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Accuracy of postpartum hemorrhage coding in the Swedish Pregnancy Register

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Abstract

Introduction: Postpartum hemorrhage (PPH) is recognized as a leading cause of obstetric morbidity and mortality. Population-wide studies have used International Classification of Diseases (ICD) diagnostic codes to track and report the prevalence of PPH. Although the 10th revision (ICD-10) was introduced in Sweden in 1997, the accuracy of ICD-10 codes for PPH is not known. Thus, the aim was to determine the accuracy of diagnostic coding for PPH in the Swedish Pregnancy Register.

Material and methods: We performed a retrospective cohort study of 609 807 deliveries in Sweden between 2014 and 2019. Information on ICD-10 codes for PPH and estimated blood loss were extracted from the Swedish Pregnancy Register. Using an estimated blood loss >1000 mL as the reference standard, we evaluated the diagnostic accuracy of ICD-10 codes for PPH by estimating sensitivity, specificity, positive predictive value and negative predictive value with exact binomial 95% confidence intervals (CIs). In our secondary analysis, we assessed the ICD-10 coding accuracy for severe PPH, defined as an estimated blood loss >1000 mL and transfusion of at least 1 unit of red blood cells registered in the Scandinavian Donations and Transfusion database.

Results: Of the 609 807 deliveries, 43 312 (7.1%) had an ICD-10 code for PPH and 45 071 (7.4%) had an estimated blood loss >1000 mL. The ICD codes had a sensitivity of 88.5% (95% CI 88.2-88.7), specificity of 99.4% (95% CI 99.4-99.4), positive predictive value of 92.0% (95% CI 91.8-92.3) and negative predictive value of 99.1% (95% CI 99.1-99.1). In our secondary analysis, on deliveries with severe PPH, the sensitivity for an ICD code was 91.3% (95% CI 90.7-91.9), whereas specificity was 83.5% (95% CI 82.3-84.6).

Conclusions: Our findings indicate that ICD-10 codes for PPH in Sweden have moderately high sensitivity and excellent specificity. These results suggest that PPH diagnostic codes in medical records and linked pregnancy and birth registers can be used for research, quality improvement and reporting PPH prevalence in Sweden.

Abbreviations: CI, confidence interval; EBL, estimated blood loss; EMR, electronic medical records; ICD-10, International Classification of Diseases, 10th Revision; PPH, postpartum hemorrhage; RBC, red blood cell; SCANDAT, Scandinavian Donations and Transfusions.

KEYWORDS

blood transfusion, cesarean section, data accuracy, delivery, obstetric, postpartum hemorrhage, sensitivity and specificity, third labor stage, validation study

1 | INTRODUCTION

Postpartum hemorrhage (PPH) is among the leading causes of maternal morbidity and mortality worldwide.[1] The prevalence of PPH has increased over time in several high-income countries such as Canada, Ireland, USA and Sweden.[2-5] Consequently, efforts to better understand the reasons behind this increase are an international public health priority.[6]

Population-wide studies have relied on administrative (billing) data, notably International Classification of Diseases, 9th revision (ICD-9) codes, to report temporal trends in PPH.[4,7,8] In a US population-wide cohort, ICD-9 codes for PPH had low sensitivity (27.8%) and high specificity (97%).[9] However, the accuracy of the International Classification of Diseases, 10th revision (ICD-10) codes for PPH is poorly reported.

The ICD-10 was introduced in Sweden in 1997 and by 2015, all industrialized countries had transitioned from using the ICD-9 to the ICD-10 system.[10,11] Examining the accuracy and reliability of ICD-10 codes is important for several reasons. These codes are useful for monitoring national and international trends in perinatal mortality and morbidity as well as the impact of safety bundles and quality improvement strategies.[12] From an epidemiological standpoint, studies examining the accuracy of ICD codes are needed to ensure that policymakers and researchers make valid inferences from these data.

Sweden is known for keeping high-quality clinical data in population-based registries including the Swedish Medical Birth Register (held by the National Board of Health and Welfare) and the Swedish Pregnancy Register (a quality register administered by antenatal and maternal clinics).[13,14] Since the Pregnancy Register contains blood loss data recorded at and after delivery, researchers are able to evaluate the ICD-10 coding accuracy for PPH against a reference standard, defined (in Sweden) as an estimated blood loss (EBL) >1000 mL.[15]

Thus, the primary aim of our study was to determine the accuracy of ICD-10 codes for PPH (O72 and O67.8) in Sweden. Further, we aimed to investigate whether the diagnostic accuracy varies by obstetric and maternal characteristics or severity of PPH, or if there is regional or temporal variation.

