Cesarean Delivery and Peripartum Hysterectomy

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OBJECTIVE: To estimate the national incidence of peripartum hysterectomy and quantify the risk associated with cesarean deliveries and other factors.

METHODS: A population-based, matched case-control study using the United Kingdom Obstetric Surveillance System, including 318 women in the United Kingdom who underwent peripartum hysterectomy between February 2005 and February 2006 and 614 matched control women.

RESULTS: The incidence of peripartum hysterectomy was 4.1 cases per 10,000 births (95% confidence interval [CI] 3.6–4.5). Maternal mortality was 0.6% (95% CI 0–1.5%). Previous cesarean delivery (odds ratio [OR] 3.52, 95% CI 2.35–5.26), maternal age over 35 years (OR 2.42, 95% CI 1.66–3.58), parity of three or greater (OR 2.30, 95% CI 1.26–4.18), previous manual placental removal (OR 12.5, 95% CI 1.17–133.0), previous myomectomy (OR 14.0, 95% CI 1.31–149.3), and twin pregnancy (OR 6.30, 95% CI 1.73–23.0) were all risk factors for peripartum hysterectomy. The risk associated with previous cesarean delivery was higher with increasing numbers of previous cesarean deliveries (OR 2.14 with one previous delivery [95% CI 1.37–3.33], 18.6 with two or more [95% CI 7.67–45.4]). Women undergoing a first cesarean delivery in the current pregnancy were also at increased risk (OR 7.13, 95% CI 3.71–13.7).

CONCLUSION: Peripartum hysterectomy is strongly associated with previous cesarean delivery, and the risk rises with increasing number of previous cesarean deliveries, maternal age over 35 years, and parity greater than 3.
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LEVEL OF EVIDENCE: II

Hemorrhage remains a significant cause of maternal mortality in the United Kingdom[1] and worldwide.[2] The most recent report of the U.K. Confidential Enquiry into Maternal and Child Health noted that maternal deaths from hemorrhage have increased.[3] The cause of this rise is uncertain, but it has been suggested that it may be related to changes in the pattern of childbearing, including an increasing number of cesarean deliveries.[3] With the small number of maternal deaths in countries with well-developed health care systems, the etiological role of these factors in fatal hemorrhage is difficult to study. Additional information may be gained through the study of "near-miss" events,[4,5] defined as "a severe life-threatening obstetric complication necessitating an urgent medical intervention to prevent likely death of the mother."[6]

Peripartum hysterectomy is usually carried out for life-threatening obstetric hemorrhage and may

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thus be regarded as a "near-miss" event. Few studies of this condition have been undertaken,[7–9] of which only one, with 22 women, collected cases prospectively and was population-based.[8] The Scottish Confidential Audit of Severe Maternal Morbidity[7] also collects information about women with severe hemorrhage undergoing hysterectomy (women with an estimated blood loss of 2.5 L or more, transfused five or more units of blood, or given treatment for coagulopathy);19 women (9% of those with hemorrhage) were reported to have had a hysterectomy in 2005. Several small studies have suggested an association between peripartum hysterectomy and previous cesarean delivery.[10–12] Currently in the United Kingdom, 23% of women undergo cesarean delivery, equating to about 160,000 women per year[13]; in the United States the figure is 29% (about 1.2 million women per year).[14] Rates of cesarean delivery are increasing worldwide and in some areas of Latin America have reached 50%.[15] Quantification of this association is therefore of international as well as national importance to women, their clinicians, and policy makers. The aim of this study was to carry out a national population-based case-control study using the U.K. Obstetric Surveillance System[16] to estimate the incidence of peripartum hysterectomy in the United Kingdom and to investigate and quantify the risk associated with previous cesarean delivery and other factors.

