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The Nordic Obstetric Surveillance Study: a study of complete uterine rupture, abnormally invasive placenta, peripartum hysterectomy, and severe blood loss at delivery

LOTTE B. COLMORN[1], KATHRINE B. PETERSEN[2], MAIJA JAKOBSSON[3], PELLE G. LINDQVIST[4], KARI KLUNGSOYR[5], KARIN KÄLLEN[6,7], RAGNHEIDUR I. BJARNADOTTIR[8,9], ANNA-MAIJA TAPPER[10,11], PER E. BØRDAHL[12], KARIN GOTTVALL[6,13], LARS THURN[14], MIKA GISSLER[15,16], LONE KREBS[17,18] & JENS LANGHOFF-ROOS[1]

[1]Department of Obstetrics, Rigshospitalet Copenhagen University Hospital/University of Copenhagen, Copenhagen, [2]Fertility Clinic, Rigshospitalet Copenhagen University Hospital, Copenhagen, Denmark, [3]Department of Obstetrics and Gynecology, Helsinki University Central Hospital, Helsinki, Finland, [4]Clinitec, Karolinska Institute/Department of Gynecology and Obstetrics, Karolinska University Hospital, Stockholm, Sweden, [5]Department of Global Public Health and Primary Care, University of Bergen/Medical Birth Register of Norway, Norwegian Institute of Public Health, Bergen, Norway, [6]Epidemiology and Methodological Support Unit, Department of Evaluation and Analysis, National Board of Health and Welfare, Stockholm, [7]Department of Obstetrics and Gynecology, Institution of Clinical Sciences, University of Lund, Lund, Sweden, [8]Department of Obstetrics and Gynecology, Landspitali University Hospital, Reykjavik, [9]Icelandic Medical Birth Register, Reykjavik, Iceland, [10]Department of Gynecology and Pediatrics, Helsinki University Central Hospital, Helsinki, [11]Department of Gynecology and Obstetrics, Hyvinkää Hospital, Helsinki and Uusimaa district, Finland, [12]Haukeland Hospital, Bergen, [13]Department of Obstetrics and Gynecology, Haukeland University Hospital/University of Bergen, Bergen, Norway, [14]Department of Public Health Sciences, Karolinska Institute, Stockholm, [15]Karlskrona County Hospital, Karlskrona, Sweden, [16]THL National Institute for Health and Welfare, Helsinki, Finland, [17]Nordic School of Public Health, Gothenburg, Sweden, and [18]Department of Obstetrics and Gynecology, Holbæk Hospital/University of Copenhagen, Holbaek, Denmark

Key words
Abnormally invasive placenta, uterine rupture, multiple blood transfusions, postpartum hemorrhage, peripartum hysterectomy

Correspondence
Lotte B. Colmorn, Department of Obstetrics, Rigshospitalet Copenhagen University Hospital, Blegdamsvej 9, 2100 Copenhagen, Denmark.
E-mail: lotte.berdiin.colmorn@regionh.dk

Conflict of interest
The authors have stated explicitly that there are no conflicts of interest in connection with this article.

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Abstract

Objective. To assess the rates and characteristics of women with complete uterine rupture, abnormally invasive placenta, peripartum hysterectomy, and severe blood loss at delivery in the Nordic countries. *Design.* Prospective, Nordic collaboration. *Setting.* The Nordic Obstetric Surveillance Study (NOSS) collected cases of severe obstetric complications in the Nordic countries from April 2009 to August 2012. *Sample and methods.* Cases were reported by clinicians at the Nordic maternity units and retrieved from medical birth registers, hospital discharge registers, and transfusion databases by using International Classification of Diseases, 10th revision codes on diagnoses and the Nordic Medico-Statistical Committee Classification of Surgical Procedure codes. *Main outcome measures.* Rates of the studied complications and possible risk factors among parturients in the Nordic countries. *Results.* The studied complications were reported in 1019 instances among 605 362 deliveries during the study period. The reported rate of severe blood loss at delivery was 11.6/10 000 deliveries, complete uterine rupture was 5.6/10 000 deliveries, abnormally invasive placenta was 4.6/10 000 deliveries, and peripartum hysterectomy was 3.5/10 000 deliveries. Of the women, 25% had two or more complications. Women with complications were more often >35 years old, overweight, with a higher parity, and a history of cesarean delivery compared with the total population. *Conclusion.* The studied obstetric complications are rare. Uniform definitions and valid reporting are essential for international comparisons. The main risk factors include previous cesarean section. The detailed information collected in

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the NOSS database provides a basis for epidemiologic studies, audits, and educational activities.

Abbreviations: AIP, abnormally invasive placenta; CS, cesarean section; NOSS, Nordic Obstetric Surveillance Study.