Key message

Using estimated blood loss >1000 mL as the reference standard, ICD-10 codes for postpartum hemorrhage in Sweden have moderate-to-high accuracy with a sensitivity of 88.5% and specificity of 99.4%.

2 | MATERIAL AND METHODS

We performed a retrospective nationwide cohort study of 611 936 deliveries that occurred in Sweden between 1 January 2014 and 31 December 2019. Data were extracted from the Swedish Pregnancy Register, established in 2013, which currently includes approximately 92% of births in Sweden.[13] The register contains detailed information on the pregnant women prospectively entered into the electronic medical records (EMR) by midwives and physicians in a standardized way at the first antenatal visit and at every subsequent visit, including ultrasound examination, delivery and postnatal care visits.[13] The register also includes ICD-10 codes, procedure codes and EBL data associated with each delivery. We excluded deliveries with missing EBL data or an EBL <50 mL. The final study cohort consisted of 609 807 deliveries (Figure 1).

2.1 | PPH reference standard

Based on guidelines from the Swedish Society of Obstetrics and Gynecology, the reference standard for PPH was based on an EBL >1000 mL and ICD-10 codes for PPH at discharge were identified.[15] EBL measurement approaches differ according to mode of delivery. For women who underwent vaginal delivery, EBL was recorded by the delivering midwife in two fields in the EMR; EBL until delivery of the placenta and EBL until 2 hours after delivery of the placenta. For cesarean deliveries, EBL was measured from the volume of blood contained in the suction canisters and surgical sponges. The intraoperative EBL was then reported to the midwife who manually entered EBL data together with the postoperative blood loss (until 2 hours after delivery) in the EMR. In Swedish delivery clinics, the recording and checking of diagnostic codes can be assigned to a midwife, an obstetrician or an administrative staff member.

2.2 | ICD codes for PPH

The ICD-10 code for PPH is O72 with the following subtypes: O72.0 (before delivery of the placenta) and O72.1 (after delivery of the placenta). In the Swedish version of ICD-10 (hereafter referred to as ICD-10SE), O72.1 can be further specified as O72.1A (atony), O72.1B (trauma) or O72.1X (not otherwise specified).[15] Delayed PPH, which occurs more than 2 hours after delivery of the placenta, is coded as O72.2 and is independent of EBL volume. Because the reference standard was an EBL >1000 mL up to 2 hours after delivery, deliveries associated with an O72.2 code and no other ICD code for PPH were classified as not being coded for PPH. The ICD-10 SE code O67.8 is defined as "excessive hemorrhage during cesarean section/