MATERIALS AND METHODS

A national population-based matched case-control study was undertaken by using the U.K. Obstetric Surveillance System. The U.K. Obstetric Surveillance System is a national system that was established to study a range of rare disorders of pregnancy in the United Kingdom through routine monthly mailings to nominated reporting clinicians. Over the study period, we anticipated identifying 300 cases and 600 controls, with an estimated power of 80% to detect an odds ratio of 2.0 or more at the 5% level of statistical significance, assuming that 9% of the controls had had a previous cesarean delivery.[17]

Cases were defined as any woman delivering a fetus or infant and undergoing a hysterectomy in the same clinical episode. Controls were defined as any woman delivering a fetus or infant who did not undergo a hysterectomy. Reporting clinicians were asked to select two controls, identified as the two women delivering immediately before the case in the same hospital. This pragmatic approach to control selection, by maintaining a link with case reporting, was adopted to maximize completeness of data collection. This control selection process effectively matched controls for hospital, date, and time of delivery. No other matching was undertaken. If the controls identified did not deliver before the case, they were deemed to have been selected erroneously, and clinicians were asked to reselect appropriate control women.

We identified cases through the first 13 monthly mailings of the U.K. Obstetric Surveillance System between February 2005 and February 2006 to all consultant-led maternity units. In the United Kingdom, women may also deliver in midwifery-led units or at home (in total, approximately 3–6% of births), but any woman in one of these settings with a major complication of pregnancy, such as the requirement for a peripartum hysterectomy will always be transferred to a consultant-led unit. Thus inclusion of all consultant-led units allowed the study to cover the entire cohort of U.K. births. Nominated clinicians (obstetricians, midwives, and obstetric anesthetists) in each hospital were sent a card each month, which, along with a series of other conditions, included a simple check-off box to indicate a case of peripartum hysterectomy and a box indicating "nothing to report." They were asked to return the card each month, whether or not there had been any cases. This "negative surveillance" was requested to ensure verification of nil reports and, hence, confirmation of the appropriate denominator for the calculation of rates.

Data collection forms were sent to clinicians reporting a case to collect details of risk factors, management, and outcomes from both case and control women. Up to five reminders were sent if completed forms were not returned. All data requested were anonymous. On receipt of data collection forms, cases were checked to confirm that they met the case definition and controls checked to ensure appropriate selection. Duplicate reports were identified by comparing the woman's year of birth, hospital, and expected date of delivery. The U.K. Obstetric Surveillance System general methodology (04/MRE02/45) and this study (04/MRE02/73) were approved by the London Multi-Center Research Ethics Committee.

Incidence rates with 95% confidence intervals (CIs) were calculated by using the most recently available national birth data (2005) as a proxy for 2005 and 2006.[18–20] This study covered the entire cohort of U.K. births, and therefore risks with 95% CIs were calculated by using the population proportions derived from the control women.

In this matched study, odds ratios (ORs) were estimated throughout by using conditional logistic