Introduction

Severe complications at delivery are under-researched (1). The reasons for this are low numbers, interactions between different severe complications, problems of validity in reporting, and the need for appropriate denominators. In the Nordic Obstetric Surveillance Study (NOSS) we addressed these issues by simultaneous collection of information on four rare severe complications at delivery: complete uterine rupture, peripartum hysterectomy, abnormally invasive placenta (AIP), and severe blood loss at delivery (Table 1). The NOSS project is a population-based study that started in 2009 as a collaborative effort between obstetricians and the national birth registers in the five Nordic countries: Denmark, Finland, Iceland, Norway, and Sweden.

There is a continuum from severe maternal morbidity to maternal mortality. The study of women at high risk of dying ("maternal near-miss") can therefore provide valuable information on the management of obstetric emergencies in comparison with women who actually die, and this may eventually lead to improvements in the content of care. The World Health Organization has suggested that the rate of severe maternal morbidity should be used as an indicator for obstetric care in high-resource countries, rather than maternal mortality (2).

This article presents the rates of complete uterine rupture, peripartum hysterectomy, AIP, and severe blood loss at delivery and assesses possible risk factors noted in the Nordic countries.

Table 1. Definitions used for the four main conditions investigated.

Complication	Definition
Complete uterine rupture	Complete rupture of the myometrium, peritoneum, and fetal membranes
Peripartum hysterectomy	Acute hysterectomy within a week after delivery
Abnormally invasive placenta	Placenta assessed as accreta, increta, or pecreta by cesarean section, or Placenta assessed as accreta, increta, or percreta by vaginal delivery AND blood transfusion within 48 h of delivery
Severe hemorrhage at delivery	Severe blood loss resulting in red blood cell transfusion with ≥6 units within a week after delivery

Material and methods

Women with complete uterine rupture, peripartum hysterectomy, AIP, and severe blood loss at delivery measured by multiple blood transfusions (>5 units of red blood cells) were included from April 2009 to August 2012, with slightly different study periods between the countries (Table 2). A total of 135 maternity units participated. In Denmark, Finland, and Iceland all units participated, but in Norway and Sweden some units did not collect data, accounting for 12–21% of the background population (Table 2). All maternity units were invited, except in Norway, where 26 units with <500 deliveries/year were not included.

Trained clinicians at the Nordic maternity units reported cases by unified electronic data collection forms (http://www.enalyzer.dk), paper data collection forms, or a combination of both. Specific data forms were elaborated in consensus in the Nordic Federation of Societies of Obstetrics and Gynecology study group and detailed information about the collected variables can be found at http://www.NOSS.nu.

Individualized and anonymized data from Denmark, Iceland, and Norway were stored in an electronic database in Denmark, whereas data from Finland and Sweden were stored in local databases. Regular reminders were sent to the clinicians at the participating clinics to ensure complete reporting. Validation of the reported numbers was done by retrieving the relevant International Classification of Diseases, 10th revision codes on diagnoses and

Key Message

Complete uterine rupture, abnormally invasive placenta, peripartum hysterectomy, and severe blood loss at delivery are rare events, where clinicians should be prepared for emergency actions. The Nordic Obstetric Surveillance Study data can be used for educational efforts to improve management of these complications.

Table 2. Prevalence rates for complications by 10 000 deliveries (95% CI).

	Study period	Total deliveries (*n*)	Included deliveries		Complete uterine rupture			Peripartum hysterectomy			Abnormally invasive placenta			Severe hemorrhage at delivery		
			n	%	*n*	Rate	95% CI	*n*	Rate	95% CI	*n*	Rate	95% CI	*n*	Rate	95% CI
Denmark	Apr 2009 to Dec 2011	168 170	168 170	100	78	4.6	3.6–5.7	50	3.0	2.1–3.8	126	7.5	6.2–8.8	223	13.3	11.5–15.0
Finland	Apr 2009 to Aug 2011	145 546	145 546	100	116	8.0	6.5–9.4	74	5.1	3.9–6.2	58	4.0	3.0–5.0	143	9.8	8.2–11.4
Iceland	Sep 2009 to Aug 2011	9540	9540	100	5	5.2	1.7–12.2	4	4.2	1.1–10.7	1	1.0	0.03–5.8	8	8.4	3.6–16.5
Norway	Sep 2009 to Aug 2011	121 608	106 531	88	51	4.8	3.5–6.1	31	2.9	1.9–3.9	46	4.3	3.1–5.6	126	11.8	9.8–13.9
Sweden	Sep 2009 to Aug 2011	221 442	175 575	79	87	5.0	3.9–6.0	52	3.0	2.2–3.8	48	2.7	2.0–5.3			
All		666 306	605 362	91	337	5.6	5.0–6.2	211	3.5	3.0–4.0	279	4.6	4.1–5.1	500	11.6	7.5–9.0

Nordic Medico-Statistical Committee Classification of Surgical Procedure codes (http://www.nordclass.se/ncsp_e.htm) from the medical birth registers, the hospital discharge registers, and the transfusion databases in each country. Cases recorded in the registers but not reported to NOSS were confirmed by the hospitals and the requested data for the true cases were then reported retrospectively. In this way we cross-checked the registers and the reported information. In Norway we were not allowed to collect case reports with person-identifiable information and so it was not possible to compare this with the national registers. Therefore the clinicians were asked to compare the reported cases with information from the local hospital database to cross-check the reported information.