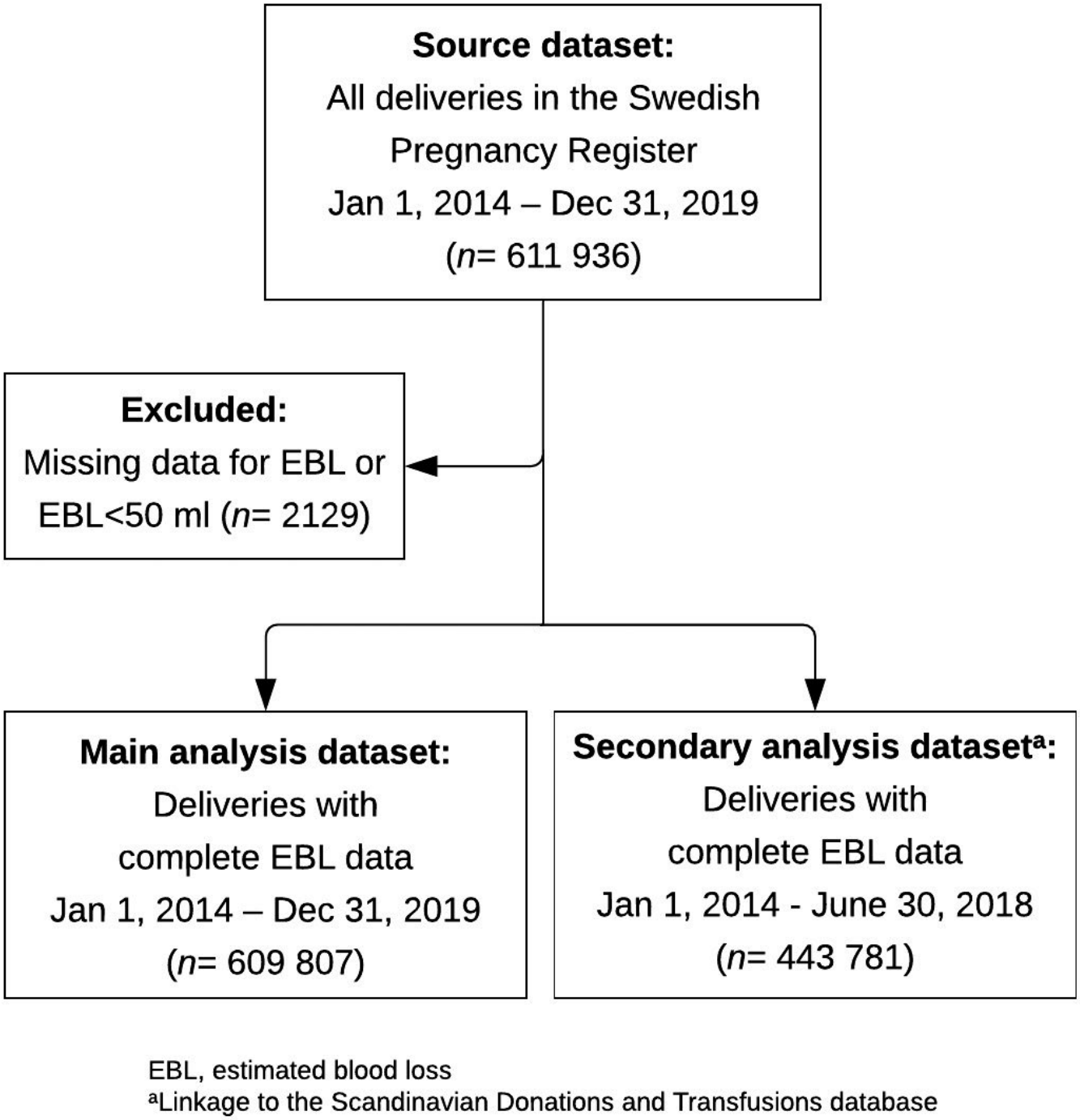

FIGURE 1 Derivation of study cohort and subcohort

perioperative hemorrhage >1000 mL". This code was included as a PPH code in our analysis. To summarize, a patient was deemed to have an ICD code for PPH if any of the following codes were present: O72.0, O72.1 (A, B, X) or O67.8.

Maternal and obstetric characteristics were retrieved, including: body mass index, smoking habits at first visit to antenatal care, parity, maternal age at delivery, gestational age at delivery, onset of labor, mode of delivery, infant birthweight, year and region of delivery. Diagnostic and procedure codes for preeclampsia, postpartum anemia, epidural analgesia and oxytocin augmentation were also collected (Table S1).

The Scandinavian Donations and Transfusions (SCANDAT) database contains data on virtually all transfusions in Sweden since 1966.[16] Data from the Swedish Pregnancy Register and the SCANDAT database were linked from 1 January 2014 to 30 June 2018 using the Swedish personal identification number to identify blood transfusions adjacent to delivery (plus/minus 7 days).[17] Women who did not have a personal identification number at delivery (immigrants without citizenship, unidentified women and foreign citizens) were excluded. The subcohort consisted of 443 781 deliveries (Figure 1).

2.3 | Statistical analysis

To assess the diagnostic accuracy of ICD codes for PPH where EBL was >1000 mL, we calculated the sensitivity, specificity, positive predictive value and negative predictive value with exact binomial 95% confidence intervals (CIs) for all deliveries in the cohort (for calculation matrix, see Table S2).

2.4 | Sensitivity analyses

We conducted a set of sensitivity analyses to assess the robustness of our results. First, coding accuracy was examined after stratifying by maternal and obstetric characteristics, mode of delivery and year of delivery. Then, we assessed geographical variations in accuracy per region of delivery. Next, we assessed coding accuracy if the ICD-10 SE code for delayed PPH (O72.2) was accounted for in our set of ICD-10 codes for PPH.

Lastly, to increase the generalizability and comparability of our estimates, we carried out analyses using the more conventional definition of EBL ≥1000 mL. This was done because international definitions of PPH tend to include cut-off criteria of either ≥500 or ≥1000 mL, whereas in Sweden, PPH is defined using the less common criterion of EBL >1000 mL.[15,18,19] This sensitivity analysis was done in three steps. First, we determined the prevalence of deliveries with EBL equal to 1000 mL and the extent to which these deliveries were coded as PPH. Secondly, we evaluated the increase in PPH prevalence if PPH was redefined as EBL ≥1000 mL. Lastly, we estimated sensitivity and specificity of PPH coding using the modified EBL standard (≥1000 mL) compared with the original standard (>1000 mL). The underlying assumption was that coders assumed that EBL = 1000 mL was included in the definition of PPH and thereby an increase in specificity would occur when redefining PPH as EBL ≥1000 mL (since EBL = 1000 mL and an associated PPH code would no longer be considered as false positive).