Table 1. Maternal Risk Factors for Peripartum Hysterectomy

Risk Factor	Number (%)* of Cases (n=315)†	Number (%)* of Controls (n=608)†	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
Sociodemographic factors				
Age (y)				
Less than 20	4 (1)	28 (5)	0.37 (0.13–1.11)	0.88 (0.27–2.86)
20–34	163 (52)	461 (76)	1‡	1‡
35 or older	148 (47)	119 (20)	3.46 (2.51–4.75)	2.42 (1.66–3.58)
Ethnicity				
White	225 (73)	486 (83)	1‡	–§
Nonwhite	85 (27)	101 (17)	2.06 (1.39–3.05)	–§
Socioeconomic group[21]				–§
Managerial and professional occupations	74 (28)	159 (30)	1‡	–§
Intermediate occupations	73 (28)	130 (24)	1.19 (0.78–1.81)	–§
Routine and manual occupations/ unemployed	117 (44)	243 (46)	1.05 (0.72–1.53)	–§
Marital status				–§
Single	19 (6)	92 (15)	0.31 (0.18–0.53)	–§
Married	229 (73)	350 (58)	1‡	–§
Cohabiting	65 (21)	159 (26)	0.66 (0.47–0.93)‡	–§
Smoking status				–§
Never smoked	229 (75)	397 (66)	1‡	–§
Gave up prior to pregnancy	15 (5)	56 (9)	0.46 (0.25–0.84)‡	–§
Current smoker	52 (17)	122 (20)	0.75 (0.51–1.10)	–§
Gave up during pregnancy	11 (4)	23 (4)	0.84 (0.40–1.78)	–§
Booking body mass index (kg/m^2)				–§
Less than 25	132 (48)	298 (56)	1‡	–§
25–29.9	82 (30)	138 (26)	1.45 (1.02–2.06)‡	–§
30 or greater	62 (22)	95 (18)	1.58 (1.06–2.35)‡	–§
Factors related to pregnancy and reproduction				
Parity				
0	58 (18)	264 (44)	1‡	1‡
1–2	163 (52)	290 (48)	2.48 (1.75–3.52)	1.00 (0.63–1.58)
3 or more	94 (30)	52 (9)	8.43 (5.23–13.6)	2.30 (1.26–4.18)
Previous cesarean delivery				
No	151 (48)	513 (85)	1‡	1‡
One previous cesarean delivery	80 (25)	76 (13)	3.00 (2.04–4.40)	2.14 (1.37–3.33)
Two or more previous cesarean deliveries	84 (27)	14 (2)	25.9 (11.9–56.6)	18.6 (7.67–45.4)
Previous uterine cavity instrumentation‖				
No	230 (74)	523 (87)	1‡	1‡
Yes	82 (26)	81 (13)	2.17 (1.52–3.07)	1.48 (0.95–2.29)
Previous myomectomy				
No	308 (99)	603 (100)	1‡	1‡
Yes	4 (1)	1 (0)	8.0 (0.89–71.6)	14.0 (1.31–149.3)
Previous manual placental removal				
No	305 (98)	603 (100)	1‡	1‡
Yes	7 (2)	1 (0)	14.0 (1.72–113.8)	12.5 (1.17–133.0)
Twin pregnancy				
No	303 (96)	602 (99)	1‡	1‡
Yes	12 (4)	6 (1)	4.13 (1.42–12.0)	6.30 (1.73–23.0)
Placenta praevia				
No	194 (62)	604 (100)	1‡	–¶
Grade 1–2 (minor)	12 (4)	1 (0)	24.0 (3.12–184.6)	–¶
Grade 3–4 (major)	102 (33)	1 (0)	232.4 (29.7–1820.8)	–¶
Grade unknown	4 (1)	1 (0)	43.1 (0.94–1965.2)	–¶
Induction of labor				
No	263 (84)	474 (78)	1‡	–¶
Yes	49 (16)	132 (22)	0.68 (0.47–0.98)	–¶

(*continued*)

Table 1. Maternal Risk Factors for Peripartum Hysterectomy (*continued*)

Risk Factor	Number (%)* of Cases (n=315)†	Number (%)* of Controls (n=608)†	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
Augmentation of labor				
No	91 (65)	403 (77)	1‡	–¶
Yes	49 (35)	120 (23)	2.00 (1.25–3.21)	–¶
Mode of delivery in current pregnancy				
Spontaneous vaginal	49 (16)	385 (63)	1‡	–¶
Assisted vaginal	13 (4)	72 (12)	1.75 (0.82–3.76)	–¶
Cesarean delivery	249 (80)	151 (25)	14.7 (9.24–23.4)	–¶
Gestation at delivery (wk)				
Less than 32	28 (9)	15 (2)	7.97 (4.87–13.0)	–¶
32–36	83 (27)	30 (5)	5.92 (2.97–11.8)	–¶
37 or more	198 (64)	562 (93)	1‡	–¶
Birth weight (g)#				
Less than 2,500	70 (24)	43 (7)	3.92 (2.55–6.02)	–¶
2,500–4,499	213 (73)	544 (91)	1‡	–¶
More than 4,500	7 (2)	13 (2)	1.34 (0.51–3.56)	–¶
Uterine rupture				
No	287 (92)	607 (100)	1‡	–¶
Yes	26 (8)	0	∞ (14.3–∞)	–¶
Placenta accreta, increta, or percreta				
No	192 (61)	567 (100)	1‡	–¶
Yes	121 (39)	0	∞ (99.5–∞)	–¶

OR, odds ratio; CI, confidence interval.
* Percentages of those with complete data.
† There were 315 cases and their 608 correctly matched controls in whom peripartum hysterectomy was not undertaken electively for malignancy.
‡ Baseline comparison group.
§ No longer significant on multivariable analysis.
‖ Including dilation and curettage, evacuation of retained products of conception, and surgical termination of pregnancy.
¶ Not included in multivariable model as involved in the causal pathway linking previous cesarean delivery with peripartum hysterectomy.
# Singleton pregnancies only.

regression. Given that peripartum hysterectomy is rare, ORs provide a robust estimate of relative risk. A parsimonious regression model was developed by including explanatory factors in a core model if there was a pre-existing hypothesis or evidence to suggest that they were causally related to peripartum hysterectomy, for example, previous cesarean delivery and uterine surgery. Potential confounding factors (eg, maternal age, ethnicity), as described in Table 1,[21] were then added to the core model and removed in a backward stepwise manner in ascending order of the likelihood ratio test score.

