coordinator for Health Information Technology: ONC Data Brief 35; May 2016;
29. Patterson JA, Roberts CL, Bowen JR, Irving DO, Isbister JP, Morris JM, Ford JB. Blood transfusion during pregnancy, birth, and the postnatal period. Obstet Gynecol. 2014; 123:126–33. [PubMed: 24463672]
30. Menard MK, Main EK, Currigan SM. Executive summary of the reVITALize initiative: standardizing obstetric data definitions. Obstet Gynecol. 2014; 124:150–3. [PubMed: 24901267]
31. Kerr R, Eckert LO, Winikoff B, Durocher J, Meher S, Fawcus S, Mundle S, Mol B, Arulkumaran S, Khan K, Wandwabwa J, Kochhar S, Weeks A. Postpartum haemorrhage: Case definition and

guidelines for data collection, analysis, and presentation of immunization safety data. Vaccine. 2016; 34:6102–9. [PubMed: 27431424]

32. Shaylor R, Weiniger CF, Austin N, Tzabazis A, Shander A, Goodnough LT, Butwick AJ. National and International Guidelines for Patient Blood Management in Obstetrics: A Qualitative Review. Anesth Analg. 2016; 124:216–32.
33. National Center for Health Statistics. International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM). Atlanta, GA: Centers for Disease Control and Prevention; Aug. 2017 URL: https://www.cdc.gov/nchs/icd/icd10cm.htm. Accessed December 10, 2017

Table 1

Patient Characteristics among all Cesarean Deliveries and among Cesarean Deliveries with an International Classification of Diseases Version 9 Code for Postpartum Hemorrhage.

	All Cesarean Deliveries (n=35,614)	Cesarean deliveries with an ICD-9 code for PPH (n=3194)
Maternal age at delivery (yr)	31.7 (5.6)	32.1 (5.8)
Race/ethnicity		
White	13968 (39.2%)	1002 (31.4%)
Black	3148 (8.8%)	271 (8.5%)
Asian	8934 (25.1%)	1080 (33.8%)
Hispanic	8397 (23.6%)	728 (22.8%)
Other	735 (2.1%)	67 (2.1%)
Unknown	432 (1.2%)	46 (1.4%)
Obesity	7557 (21.2%)	626 (19.6%)
Chronic anemia	8539 (24%)	993 (31.1%)
Gestational age at delivery (wks)		
<37	5117 (14.4%)	588 (18.4%)
37–41	27707 (77.8%)	2221 (69.5%)
>41	2790 (7.8%)	385 (12.1%)
Grand multiparity	101 (0.3%)	12 (0.4%)
Number of prior CD		
0	27807 (78.1%)	2686 (84.1%)
1	7071 (19.9%)	467 (14.6%)
≥2	736 (2.1%)	41 (1.3%)
Multiple gestation	3340 (9.4%)	579 (18.1%)
Fibroids	2293 (6.4%)	229 (7.2%)
Stillbirth	37 (0.1%)	1 (0.03%)
Placenta previa	973 (2.7%)	193 (6%)
Preeclampsia	3134 (8.8%)	434 (13.6%)
Induction of Labor	5732 (16.1%)	828 (25.9%)
Labor	19552 (54.9%)	2103 (65.8%)
Prolonged labor	922 (2.6%)	184 (5.8%)
Chorioamnionitis	3267 (9.2%)	693 (21.7%)
Polyhydramnios	268 (0.7%)	29 (0.9%)
Antepartum hemorrhage	1191 (3.3%)	229 (7.2%)
Placental abruption	671 (1.9%)	107 (3.3%)
Coagulopathy	331 (0.9%)	110 (3.4%)
Uterine rupture	91 (0.3%)	22 (0.7%)
Hysterectomy	86 (0.2%)	74 (2.3%)

Data presented as n (%).

CD= Cesarean Deliveries; ICD-9 = International Classification of Diseases, version 9; PPH = postpartum hemorrhage

Table 2

Performance Characteristics of International Classification of Diseases Version 9 Codes for Postpartum Hemorrhage.