2.5 | Secondary analysis

In an effort to evaluate whether coding accuracy was modified by severity of PPH, we estimated the accuracy of PPH diagnostic codes in the subcohort, defining severe PPH as EBL >1000 mL and a blood transfusion of at least 1 unit of red blood cells (RBC) and ≥4 units of RBCs in the SCANDAT database.

All statistical analyses were performed using the SAS software version 9.4 (SAS Institute).

2.6 | Ethical approval and consents

The study was approved by the regional ethics committee, Karolinska Institutet, Stockholm, Sweden, 11 January 2018 (DNR 2017/2385-31/5) and on 27 March 2018 (DNR 2018/601-32). On 11 March 2020, an amendment of the application for the inclusion of data on blood transfusions from the SCANDAT database was approved by the Swedish Ethical Review Authority (DNR 2020-00841).

3 | RESULTS

Of the 609 807 deliveries, 43 312 (7.1%) had an ICD-10 code for PPH and 45 071 (7.4%) an EBL >1000 mL. The EBL was ≥500 mL in 35.1% (n = 213 923) of deliveries (for distribution of EBL, see Table S3). The characteristics of deliveries with and without an ICD-10 code for PPH are presented in Table 1. Almost half (49.8%) of vaginal deliveries with PPH were specified as due to atony, whereas the majority of cesarean deliveries (82.3%) with PPH were specified as O67.8 (i.e. excessive hemorrhage during cesarean section >1000 mL; Table 2).

The performance characteristics of ICD-10 codes for PPH are presented in Table 3. The overall accuracy was high, with a sensitivity of 88.5% (95% CI 88.2-88.7). The positive predictive value of a PPH diagnosis was 92.0% (95% CI 91.8-92.3), specificity was 99.4% (95% CI 99.4-99.4) and the negative predictive value was 99.1% (95% CI 99.1-99.1).

3.1 | Sensitivity analyses

When stratified by mode of delivery, the sensitivity was highest in spontaneous vaginal delivery (92.9%; 95% CI 92.6-93.2) and lowest in emergency cesarean delivery (78.3%; 95% CI 77.4-79.1). The diagnostic accuracy was not altered by other maternal or obstetric characteristics (Table 3). The only exception was in deliveries with a diagnosis of postpartum anemia, where sensitivity for PPH was higher (94.2%; 95% CI 93.9-94.5% vs 82.6%; 95% CI 82.1-83.1) and specificity lower (93.0%; 95% CI 92.7-93.3% vs 99.7%; 95% CI 99.7-99.7) compared with deliveries without the code for postpartum anemia (data available upon request).

There were geographical variations in coding accuracy, with sensitivity ranging from 51.7% (95% CI 48.7-54.6) in the Gävleborg region to 93.4% (95% CI 93.0-93.8) in the Stockholm region. When including the ICD-10 SE code O72.2, the sensitivity slightly increased for all deliveries (89.2%; 95% CI 89.0-89.5) but specificity was virtually unchanged (99.0%; 95% CI 99.0-99.0) (data available upon request).

Of deliveries with EBL equal to 1000 mL (n = 4851), 28.9% had an ICD-10 code for PPH. The prevalence of EBL ≥1000 mL was 8.2% (95% CI 8.1-8.3), 11.1% higher than the prevalence of EBL >1000 mL (7.4%, 95% CI 7.3-7.5). When redefining the volume criteria for PPH to EBL ≥1000 mL, the specificity was practically unchanged (99.6%; 95% CI 99.6-99.7), whereas the sensitivity was lower (82.7%; 95% CI 82.3-83.0) compared with using the standard definition of >1000 mL.

3.2 | Secondary analysis

In the subcohort, the prevalence of transfusion of at least 1 unit of RBCs was 2.9% (95% CI 2.9-2.9) among all deliveries and 27.3% (95%

TABLE 1 Characteristics of vaginal and cesarean deliveries without and with an ICD-10 SE diagnostic code for postpartum hemorrhage. Data from the Swedish Pregnancy Register (2014-2019)