Factors that did not contribute significantly to the fit of the model on likelihood ratio testing ($P<.05$) were excluded. Continuous variables were tested for departure from linearity by the addition of quadratic terms to the model, and potential interactions were tested by the addition of interaction terms and subsequent likelihood ratio testing on removal. A correlation matrix of the covariates was constructed to check for colinearity. Factors thought likely to be on the causal pathway between previous cesarean delivery and peripartum hysterectomy, such as placenta praevia, were not included in the multivariable model because this leads to overadjustment. To estimate the proportion of cases attributable to specific causes, we calculated population proportional attributable risks (etiologic fraction) by using the adjusted odds ratios from the multivariable analysis and the proportion of controls exposed as an estimate of population exposure.[22] All analyses were carried out using STATA 9 software (StataCorp, College Station, TX). The funding sources played no part in the study design, data collection, analysis, and interpretation in the writing of the paper or the decision to submit the paper for publication.

RESULTS

All 229 eligible U.K. hospitals participated in the U.K. Obstetric Surveillance System, representing 100% participation. Sixty-one percent of hospitals returned all their monthly case notification cards, 87% of hospitals returned at least 11 of 13 monthly cards, and 91% of cards were returned overall. Only five hospi-

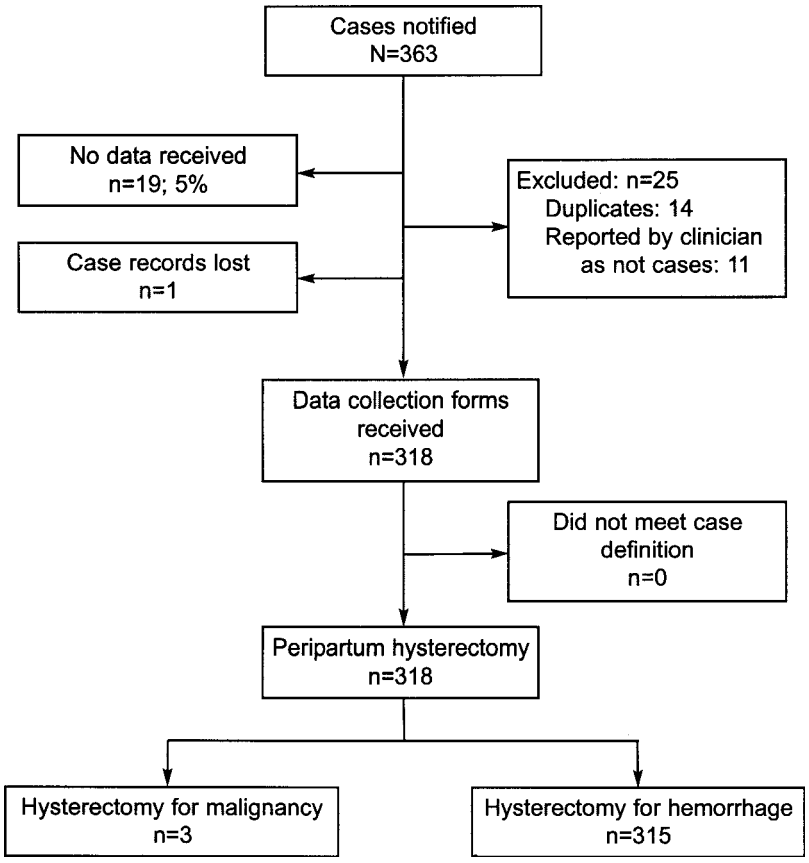

Fig. 1. Case reporting and completeness of data collection.
Knight. Cesarean Delivery and Peripartum Hysterectomy. Obstet Gynecol 2008.

tals returned seven or fewer cards; two were tertiary referral units and three local district hospitals. Data collection forms were received for 94% of notified cases (Fig. 1). There were 318 confirmed cases of peripartum hysterectomy in an estimated 775,186 women delivering,[18–20] giving an incidence of 4.1 per 10,000 women delivering (95% CI 3.6–4.5). Information about 614 correctly selected controls was obtained. Compared with the controls, women who had a peripartum hysterectomy were, on average, older, more likely to be nonwhite, married, and nonsmokers, with a higher body mass index although with a similar socioeconomic profile (Table 1). They were also more likely to deliver preterm and have low birth weight infants.