In Denmark and Iceland all cases with blood transfusions are recorded in national databases (http://www.dtdb.dk, http://www.blodbankinn.is) and we used this information to validate cases of severe blood loss at delivery. In Finland and Norway, information about transfusion is stored in local blood banks and is not easily accessible at a national level. Hence, validation of the reported cases of severe blood loss at delivery was not possible. Sweden did not collect information on women with severe blood loss at delivery as isolated events and Sweden was excluded from the denominator for this variable. The estimated blood loss at delivery and the number of blood transfusions were described for all cases of uterine rupture, peripartum hysterectomy, and AIP. The background population (denominators) otherwise comprised all women who delivered in the participating clinics during the study period. Data on denominators were collected from the Nordic medical birth registers and the hospital discharge registers (3,4).

Ethical approval was obtained in each country according to national legislation. In Denmark, the study was approved by the Danish Data Protection Agency, in Finland by the Ministry of Social Affairs and Health, in Sweden by the Central Ethical Board for Medical Research, in Norway by Regional Ethical committees, and in Iceland by the Directorate of Health and the National Bioethics Committee.

Statistical analysis

Data were managed in SAS Enterprise Guide 9.4 (SAS Institute, Cary, NC, USA) and Microsoft Office, Excel 2010 (Microsoft, Redmond, WA, USA). Prevalence rates are presented per 10 000 deliveries with exact 95% CI. Risks are presented as the odds of having a complication belonging to a specific subgroup, such as for the age group 30–34 years. Chi-squared and Fisher's exact tests were used to compare proportions and associations

between complications and risk factors, with a $p < 0.05$ considered significant.

Results

The NOSS study included 605 362 deliveries during a 2-year period, corresponding to 91% of all Nordic deliveries (n = 666 306). A total of 1019 cases were reported with one or more complications (19/10 000 deliveries). Severe blood loss at delivery was reported for 500 women (11.6/10 000 deliveries), complete uterine rupture was reported in 337 women (5.6/10 000 deliveries), AIP in 279 women (4.6/10 000 deliveries), and peripartum hysterectomy in 211 women (3.5/10 000 deliveries) (Table 2). The rates varied significantly between the Nordic countries: Finland had a significantly higher rate of complete uterine rupture and peripartum hysterectomy than Denmark, Norway, and Sweden (Table 2). Denmark had a significantly higher rate of AIP than the other Nordic countries and a significantly higher reported rate of severe blood loss at delivery than Finland. One maternal death was registered among the 1019 reported cases in NOSS.

One-fourth of the women had more than one complication. Of women with complete uterine rupture, 16% had other complications, most frequently severe blood loss at delivery (7%) or severe blood loss at delivery *and* peripartum hysterectomy (5%). AIP with other complications was reported in 49% of the cases, almost exclusively hemorrhage and hysterectomy (23%), or each of these alone (16% vs. 10%). Complete uterine rupture was seen in only 1% of all cases with AIP. Women with peripartum hysterectomy had other complications in 92% of the cases: 37% had severe blood loss at delivery, 13% had AIP, and 30% had a combination of both. Severe blood loss at delivery affected about 53% of all the women included and was the complication most often combined with any of the other complications (87%) (Figure 1).

More than half of all Nordic parturients during the study period had one or more previous deliveries, were between 25 and 34 years old and had a normal body mass index (BMI) (18.5–24.9 kg/m^2). Danish women were on average slightly older and Swedish women had a slightly higher BMI than women in the other countries. More than 75% of the parturients had a spontaneous vaginal delivery at term. The total rate of cesarean section (CS) was 18%, highest in Denmark (21%), and lowest in Iceland (15%). A history of previous CS was reported in 9% of all women and of these, 77% had an intended vaginal delivery with an estimated success rate of 64%. More details of the background population are shown in Table 3.

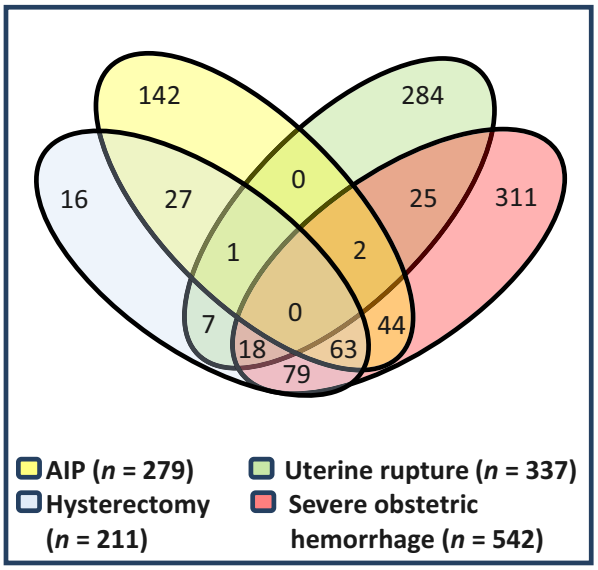

Figure 1. Overlap of complications. AIP, abnormally invasive placenta.