Characteristics	Deliveries without PPH diagnosis (n)	%	Deliveries with PPH diagnosis (n)	%
Total n = 609 807	566 495	92.9	43 312	7.1
Age (years)				
≤24	69 197	12.2	4302	9.9
25-34	372 691	65.8	27 795	64.2
35-39	100 250	17.7	8681	20.1
≥40	24 176	4.3	2529	5.8
Missing	181		5	
BMI (kg/m^2)				
Underweight (<18.5)	12 744	2.5	775	1.9
Normal weight (18.5-24.9)	295 734	57.0	21 681	54.4
Overweight (25.0-29.9)	136 297	26.3	11 030	27.7
Obese (30+)	74 345	14.3	6406	16.1
Missing	47 375		3420	
Current smoker at 1st antenatal care visit	25 034	5.0	1534	4.0
Missing	66 003		4476	
Parity				
Nulliparous	231 947	41.9	21 446	50.5
Multiparous				
No previous cesarean section	264 746	47.8	15 939	37.5
Previous cesarean section	57 212	10.3	5112	12.0
Missing	12 590		815	
Preeclampsia [a]	16 126	2.9	2280	5.3
Multifetal pregnancy	6975	1.2	1632	3.8
Gestational age at delivery, weeks				
Preterm (<37)	31 435	5.6	2679	6.2
Term (37-41+6)	505 357	89.2	36 796	85.0
Post term (≥42+0)	29 700	5.2	3837	8.9
Missing	3		0	
Onset of labor				
Spontaneous	424 008	74.9	28 409	65.6
Induction	102 054	18.0	10 943	25.3
Planned cesarean section	40 433	7.1	3960	9.1
Epidural analgesia [a,b]	183 117	34.8	17 626	44.8
Intrapartum oxytocin augmentation [a,c]	125 221	29.5	12 367	43.5
Mode of delivery				
Spontaneous vaginal	443 325	78.3	27 982	64.6
Instrumental vaginal	29 058	5.1	3644	8.4
Cesarean section				
Planned cesarean section	40 433	7.1	3960	9.1
Emergency cesarean section	53 678	9.5	7726	17.8
Episiotomy [d]	19 823	4.2	2205	7.0
Birthweight >4500 g	16 094	2.9	2957	6.8
Missing	1578		70	
Postpartum anemia [a]	24 992	4.4	23 145	53.4

Note: Values presented as n, %.

Abbreviations: BMI, body mass index; ICD-10, International Classification of Diseases 10th revision; PPH, postpartum hemorrhage; SE, Swedish version.

[a]According to ICD-10 SE or the Swedish Classification of Health Interventions, see Table S1.

[b]Among women with spontaneous onset of labor or labor induction, n = 565 414.

[c]Among women with spontaneous onset of labor n = 452 417.

[d]Among women with vaginal delivery, n = 504 010.

TABLE 2 Subtypes of postpartum hemorrhage according to ICD-10 SE codes, stratified by mode of delivery

Subtypes	Vaginal delivery with an ICD-10 code for PPH (n)	%	Cesarean delivery with an ICD-10 code for PPH (n)	%
Atony	15 754	49.8	1049	9.0
Placental retention	8412	26.6	44	0.4
Trauma	3078	9.7	56	0.5
Not otherwise specified [a]	4382	13.9	917	7.9
Excessive hemorrhage during CS	NA	NA	9620	82.3
Total n = 43 312	31 626		11 686	

Note: Values presented as n, %.

Abbreviations: CS, cesarean section; ICD-10, International Classification of Diseases 10th revision; NA, not applicable; PPH, postpartum hemorrhage; SE, Swedish version.

For ICD-10 SE codes see Table S1.

[a]Deliveries with more than one specific code were classified as not otherwise specified.

CI 26.8-27.8) among deliveries with an ICD code for PPH. Sensitivity for PPH was 91.3% (95% CI 90.7-91.9) and specificity was 83.5% (95% CI 82.3-84.6) for deliveries with at least 1 unit of RBC transfusion and 88.0% (95% CI 87.6-88.4) and 99.6% (95% CI 99.6-99.6), respectively, for deliveries without a transfusion. For deliveries accompanied by transfusion of ≥4 units of RBCs, sensitivity for PPH was 90.3% (95% CI 88.9-91.6) and specificity was 73.6% (95% CI 69.8-77.1) (Table 4).

4 | DISCUSSION

In this large cohort study of deliveries in the Swedish Pregnancy Register, we observed that ICD-10 codes for PPH were reported with moderately high sensitivity and excellent specificity. The accuracy was not importantly modified by maternal characteristics. The sensitivity for a PPH diagnosis increased if the women had received transfusion of at least 1 unit of RBCs.

Population-based registers containing routinely collected health data are valuable resources from both an epidemiological and a public health point of view. Validated birth and pregnancy registers allow quality improvement in perinatal care and facilitate retrospective studies and registry-based randomized controlled trials.[20] In the era of Big Data, medical researchers and health authorities have become increasingly dependent on the ICD-coding system for tracking patterns in obstetric-related morbidities. To ensure that prevalence estimates of PPH are accurate, there is a critical need to assess the accuracy of ICD codes for PPH. Our study results suggest that the ICD-10 codes for PPH are very accurate in Sweden, which is reassuring, since these codes can hereafter be used as substitutes if EBL data are not available.