Three hysterectomies were undertaken electively for management of malignancy (one ovarian, two cervical cancers), with the remaining 315 undertaken for management of hemorrhage (Fig. 1). Analysis of risk factors was carried out with only the 315 cases in which peripartum hysterectomy was undertaken for management of hemorrhage and their 608 correctly selected controls. The most commonly reported causes of hemorrhage were uterine atony (53%), morbidly adherent placenta (39%), uterine rupture (8%), and extension of uterine incision at delivery (6%). Other individual causes each accounted for 5% or fewer of cases.

After adjustment, the only sociodemographic factor significantly affecting the risk of peripartum hysterectomy was maternal age (Table 1), for which there was a linear increase in risk with increasing age. Women having a hysterectomy were six times more likely to be carrying twins. Hysterectomy was associated with both manual placental removal in a previous pregnancy (OR 12.5, 95% CI 1.17–133.0), previous myomectomy (OR 14.0, 95% CI 1.31–149.3), and previous uterine cavity instrumentation (OR 1.48, 95% CI 0.95–2.29), although the latter was not statistically significant.

Compared with controls, women who had had a peripartum hysterectomy were over three times (OR 3.52, 95% CI 2.35–5.26) more likely to have had a previous cesarean delivery. This risk increased with the number of previous cesarean deliveries, such that women with a peripartum hysterectomy were over eighteen times more likely to have had two or more previous cesarean deliveries. There was some evi-

Table 2. Causes of Hemorrhage in Women Who Have Had a Peripartum Hysterectomy and Previous Cesarean Delivery (n=164)

Factor	n (%)
Placenta previa	27 (16)
Placenta accreta	17 (10)
Uterine rupture	7 (4)
Praevia and accreta	63 (38)
Previa and rupture	2 (1)
Rupture and accreta	2 (1)
Previa, rupture, and accreta	1 (less than 1)
None of previa, rupture, or accreta	40 (24)*
Missing	5 (3)

* In 33 of these women, hemorrhage was attributed to uterine atony, in three to infection, and in the remainder to other single causes.

dence of an interaction between previous cesarean delivery and age; the risk associated with previous cesarean delivery was higher in women aged less than 35 years (OR 6.87, 95% CI 4.01–11.77) than in those aged 35 years or older (OR 2.21, 95% CI 1.22–4.01). After adjustment, an independent relationship between the risk of peripartum hysterectomy and parity was evident only for women of parity three and above.

Peripartum hysterectomy cases were more likely to receive augmentation in labor (OR 2.0) although less likely to have had labor induced (OR 0.68) (Table 1). They were also 14 times more likely to undergo cesarean delivery in the current pregnancy. To explore this relationship further and to eliminate the effect of previous cesarean delivery, we investigated the risk of peripartum hysterectomy associated with cesarean delivery in the current pregnancy in the subgroup of women who had not had a previous cesarean delivery, adjusted for age, multiple pregnancy, previous uterine surgery, manual placental removal, and myomectomy. From this we estimated the odds ratio of the effect of cesarean delivery in the current pregnancy, independently of these adjustment factors, as 7.13 (95% CI 3.71–13.7).

A number of factors in the current pregnancy thought to be on the causal pathway between previous cesarean delivery and peripartum hysterectomy were not included in the adjusted analysis, but were, by themselves, strongly associated with peripartum hysterectomy. Both uterine rupture and placenta accreta were strongly associated with peripartum hysterectomy risk. In the absence of controls with these conditions, we can only estimate the lower confidence limit of the odds ratio, which was 14.3 for uterine rupture and 99.5 for placenta accreta. Three (0.5%) of the controls and 38% of the cases had some grade of placenta praevia (89% major), giving an unadjusted odds ratio of 113.3 (95% CI 28.0–458.4). These represent very high risks but should be interpreted with caution, given the instability of the estimate. Nearly 70% of the cases who had had a previous cesarean delivery had abnormal placentation in their current pregnancy (Table 2), compared with only 30% of those who had not had a precious cesarean delivery (45 of 151 women, data not shown).