Age, number of previous deliveries, previous CS, mode of delivery, induction of labor, and gestational age were associated with all the studied complications. BMI was not associated with AIP and multiple pregnancy was not associated with complete uterine rupture (Table 4).

Approximately 60% of all cases were collected prospectively. In Sweden, all cases were reported prospectively from the clinicians and no additional cases were retrieved from the registers. In Finland about 80% and in Denmark and Norway about 50% and 60% of cases, respectively, were reported prospectively by clinicians. In Iceland all cases were collected retrospectively by use of the national registers. In Denmark some of the cases reported to NOSS were not reported with the relevant codes to the national health registers. In 13 of 78 (17%) reported cases of complete uterine rupture, 39 of 126 (31%) of AIP cases, and five of 50 (10%) cases of peripartum hysterectomy, the registration of the event was absent in the Danish National Discharge Register. From the Danish National Discharge Register we identified 377 women with a diagnosis of uterine rupture of whom 236 were observational diagnoses not confirmed clinically and 76 were incomplete ruptures with intact fetal membranes and/or peritoneum. AIP was registered in 129 women, where 12 were not confirmed by the medical records and 28 did not meet our definition. Peripartum hysterectomy was registered in 53 cases, where six women first had a hysterectomy after 7 days postpartum and two women had no peripartum hysterectomy at all. All cases that were not registered both into the NOSS project and in the national health registers were double-checked by asking

Table 3. Maternal characteristics of the background population in the Nordic countries.

Country	Denmark		Finland		Iceland		Norway		Sweden		Total	
Maternal characteristics[a]	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Age (years), mean (SD)	30.9 (5.0)		30.2 (5.3)		29.3 (5.5)		30.0 (5.2)		30.1 (5.3)			
<20	2410	1	3293	2	290	3	1761	2	2975	2	10 729	2
20–24	18 460	11	22 220	15	1584	17	14 643	14	24 713	14	81 620	13
25–29	50 817	30	46 605	32	3129	33	33 036	31	51 708	29	185 295	31
30–34	61 220	36	47 090	32	2758	29	35 527	33	58 255	33	204 850	34
35–39	29 754	18	21 139	15	1468	15	17 949	17	31 355	18	101 665	17
40+	5508	3	5199	4	311	3	3588	3	6569	4	21 175	3
Missing	1	<1	0	0	0	0	27	<1	0	0	28	<1
BMI (kg/m^2), mean (SD)	24.4 (5.1)		24.4 (4.8)				24.3 (4.8)		24.8 (4.7)			
<18.5	6716	4	5227	4			2096	4	3879	2	17 918	3
18.5–24	98 448	59	88 413	61			32 534	62	96 318	55	315 713	61
25–29	33 927	20	31 372	22			11 667	22	41 922	24	118 888	23
30–34	13 318	8	11 642	8			4260	8	14 967	9	44 187	9
35+	7089	4	5585	4			2072	4	6458	4	21 204	4
Missing	8672	5	3307	2	9540	100	53 902	51	12 031	7	87 452	14
Previous deliveries												
0	74 395	44	61 076	42	3794	40	45 731	43	77 350	44	262 346	44
1	60 936	36	49 047	34	3223	34	38 655	36	64 905	37	216 766	36
2	22 157	13	21 335	15	1946	20	15 832	15	23 077	13	84 347	14
3+	7599	5	14 088	10	577	6	6313	6	10 243	6	38 820	6
Missing	3083	2	0		0	0	0	0	0		3083	1
Multiple pregnancy												
No	164 452	98	143 354	98	9409	99	104 577	98	173 009	99	594 801	98
Yes	3718	2	2192	2	131	1	1954	2	2566	1	10 561	2
Previous cesarean section												
No	148 544	88	131 379	90	8506	89	96 345	90	159 958	91	544 732	90
Yes	19 626	12	14 167	10	1034	11	10 186	10	15 617	9	60 630	10
Actual mode of delivery												
Vaginal	132 502	79	122 004	84	8121	85	88 841	83	146 248	83	497 716	82
Emergency cesarean section	20 471	12	14 440	10	873	9	11 041	10	16 992	10	63 817	11
Planned cesarean section	15 197	9	9102	6	534	6	6649	6	12 335	7	43 817	7
Missing	0		0	0	12	<1	0	0	0	0	12	<1
TOLAC	9599	49	10 182	72	703	68	6999	69	10 196	65	37 679	71
VBAC	6867	35	7645	54	480	46	4835	47	7056	45	26 883	50
VBAC of TOLAC		72		75		68		69		69		71
Labor induction												
Yes	29 841	18	27 225	19	2125	22	20 757	19	24 039	14	103 987	17
GA at delivery (full weeks), mean (SD)	39.7 (2.0)		39.8 (1.9)		39.3 (1.9)		39.3 (2.1)		39.7 (1.9)			
<32	1489	1	1199	1	68	1	1086	1	1574	1	5416	1