In 2018, Butwick et al[9] analyzed the accuracy of ICD-9 codes for PPH after cesarean delivery in a US setting and found a low sensitivity for PPH (27.8%) when using EBL ≥1000 mL as the reference standard, suggesting that PPH rates after cesarean delivery in this setting were largely underestimated. The sensitivity for PPH in our study was poorer in cesarean deliveries than in vaginal deliveries, although still high in comparison with the study by Butwick et al.[9] This variability is rather surprising, since it could be expected that when abstracting information from medical records after complicated hospital stays, such as an emergency cesarean delivery, coders would be more, not less, disposed to search for secondary diagnoses.

Among vaginal deliveries, the midwife is in charge of measuring and reporting the EBL in the EMR. This differs from cesarean deliveries where the obstetrician (and operating room staff) are responsible for (a) estimating the intraoperative blood loss, (b) entering this data in a cesarean delivery-template in the EMR and (c) communicating this information to the midwife. These data are subsequently combined with the postoperative blood loss (occurring in the postanesthetic care unit or back in the delivery ward) and manually transferred to the EBL field in the EMR by the midwife in charge, which increases the risk of transcription error.[21] This makes data on EBL in cesarean delivery less reliable than in vaginal delivery. The same reasoning can be applied to other obstetric procedures for managing severe PPH, including laceration repair and manual placental removal.

PPH diagnostic accuracy was not significantly modified by the majority of maternal and obstetric characteristics. The only exceptions were in deliveries accompanied by a diagnosis of postpartum anemia or RBC transfusion, where specificity for PPH was lower if a woman had anemia or had been transfused. A possible explanation for this finding is that coders are more likely to code for PPH when RBCs are transfused, irrespective of the indication for transfusion. Since clinicians are aware that estimates of blood loss are unreliable, these findings could indicate an underestimation and convince the clinician to diagnose PPH despite EBL <1000 mL. Of note, both the laboratory testing of hemoglobin levels and the diagnostic coding for postpartum anemia required for this diagnosis are more likely to be performed among women who have suffered from PPH, and the ICD-10 code for postpartum anemia has not been validated against laboratory values. An interesting finding was that the specificity for PPH was lower when comparing deliveries with transfusion of ≥4 units of RBCs as compared with deliveries with ≥1 unit transfused, indicating more false positives. Since it is highly unlikely, unless the

TABLE 3 Prevalence and accuracy of ICD-10 SE codes for postpartum hemorrhage with estimated blood loss >1000 mL as reference standard, stratified by maternal and obstetric characteristics and by calendar year. Data from the Swedish Pregnancy Register (2014-2019)