	Sensitivity % (95% CI)	**Specificity % (95% CI)**	**PPV % (95% CI)**	**NPV % (95% CI)**
All women	27.8 (26.9–28.8)	97 (96.8–97.2)	74.5 (72.9–76)	80.9 (80.5–81.4)
Maternal age (yr)				
<35	27.5 (26.3–28.7)	97 (96.8–97.3)	81.9 (81.3–82.4)	73.3 (71.3–75.2)
≥35	28.4 (26.8–30.1)	96.9 (96.5–97.3)	76.7 (74.1–79.2)	79 (78.1–79.7)
Race/ethnicity				
White	24.2 (22.8–25.8)	97.8 (97.5–98.1)	76.5 (73.8–79.1)	81.5 (80.8–82.2)
Black	24.8 (21.9–28)	96.9 (96.2–97.6)	73.4 (67.8–78.6)	79.1 (77.5–80.5)
Hispanic	26.4 (24.5–28.4)	96.7 (96.2–97.1)	70.5 (67–73.8)	81.4 (80.5–82.2)
Asian	34.5 (32.6–36.5)	95.9 (95.4–96.4)	75 (72.3–77.6)	80.4 (79.5–81.3)
Other	27.5 (21.1–34.7)	96.8 (94.9–98.1)	73.1 (60.9–83.2)	80.7 (77.5–83.6)
Unknown	32.8 (24.7–41.8)	98.4 (96.2–99.5)	89.1 (76.4–96.4)	78.2 (73.8–82.3)
Obesity	23.7 (21.8–25.7)	96.9 (96.4–97.3)	72 (68.4–75.5)	79.1 (78.1–80)
Chronic anemia	31 (29.2–32.9)	96 (95.5–96.5)	75.1 (72.3–77.8)	78 (77–78.9)
Gestational age at delivery (wks)				
<37	30.9 (28.5–33.4)	95.9 (95.2–96.5)	73.8 (70.1–77.3)	78.5 (77.3–79.7)
37–41	26 (24.9–27.1)	97.2 (97–97.4)	73.1 (71.2–75)	81.8 (81.4–82.3)
>41				
Grand multiparity	27.6 (12.7–47.2)	94.4 (86.4–98.5)	66.7 (34.9–90.1)	76.4 (66.2–84.8)
Number of prior CD				
0	28.8 (27.7–29.8)	96.8 (96.6–97.1)	75.6 (73.9–77.2)	80 (79.5–80.5)
1	23.3 (21–25.6)	97.4 (96.9–97.8)	68.1 (63.7–72.3)	84.1 (83.2–85)
≥2	23.1 (16.1–31.3)	98.2 (96.8–99.1)	73.2 (57.1–85.8)	85.6 (82.8–88.1)
Multiple gestation	32.3 (29.9–34.9)	93.3 (92.1–94.3)	77.2 (73.6–80.6)	66.1 (64.3–67.9)
Fibroids	26.2 (23.1–29.6)	97.7 (96.8–98.4)	84.3 (78.9–88.7)	73.7 (71.7–75.6)

	Sensitivity % (95% CI)	**Specificity % (95% CI)**	**PPV % (95% CI)**	**NPV % (95% CI)**
Stillbirth	9.1 (0.2–41.3)	100 (86.8–100)	100 (2.5–100)	72.2 (54.8–85.8)
Placenta previa	36.9 (32.3–41.6)	93.4 (91–95.3)	81.3 (75.1–86.6)	65.5 (62.1–68.8)
Preeclampsia	32.9 (29.8–36)	93.8 (92.7–94.8)	68.2 (63.6–72.6)	77.6 (76–79.2)
Induction of Labor	36.1 (33.8–38.3)	95.3 (94.6–96)	77.7 (74.7–80.5)	76.8 (75.5–77.9)
Labor	30.2 (29–31.5)	96.7 (96.3–96.9)	77.5 (75.6–79.2)	78.4 (77.8–79)
Prolonged labor	43.1 (37.6–48.7)	92.6 (90.2–94.6)	76.1 (69.3–82.1)	74.9 (71.6–78)
Chorioamnionitis	42.6 (39.9–45.3)	92.9 (91.7–94)	79.8 (76.6–82.7)	71.1 (69.3–72.8)
Polyhydramnios	21.6 (12.9–32.7)	93.3 (88.8–96.4)	55.2 (35.7–73.6)	75.7 (69.8–81)
Antepartum hemorrhage	37.3 (32.9–41.8)	92.6 (90.5–94.4)	76.9 (70.8–82.2)	69.2 (66.2–72.1)
Placental abruption	34.3 (28.2–40.9)	93.7 (91–95.7)	73.8 (64.4–81.9)	73.2 (69.4–76.8)
Coagulopathy	62.6 (54–70.6)	88 (82.6–92.3)	79.1 (70.3–86.3)	76.5 (70.3–81.9)
Uterine rupture	33.9 (21.8–47.8)	91.4 (76.9–98.2)	86.4 (65.1–97.1)	46.4 (34.3–58.8)
Hysterectomy	85.2 (75.6–92.1)	0 (0–52.2)	93.2 (84.9–97.8)	0 (0–26.5)