Table 3. Continued

Country	Denmark		Finland		Iceland		Norway		Sweden		Total	
Maternal characteristics[a]	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
32–36^{+6}	5180	3	6242	4	388	4	5231	5	8377	5	25 418	4
37–41^{+6}	124 110	75	131 030	90	8836	93	94 493	89	153 967	88	512 436	85
42+	35 703	21	7075	5	242	3	5083	5	11 657	7	59 760	10
Missing	1688	1	0	0	6	<1	638	1	0	0	2332	<1

BMI, body mass index; GA, gestational age; TOLAC, trial of labor after cesarean section; VBAC, vaginal birth after cesarean section.
[a]Percentages are adjusted for missing values.

the local clinician to re-confirm the case from the medical records and if confirmed, the maternity unit was asked to report the case correctly to the register.

Discussion

In this Nordic collaboration we found that complete uterine rupture, AIP, peripartum hysterectomy, and severe blood loss at delivery were associated with maternal age, parity, previous CS, mode of delivery, induction of labor, and gestational age, whereas BMI and multiple pregnancy were not associated with AIP and complete uterine rupture, respectively. The results indicate that increasing maternal age, BMI, and parity as well as preterm delivery increases the risk of complications. Likewise previous CS, multiple pregnancy, labor induction, and trial of labor after CS seemed to be associated with a higher risk of complications, but as the results are presented as crude odds, more analyses are needed to confirm such actual associations; the NOSS group are continuously working to publish new results and guidance to management of the studied complications.

The NOSS study covered 91% of all Nordic deliveries in an approximately 2-year period for each country. Our results are based on a relatively high number of cases with severe obstetric maternal complications, which it is difficult to collect in a smaller population. A major strength of this study is the consecutive detailed data collection from medical records combined with register-based identification of cases and validation of reported cases. This is an advantage compared with other small studies based on prospective data collection (5,6), register-based studies (3,7,8), and even controlled prospective data collections like the UK obstetric surveillance system (9). The simultaneous collection of data on conditions associated with severe blood loss at delivery, and the collection of data on multiple transfusions, implied that we could cross-check and identify severe cases of uterine rupture, peripartum hysterectomy, and AIP that were not reported initially. A limitation of the study is that the material was not complete and a few medium and large maternity units from Sweden and Norway did not participate in the project, or reported lower rates than expected. This may result in an underestimation of the rates, but since severe complications tend to accumulate in highly specialized units from which reports were received, the data collected should approach completeness.

Despite efforts to unify data collection, national differences in the methods of data collection might explain some of the differences in the results. The possibility to validate and seek out cases with massive transfusions from the registers in Denmark and Iceland are expected

Table 4. Maternal characteristics and risk factors.