Characteristics	PPH prevalence (95% CI)	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)
All deliveries	7.1 (7.0-7.2)	88.5 (88.2-88.7)	99.4 (99.4-99.4)	92.0 (91.8-92.3)	99.1 (99.1-99.1)
Age (years)					
<30	6.4 (6.3-6.5)	88.4 (87.9-88.9)	99.4 (99.4-99.4)	91.2 (90.8-91.6)	99.2 (99.2-99.2)
≥30	7.7 (7.6-7.7)	88.5 (88.1-88.8)	99.4 (99.4-99.4)	92.6 (92.3-92.9)	99.0 (99.0-99.0)
Obesity	7.9 (7.7-8.1)	85.3 (84.5-86.2)	99.3 (99.2-99.4)	91.9 (91.2-92.5)	98.6 (98.6-98.7)
Gestational age, weeks					
Preterm (<37)	7.9 (7.6-8.1)	80.8 (79.3-82.2)	99.3 (99.2-99.4)	92.2 (91.1-93.2)	98.1 (98.0-98.3)
Term (37-41+6)	6.8 (6.7-6.9)	89.1 (88.7-89.4)	99.4 (99.4-99.4)	91.9 (91.6-92.2)	99.2 (99.2-99.2)
Post term (≥42+0)	11.4 (11.1-11.8)	88.5 (87.5-89.5)	99.1 (99.0-99.2)	93.1 (92.2-93.9)	98.4 (98.3-98.6)
Parity					
Nulliparous	8.5 (8.4-8.6)	88.8 (88.4-89.2)	99.3 (99.3-99.3)	92.4 (92.1-92.8)	98.9 (98.9-99.0)
Multiparous, no previous CS	5.7 (5.6-5.8)	89.4 (88.9-89.8)	99.5 (99.5-99.5)	91.4 (90.9-91.8)	99.4 (99.3-99.4)
Multiparous with previous CS	8.2 (8.0-8.4)	84.2 (83.3-85.2)	99.3 (99.3-99.4)	92.6 (91.9-93.4)	98.5 (98.4-98.6)
Multifetal pregnancy	19.0 (18.1-19.8)	84.1 (82.3-85.7)	98.6 (98.3-98.9)	94.2 (93.0-95.3)	95.8 (95.3-96.3)
Preeclampsia	12.4 (11.9-12.9)	85.4 (83.9-86.8)	98.6 (98.4-98.8)	90.3 (89.0-91.5)	97.8 (97.6-98.0)
Onset of labor					
Spontaneous onset	6.3 (6.2-6.4)	89.9 (89.5-90.2)	99.4 (99.4-99.5)	91.5 (91.1-91.8)	99.3 (99.3-99.3)
Induction	9.7 (9.5-9.9)	88.1 (87.5-88.7)	99.2 (99.1-99.2)	92.5 (92.0-93.0)	98.7 (98.6-98.7)
Mode of delivery					
Spontaneous vaginal	5.9 (5.9-6.0)	92.9 (92.6-93.2)	99.4 (99.4-99.5)	91.1 (90.7-91.4)	99.6 (99.5-99.6)
Instrumental vaginal	11.1 (10.8-11.5)	90.9 (89.9-91.8)	98.8 (98.6-98.9)	90.2 (89.2-91.1)	98.9 (98.7-99.0)
Cesarean section	11.0 (10.9-11.2)	79.0 (78.4-79.7)	99.4 (99.3-99.4)	94.9 (94.5-95.3)	96.9 (96.8-97.0)
Planned CS	8.9 (8.7-9.2)	80.5 (79.4-81.7)	99.5 (99.4-99.6)	95.0 (94.3-95.6)	97.8 (97.6-97.9)
Emergency CS	12.6 (12.3-12.8)	78.3 (77.4-79.1)	99.2 (99.2-99.3)	94.9 (94.4-95.4)	96.2 (96.1-96.4)
Year of delivery					
2014	7.1 (6.9-7.3)	89.7 (88.9-90.4)	99.3 (99.3-99.4)	91.0 (90.3-91.7)	99.2 (99.1-99.3)
2015	7.0 (6.8-7.2)	88.8 (88.1-89.5)	99.4 (99.4-99.5)	92.4 (91.8-93.0)	99.1 (99.1-99.2)
2016	7.1 (7.0-7.3)	89.1 (88.4-89.8)	99.4 (99.4-99.5)	92.4 (91.8-93.0)	99.1 (99.1-99.2)
2017	6.9 (6.8-7.1)	87.7 (86.9-88.4)	99.4 (99.3-99.4)	91.8 (91.2-92.5)	99.0 (99.0-99.1)
2018	7.3 (7.2-7.5)	89.0 (88.3-89.7)	99.4 (99.4-99.5)	92.5 (91.9-93.1)	99.1 (99.0-99.2)
2019	7.1 (7.0-7.3)	86.6 (85.9-87.4)	99.4 (99.3-99.4)	91.9 (91.3-92.6)	98.9 (98.9-99.0)

Note: Values presented in percentages (95% CI).

Abbreviations: CI, confidence interval; CS, cesarean section; ICD-10, International Classification of Diseases 10th revision; NPV, negative predictive value; PPH, postpartum hemorrhage; PPV, positive predictive value; SE, Swedish version.

source of bleeding is somewhere outside the uterus/birth canal, that a woman requiring repeated transfusions as such at delivery/in the postpartum period has an EBL <1000 mL, this is likely to be caused by (a) an underestimation of EBL, (b) inaccurate reporting of EBL to the EMR by the midwife or (c) blood loss occurring more than 2 hours after delivery.

Since the reliability in EBL measurements has been questioned, attempts have been made to provide a more clinically oriented definition of severe PPH using an addition of blood transfusion and hysterectomy as proxies for severity.[4] It has been reported that the obstetric coding accuracy improves when the diagnosis is based on documented procedures or laboratory findings.[22] However, this approach has limitations, as transfusion practices vary widely and the need for RBC transfusion may be increased if women have moderate-to-severe antepartum anemia close to delivery.[23] If PPH was to be defined using postpartum transfusion, PPH rates in groups with high prevalence of severe, antenatal iron-deficiency anemia would be overestimated. Conversely, in settings where linkage with transfusion databases is not possible, investigators would have to rely on transfusion variables and procedure codes, which might underestimate rates of blood transfusion.[24]

TABLE 4 Prevalence and accuracy of ICD-10 SE codes for postpartum hemorrhage with estimated blood loss >1000 mL as reference standard for deliveries with and without red blood cell transfusion. Linked data from the Swedish Pregnancy Register and the Scandinavian Donations and Transfusions database (2014-2018)