Table 4. Estimated Population Proportional Attributable Risks

Risk Factor	PAR (%)
Previous cesarean delivery	28
Age 35 years or older	24
Parity 3 or greater	11
Previous uterine instrumentation	6
Twin pregnancy	5
Previous manual placental removal	2
Previous myomectomy	2

PAR, proportional attributable risk.

Estimated risks of needing a hysterectomy after delivery in different groups of women are shown in Table 3, calculated using the number of cases in the study and population proportions from the controls.

Population attributable risks are shown in Table 4. Assuming causality, 28% of hysterectomies were attributable to previous cesarean delivery, 24% to age 35 years or over, and 11% to parity of three or greater.

Two women died after hysterectomy, a case fatality of 0.6% (95% CI 0–1.5%). Eighty-four percent of cases were admitted to intensive care for a median of 2 days (range 1–26). Fetal/infant outcomes were

Table 3. Estimated Risk of Needing a Peripartum Hysterectomy in Different Categories of Women

Category	Risk of Requiring Peripartum Hysterectomy (95% CI)
Woman undergoing her first delivery vaginally	1 in 30,000 (1:17,000–1:152,000)
Woman undergoing her first delivery by cesarean	1 in 1,700 (1:1,300–1:2,300)
Subsequent delivery in a woman who has had one previous cesarean delivery	1 in 1,300 (1:1,000–1:1,600)
Subsequent delivery in a woman who has had two or more previous cesarean deliveries	1 in 220 (1:180–1:270)

CI, confidence interval.

known for 310 pregnancies (298 singleton and 12 twin pregnancies). There were four pregnancies in which hysterectomies were performed after second-trimester deliveries. In the remaining pregnancies, there were seven stillbirths and one neonatal death, giving a perinatal mortality rate of 25 per 1,000 total births (95% CI 7.9–42).

DISCUSSION

The U.K. Obstetric Surveillance System represents the only collection of detailed clinical information about rare conditions of pregnancy with controls using a system specifically designed for this purpose. This has important advantages over using data derived from routine data systems, which often do not include nuanced clinical information of relevance to the natural history of rare conditions and events. The U.K. Obstetric Surveillance System represents a ground-breaking extension of the principles of the Confidential Enquiry into Maternal Deaths, enabling the investigation of "near-miss" events, recognizing the fact that, in countries with well-developed health care systems where maternal deaths are rare, we need to extend our investigations beyond just death, which may not be typical of all events placing women at near risk of death.

The U.K. national incidence of peripartum hysterectomy, as estimated by this study, is 4.1 per 10,000 women delivering, or approximately 1 per 2,500 births. This estimate is compatible with the incidence identified from previous regional population-based studies in the United Kingdom, which identified a rate of 4.5 hysterectomies per 10,000 births (95% CI 2.6–6.4) in 1997–1998 in the South East Thames region[8] (based on 22 cases), when the cesarean delivery rate was 18%,[17] and 4.3 per 10,000 births (95% CI 3.0–5.6) in Scotland in 2003–2004[23] (44 cases),[7] when the cesarean delivery rate was 24%.[7] However, given the small size of the studies available for comparison, our results may also represent any figure between a decrease of 44% and an increase of 73% in the incidence of peripartum hysterectomy between 1997–1998 and 2005.

Our incidence estimate is also compatible with incidence rates in non-U.K. population-based studies. A recent prospective study in the Netherlands reported a rate of peripartum hysterectomy of 3.3 per 10,000 births (95% CI 2.0–4.6, 48 cases).[9] Four other population-based studies conducted by retrospective database review report higher rates: 4.8 per 10,000 in Israel (95% CI 3.5–6.0),[24] 5.5 per 10,000 in Canada (95% CI 4.4–6.7),[25] 6.8 per 10,000 in Germany (95% CI 5.9–7.7),[26] and 7.7 per 10,000 in the United States (95% CI 7.3–8.1).[27] Only the German and U.S. studies had confidence intervals with which ours did not overlap. In view of our findings, the variations may be related to differing rates of cesarean delivery and different patterns of parity, maternal age at childbirth, and other risk factors. In view of the known limitations of retrospective database review, we cannot, however, exclude the possibility that these observed differences in incidence are simply due to differences in study methodology.