	Complete uterine rupture (*n* = 337)				Hysterectomy (*n* = 211)				Abnormally invasive placenta (*n* = 279)				Multiple blood transfusions (*n* = 500)				Background (*n* = 605 362)	
	n	%	Odds[a]	*p*	*n*	%	Odds[a]	*p*	*n*	%	Odds[a]	*p*	*n*	%	Odds[a]	*p*	*n*	%
Age (years)																		
<20	2	1	1.9	<0.0001	0	0		<0.0001	1	0	0.9	<0.0001	3	1	2.8	<0.0001	10 729	2
20–24	16	5	2.0		4	2	0.5		12	4	1.5		32	6	3.9		81 620	13
25–29	57	17	3.1		32	15	1.7		42	15	2.3		120	24	6.5		185 295	31
30–34	144	43	7.0		78	37	3.8		109	39	5.3		172	34	8.4		204 850	34
35–39	97	29	9.5		64	30	6.3		78	28	7.7		132	26	13.0		101 665	17
40+	21	6	9.9		33	16	15.6		37	13	17.5		41	8	19.4		21 175	3
Missing	0	0	.		0	0			0	0			0	0			28	<1
BMI (kg/m^2)																		
<18.5	12	4	6.7	0.0003	5	3	2.8	<0.0001	10	4	5.6	0.303	25	5	14.0	0.020	17 918	3
18.5–24	151	49	4.8		93	48	2.9		149	57	4.7		268	59	8.5		315 713	61
25–29	95	31	8.0		51	26	4.3		59	23	5.0		103	23	8.7		118 888	23
30–34	27	9	6.1		25	13	5.7		28	11	6.3		32	7	7.2		44 187	9
35+	21	7	9.9		19	10	9.0		16	6	7.5		28	6	13.2		21 204	4
Missing	31	9			18	9			17	6			44	9			87 452	14
Previous deliveries																		
0	74	22	2.8	<0.0001	43	23	1.6	<0.0001	94	35	3.6	<0.0001	217	46	8.3	<0.0001	262 346	44
1	202	60	9.3		65	34	3.0		81	30	3.7		157	33	7.2		216 766	36
2	37	11	4.4		30	16	3.6		44	16	5.2		49	10	5.8		84 347	14
3+	21	6	5.4		51	27	13.1		42	16	10.8		53	11	13.7		38 820	6
Missing	3	1			22	10			10	4			24	5			3083	1
Multiple pregnancy																		
Singleton	328	97	5.5	0.194	190	90	3.2	<0.0001	265	95	4.5	0.0005	453	91	7.6	<0.0001	594 801	98
Twins or more	9	3	8.5		21	10	19.9		14	5	13.3		47	9	44.5		10 561	2
Previous cesarean section																		
No	32	9	0.6	<0.0001	116	55	2.1	<0.0001	163	58	3.0	<0.0001	349	70	6.4	<0.0001	544 732	90
Yes	305	91	50.3		95	45	15.7		116	42	19.1		151	30	24.9		60 630	10
Actual mode of delivery																		
Vaginal	46	14	0.9	<0.0001	47	22	0.9	<0.0001	96	34	1.9	<0.0001	47	46	0.9	<0.0001	497 716	82
Emergency CS	280	83	43.9		94	45	14.7		70	25	11.0		180	36	28.2		63 817	11
Planned CS	11	3	2.5		70	33	16.0		113	41	25.8		91	18	20.8		43 817	7
Missing	0				0				0				0	0			12	<1
Intended CS after CS	81	27	35.3	<0.0001	45	47	19.6	<0.0001	67	58	29.2	<0.0001	54	36	23.5	<0.0001	22 951	
TOLAC	224	73	59.4	<0.0001	50	53	13.3	<0.0001	49	42	13.0	<0.0001	97	64	25.7	<0.0001	37 679	71
VBAC	33	11	12.3		12	13	4.5		18	16	6.7		36	24	13.4		26 883	50
VBAC-2 (of TOLAC)		15				24				37				37				71
Labour induction[b]																		
Yes	119	35	11.4	<0.0001	48	23	4.6	<0.0001	57	20	5.5	<0.0001	174	35	16.7	<0.0001	103 987	17

Table 4. Continued

	Complete uterine rupture (n = 337)				Hysterectomy (n = 211)				Abnormally invasive placenta (n = 279)				Multiple blood transfusions (n = 500)				Background (n = 605 362)	
	n	%	Odds[a]	p	n	%	Odds[a]	p	n	%	Odds[a]	p	n	%	Odds[a]	p	n	%
GA at delivery (full weeks)																		
<32	9	3	16.6	<0.0001	13	6	24.0	<0.0001	21	8	38.8	<0.0001	25	5	46.2	<0.0001	5416	1
32–36^{+6}	21	6	8.3		57	27	22.4		79	28	31.1		73	15	28.7		25 418	4
37–41^{+6}	272	81	5.3		127	61	2.5		171	61	3.3		354	73	6.9		512 436	85
42+	32	10	5.4		12	6	2.0		8	3	1.3		36	7	6.0		59 760	10
Missing	3	1			2	1			0	0			12	2			2332	<1

Percentages are adjusted for missing values.
BMI, body mass index; CS, cesarean section; GA, gestational age; TOLAC, trial of labor after cesarean section; VBAC, vaginal birth after cesarean section.
[a]Odds is the risk of a given complication per 10 000 deliveries, due to, for example, being in a given age group, etc.
[b]Risk of induction in women with intended vaginal delivery (vaginal delivery and emergency CS).

to give a more exact estimate of the NOSS cases, including the rate of severe blood loss at delivery. Likewise the Danish study group identified cases of AIP from the registers by combining the procedure-code for manual placental removal with information of blood transfusion within 48 h postpartum. This, and a significantly higher CS rate in Denmark, could possibly explain the higher rates of severe blood loss at delivery and of AIP observed in Denmark.

Data from medical records on major complications and interventions, including surgery, are considered valid, whereas minor procedures may have been incomplete or insufficiently described in the medical records. The use of the registers to obtain population-based background information, implies that we have information on a very large number of parturients. The available information in the registers, however, limits the research questions that can be addressed, especially regarding risk factors. Register-based denominators, on the other hand, provide a valid population-based estimate of rates.

In this study we had only one maternal death. According to personal correspondence with the Nordic Maternal Mortality Collaboration, there are about 10 direct maternal deaths in the Nordic countries each year. About 10% of these will be related to hemorrhage, which would give an expected number of about two to three maternal deaths in the NOSS cohort. The last report from MBBRACE-UK revealed a rate of 0.59 maternal deaths related to hemorrhage per 100 000 deliveries in the UK from 2009 to 2011, which could equate to an expected number of three to four maternal deaths in a population of our size (10). As maternal death is a very traumatic experience for the departments involved, we do not believe that maternal death was underreported. The reason for the low number is probably that maternal deaths are not evenly distributed over time and more deaths due to hemorrhage might have occurred outside our study period.