CD = Cesarean Delivery; CI = Confidence Interval

Table 3

Unadjusted and Adjusted Odds Ratios for Correct Postpartum Hemorrhage Assignment with International Classification of Diseases Version 9 Codes.

	Unadjusted Odds Ratio (95% CI)	Adjusted Odds Ratio (95% CI)[a]
Maternal age (yr)		
<35	Reference	Reference
≥35	0.6 (0.81 – 0.91)	**0.89 (0.84 – 0.94)**
Race/ethnicity		
White	Reference	Reference
Black	0.85 (0.77 – 0.94)	**0.88 (0.80 – 0.97)**
Hispanic	0.95 (0.89 – 1.02)	0.93 (0.87 – 1.00)
Asian	0.91 (0.86 – 0.98)	0.94 (0.87 – 1.00)
Other	0.93 (0.77 – 1.12)	0.96 (0.79 – 1.16)
Unknown	0.89 (0.70 – 1.13)	0.87 (0.68 – 1.10)
Obesity	0.86 (0.81 – 0.92)	**0.83 (0.78 – 0.89)**
Chronic anemia	0.80 (0.76 – 0.85)	**0.85 (0.80 – 0.90)**
Gestational age at delivery (wks)		
<37	0.82 (0.77 – 0.89)	**1.25 (1.14 – 1.36)**
37–41	Reference	Reference
>41	0.78 (0.71 – 0.86)	**0.84 (0.76 – 0.93)**
Grand multiparity	0.74 (0.47 – 1.17)	-
Number of prior CD		
0	Reference	Reference
1	1.26 (1.18 – 1.35)	1.04 (0.97 – 1.12)
≥2	1.44 (1.18 – 1.77)	1.15 (0.94 – 1.42)
Multiple gestation	0.48 (0.44 – 0.52)	**0.44 (0.40 – 0.48)**
Fibroids	0.71 (0.64 – 0.78)	
Stillbirth	0.66 (0.32 – 1.36)	0.79 (0.37 – 1.66)
Placenta previa	0.52 (0.45 – 0.60)	**0.53 (0.45 – 0.63)**
Preeclampsia	0.77 (0.70 – 0.84)	**0.82 (0.75 – 0.90)**
Induction of Labor	0.78 (0.73 – 0.83)	**0.89 (0.82 – 0.96)**
Labor	0.75 (0.71 – 0.79)	**0.87 (0.82 – 0.93)**
Prolonged labor	0.73 (0.63 – 0.85)	**0.85 (0.73 -0.99)**
Chorioamnionitis	0.63 (0.58 – 0.68)	**0.64 (0.58 – 0.70)**
Polyhydramnios	0.68 (0.51 – 0.89)	**0.68 (0.52 – 0.90)**
Antepartum hemorrhage	0.58 (0.51 – 0.65)	**0.67 (0.53 – 0.84)**
Placental abruption	0.67 (0.60 – 0.79)	0.97 (0.73 – 1.28)
Coagulopathy	0.83 (0.64 – 1.08)	-
Uterine rupture	0.31 (0.20 – 0.47)	**0.32 (0.21 – 0.49)**

	Unadjusted Odds Ratio (95% CI)	Adjusted Odds Ratio (95% CI)[a]
Hysterectomy	0.99 (0.58 – 1.69)	-

CD = Cesarean Delivery; CI = Confidence Interval

[a] Statistically significant associations in the multivariable model are denoted by bold text.