Deliveries	PPH prevalence (95% CI)	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)
All	7.1 (7.0-7.2)	88.9 (88.5-89.2)	99.4 (99.4-99.4)	92.2 (91.9-92.5)	99.1 (99.1-99.1)
Without RBC transfusion	5.3 (5.3-5.4)	88.0 (87.6-88.4)	99.6 (99.6-99.6)	92.3 (92.0-92.7)	99.3 (99.3-99.3)
With transfusion of ≥1 unit of RBCs	67.0 (66.1-67.8)	91.3 (90.7-91.9)	83.5 (82.3-84.6)	92.0 (91.4-92.5)	82.2 (81.0-83.3)
With transfusion of ≥4 units of RBCs	75.3 (73.6-77.0)	90.3 (88.9-91.6)	73.6 (69.8-77.1)	91.7 (90.4-92.9)	70.1 (66.3-73.7)

Note: Subcohort of deliveries 2014-2018, total n = 443 781 (see Figure 1). RBC transfusion = registered transfusion of RBCs in the SCANDAT database ± 7 days to delivery. Values presented in percentages (95% CI).

Abbreviations: CI, confidence interval; ICD-10, International Classification of Diseases 10th revision; NPV, negative predictive value; PPH, postpartum hemorrhage; PPV, positive predictive value; RBC, red blood cells; SE, Swedish version.

The employee category responsible for coding, the amount of time allocated to this assignment and to what extent the clinic's payment system relies on ICD codes can influence coding practice. In the Stockholm region, coders are generally better trained, which may explain the high sensitivity for PPH compared with other regions. The Diagnostic-related group system is based largely on ICD codes and can be used as a prospective payment system and for planning of healthcare. The introduction of this system in Sweden was followed by an increase of diagnoses in regions with reimbursement methods based on Diagnostic-related groups. The first region to introduce this concept was the Stockholm region, which could, at least in part, explain the high coding accuracy in this area with a strong tradition of using the Diagnostic-related group system for healthcare reimbursement and management.[25] Since the diagnosis of PPH is volume-dependent, an automated ICD-coding for PPH in the EMR of deliveries with EBL >1000 mL could be a convenient approach to reduce misclassification.

The overall prevalence of PPH according to ICD-10 codes was high in our study: 7.1% in total and almost twice as high for cesareans as compared to spontaneous vaginal deliveries. However, it is somewhat problematic to compare rates of PPH between countries due to the large variations in definitions and coding practice for PPH. Nevertheless, a large proportion (nearly one-third of all deliveries) would have been diagnosed with PPH if the lower threshold of EBL ≥500 mL (World Health Organization definition of PPH) had been applied.[18] Future studies aiming to understand the reasons for these high rates of PPH in Sweden are warranted.

Among deliveries with EBL = 1000 mL, almost one-third had an ICD-10 code for PPH. Our sensitivity analysis showed that lowering the threshold for PPH to include EBL equal to 1000 mL resulted in an 11.1% increase in PPH prevalence (based on EBL). Since most deliveries (>70%) with EBL equal to 1000 mL did not have a PPH code, we found a slight decrease in sensitivity (due to more false negatives) when redefining the volume criteria to include EBL = 1000 mL, which suggests that coders were mostly aware of the cut-off criteria.

The strength of our study is its large study population derived from a high-quality register with a low proportion of missing data; only 0.3% from the source dataset had missing data on EBL. A limitation of the study is that we did not review medical records directly to collect data on EBL or ICD-10 codes. However, since the transfer of data from the EMRs to the Swedish Pregnancy Register is direct and transmitted electronically, the risk of error is minimal and data transfer has been validated locally at clinics.[13] Using the EMR-recorded EBL as reference standard requires this volume to have been correctly entered, yet this task can be performed under stressful circumstances, increasing the risk of transcription errors. However, we believe these assumed misclassifications to be nondifferential, biasing towards the null.

Since EBL was only recorded up until 2 hours after delivery of the placenta, the ICD-10 code for delayed/secondary PPH was excluded, which could mean that deliveries with EBL >1000 mL, only receiving this PPH code would be interpreted as false negatives, leading to a decreased sensitivity. However, in a sensitivity analysis, including this code only minimally improved sensitivity. Lastly, it is possible that the field in the EMR for EBL until delivery of the placenta could be interpreted as including intrapartum hemorrhages. In this case, women who experience major intrapartum hemorrhage (>1000 mL) would have EBL >1000 mL but no PPH code, which would be correct but would result in false negatives and a decreased sensitivity.

5 | CONCLUSION

ICD-10 codes for PPH, with EBL >1000 mL as reference standard, are accurate in the Swedish Pregnancy Register. Our results suggest that these diagnostic codes in Swedish EMRs and linked pregnancy and birth registers can be used both for quality improvement and for research when data on total EBL cannot be provided.

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CONFLICT OF INTEREST

None.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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