In comparison with other population-based studies, we found that the rate of peripartum hysterectomy was compatible with rates in other northern European countries. A prospective study from the Netherlands reported a rate of 3.3/10 000, and in the UK 4.1/10 000 deliveries (11,12). In the USA (7.7/10 000), Canada (8.0/10 000) and Italy (8.6/10 000) higher rates of peripartum hysterectomy have been reported (8,13,14). A previous Danish population-based study from 1995 to 2004 showed a rate of 2.4/10 000, comparable with the rate of 3.0/10 000 in this study (15). The observed rate differences may reflect different populations or management of complications leading to peripartum hysterectomy. A recent Dutch study suggests that the low rate of hysterectomies among women with major obstetric hemorrhage observed in the

Netherlands (3.0/10 000 deliveries) could partly be explained by the frequent use of arterial embolization, which prevented peripartum hysterectomy in half of the studied cases (16). It is our impression that arterial embolization is not frequently used in the Nordic countries and we cannot say whether embolization would have changed the peripartum hysterectomy rate. We think there is a need for further in-depth analysis including audit and cross-country comparisons of risk profiles and management of the complications leading to peripartum hysterectomy to decide how peripartum hysterectomy could be made potentially avoidable.

The complete uterine rupture rates were compatible with rates from population-based studies in the Netherlands and Israel at 5.9 and 6.0/10 000 deliveries, respectively (17,18). The UK and Canada have reported very low rates at 1.9 and 1.6/10 000 deliveries, respectively (7,19). As uterine rupture is known to be associated with previous CS, the difference in rates could be explained by different rates of parturients with previous CS and trial of labor or vaginal birth after CS situations. Studies from the Netherlands and Canada report a previous CS rate of about 10%, corresponding to the highest rates seen in the Nordic countries (17,20,21). In Canada, the UK, and the Netherlands, the rates of trial of labor after a previous CS are reported to be 39, 52 and 72%. Rate of successful vaginal birth after CS were 27, 63 and 54%, respectively. Except for the Netherlands, these rates are much lower than the corresponding rates in our study, where trial of labor after a previous CS ranged from 65 to 80% with a successful vaginal birth after CS ranging from 40 to 75% (21–23). This may indicate that the higher rates of women trying to deliver vaginally after previous CS in the Netherlands and the Nordic countries lead to higher rates of complete uterine rupture.

Rates of AIP are reported with a very wide range. Two old studies from California and Israel reported rates of 4 and 90/10 000 deliveries (5,6). In a more recent study from the UK a rate of 1.7/10 000 deliveries was reported (24). The wide range may reflect that placental disorders are a heterogeneous group. There is an ongoing discussion among clinicians of the diagnostic criteria for AIP. Our data represent a broader spectrum from partly adherent placenta in women delivering vaginally, to the most severe cases of placenta percreta. Due to this we expected and verified a higher rate in our study compared with studies with stricter definitions. To be able to compare rates worldwide, there is a current call for a unified international definition of AIP (http://www.ew-aip.org).

The study of severe blood loss at delivery is also challenged by a lack of uniform international definitions. A Scottish study reported a rate of 19/10 000 deliveries (definition: transfusion of ≥5 red blood cell units), and a Dutch study reported 61/10 000 deliveries (definition: ≥4 red blood cell units) (25,26). The difference in transfusion rates may reflect diverse risk factors, definitions, and clinical management in the populations, but they may also indicate variations in the definition of the complications. There is a need for uniform definitions and cut-off values to ease international comparisons of maternal health as suggested by the CROWN initiative (27).

The risk associations identified in this study support results from several other studies. Fitzpatrick et al. showed increased maternal age and previous CS to be risk factors for placenta accreta or percreta, but did not find any relation between BMI or multiparity (24). Maternal age and previous CS were also risk factors in studies by Miller et al. and Gielchinsky et al. (5,6). The latter reported also a relation between multiple pregnancy and increased parity as risk factors for AIP.

Ronel et al. identified increased risk of complete uterine rupture in women with previous CS, preterm delivery, and high parity (18). In women with previous CS, Fitzpatrick et al. (24) showed an increased risk of complete uterine rupture after two or more previous CS, with intended vaginal delivery after CS and in cases with induced and/or augmented labor. For the small fraction of women with complete uterine rupture without a previous CS, the risk was also related to maternal age. For these women, there was no risk difference in relation to BMI, parity, or multiple pregnancy (19). A high BMI, multiple pregnancy, higher parity, previous CS, preterm delivery, and CS were associated with higher risk for peripartum hysterectomy in previous studies (8,12,13). Vaginal birth after CS was associated with a higher risk of peripartum hysterectomy (12,13).

In conclusion, NOSS provides solid population-based estimates of the rates and risk factors of peripartum hysterectomy, complete uterine rupture, AIP, and severe blood loss at delivery in the Nordic countries. With detailed information about medical history, management of labor, and complications during labor, we were able to perform cross-national audits to describe a variety of emergency situations and identify typical cases at risk. This may lead to new research hypotheses. It is important that obstetricians retain a proper awareness of the rarity and severity of these complications. It is equally important that obstetricians maintain an emphasis on pregnancy and childbirth as a normal event, and at the same time are mentally prepared for emergency actions when needed. Due to the rarity of these complications, individual experience is usually insufficient and there is a need for educational efforts and organizational measures to ensure optimal handling of these serious complications when they occur.

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Study group (reporting clinicians):

Danish NOSS

Bornholm; Clevin L, Bruun A, Esbjerg; Poulsen H, Ring C, Frederiksberg; Rasmussen IM, Gentofte; Zikkenheimer M, Glostrup; Svare J, Haderslev; Bøttcher T, Herlev; Andersen BB, Herning; Forstholm M, Hillerød; Bødker B, Hjørring; Flint C, Holbæk; Krebs L, Holstebro; Andersson S, Horsens; Dupont G, Christensen M, Hvidovre; Flems C, Kolding; Iversen M, Winther L, Olesen MS, Sørensen RK, Højgaard H, Nykøbing F.; Youssef W, Næstved; Jønsson L, Odense; Poulsen VT, Ørskov M, Randers; Østergård M, Rasmussen OB, Bendstrup M, Rigshospitalet; Fabricius M, Eskildsen L, Nim J, Roskilde; Scharff LJ, Silkeborg; Frost L, Jeppesen LE, Skejby; Hvidman L, Slagelse; Vestmark V, Sørensen BL, Svendborg; Vaujany I, Grunnet I, Sønderborg; Bøttcher T, Thisted/Thy; Christensen P, Udsylius E, Gavai M Viborg; Farlie R, Holmskov A, Ålborg; Møller M. Former consultant at the Danish Medical Birth Register; Rasmussen S.

Finnish NOSS

Oulu; Ojala K, Kuopio; Ordén MR, Turku; Paalasmaa N, Tampere; Palomäki O.

Icelandic NOSS

Reykjavik; Bjarnadottir RI, Akranes; Kiernan E, Akureyri; Smarason AK, Ingthorsson O.

Norwegian NOSS

Ahus/Oslo; Sitras V, Bodø; Mathisen M, Sivertsen H, Bærum; Novakovic Z, Haukeland; Mohammad HA, Magne Skulstad S, Baghestan E, Haugesund; Eikeland T, Hahn T, Kristiansund; Hals T, Molde; Walter F, Rikshospitalet/Oslo; Ellingsen L, Skien/Telemark; Klovning K, Stavanger; Kirial K, Retz K, Bærheim G, Kvie Sande R, Munk AC, Orkanger/Trondheim; Tappert C, Vestfold; Margas E, Østfold; Hoel EM, Sjøborg K, Tromsø; Pettersen ÅTR, Ulleval/Oslo; Murzakanova G, Drammen; Lauritzen N, Rosenberg M, Kristiansand; Liv Myren LA, Ålesund; Hjelle S, Kongsvinger; Polvinen H, Ringerike; Eng G, Elverum; Gabrielsen AG, LilleHammer; Nakling J, Voss; Skorve H.

Swedish NOSS

Trollhättan; Almström E, Sunderbyn; Andersson L, Linköping; Blomberg M, Jönköping; Boij R, Sundsvall; Bolin M, Skellefteå; Bondestam E, Örebro; Bryngelsson AL, Östersund; Eriksson M, Sollefteå; Erlandsson H, MBR; Gottvall K, Västerås; Gunnarsson A, Värnamo; Gunnervik C, Karlstad; Hansson A, BB Stockholm; Hjelm A, Göteborg; Jeppsson A, Wennerholm UB Örebro; Kullberg G, Skövde; Leyon J, Kalmar; Lindholm L, Wanby AS Huddinge; Pettersson K, Lindqvist PG, Uppsala; Lutvica A, Halmstad; Malmström O, Helsingborg; Matthiesen L, Lycksele; Moraiti E, Solna; Nord E, Nordström L, Eskilstuna; Ouvrier B, Gävle/Sandviken; Palm M, Borås; Pihl K, Gällevare; Pschera H, Hudiksvall; Rothenhöfer I, Falun; Råssjö EB, Stockholm; Saltvedt S, Rune Kristianstad; Stale H, Varberg; Tejler A, Karlskrona; Thurn L, Ystad; Wallin M,, Norrköping; Werner A, Umeå; Wihlbäck AC, Eksjö; Wärnsberg M, Örnsköldsvik; Almroth K,.

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