Evidence about the potential harm associated with cesarean delivery is scarce, and a recent influential National Institutes of Health consensus conference in the United States was unable to make any recommendations about how women requesting "unnecessary" cesarean delivery should be advised.[14] This study has confirmed the significant risk of peripartum hysterectomy associated with prior cesarean delivery. These data provide evidence that cesarean delivery leads to a greater than seven times increase in the odds of having a peripartum hysterectomy to control hemorrhage. A similar risk was noted in a recent U.S. study using the Nationwide Inpatient Sample.[27] We have also been able to identify that the risk also then extends beyond the initial cesarean delivery into subsequent deliveries; women who have had one previous cesarean delivery have more than double the risk of peripartum hysterectomy in the next pregnancy, and women who have had two or more previous cesarean deliveries have more than eighteen times the risk. This full quantification of these risks provides the evidence needed to comprehensively counsel women about the risks of primary cesarean delivery and to counsel against cesarean delivery without a specific medical indication. The mechanisms do not exist to conduct a similar study elsewhere in the world.

These findings also have implications for service planning in the light of rising cesarean delivery rates and rising age at childbirth. The most recent figures for 2004/2005 indicate that, currently, 23% of deliveries in England are cesarean deliveries.[13] This rate has risen every year since 1955.[13] The average age of mothers in England and Wales at the birth of their first child has risen from 28.4 to 29.4 in the past 10 years.[28] Over the same time period, births to mothers over 35 years of age have increased from 11% to 19% of all births.[28] Multiple births have also increased.[28] Our figures suggest that 28% of peripartum hysterectomies are attributable to prior cesarean delivery, 24% to maternal age over 35 years, and 5% to twin pregnancy. These trends, if they continue, may thus be expected to lead to an increase in the numbers of

women in the future requiring peripartum hysterectomy. Women who require a peripartum hysterectomy are managed with a range of other therapies to treat the associated hemorrhage as well as requiring intensive care support. The resources required to manage these women therefore extend well beyond surgical costs and can also be expected to increase. We have no information from our study about longer-term morbidity in women who have undergone peripartum hysterectomy; if significant, this will increase the resource requirements further.

We were not able to investigate the relative contribution of factors thought to be on the causal pathway between previous cesarean delivery and peripartum hysterectomy in an adjusted analysis. Thus, although we can report that women requiring hysterectomy were more likely to have abnormal placentation and we hypothesize that this is the major cause, we cannot exclude a contributory role to the requirement for hysterectomy from other factors such as preterm delivery or augmentation of labor.

In addition to quantifying the risk associated with previous cesarean delivery, we have also documented an increased risk of peripartum hysterectomy associated with other forms of uterine surgery. A small increase is associated with previous uterine instrumentation and a larger increase with both previous manual placental removal and myomectomy. These results have not been previously reported. Each of these findings has importance for the counseling of women planning pregnancy and for their care during and after delivery. However, although this was a population-based study including an estimated 780,000 births, the number of women who had had a previous myomectomy or manual placental removal was still small, and hence these risks have wide confidence intervals.

The U.K. Obstetric Surveillance System was the only source used to ascertain cases for this study. There is no routine data source through which to obtain comparable information in the United Kingdom. To check case ascertainment, at the midpoint of the study, we attempted to identify cases of peripartum hysterectomy through hospital pathology departments and intensive care units. Only one additional case was reported, which, on subsequent investigation, was found not to be a case. Although this is reassuring, we plan to undertake studies in the future to investigate the completeness of case ascertainment through the U.K. Obstetric Surveillance System more comprehensively.

The main strength of our study is that we have collected comprehensive population-based national information about women undergoing peripartum hysterectomy, together with information about control women, and, thus, we are able to quantify associated risk factors. Data collection for this study was undertaken through hospital case record review, so we have only been able to investigate factors that are adequately recorded in these records. However, before commencing the study, we did not identify any hypothesized factors that would be insufficiently well recorded to investigate using this methodology. Additionally, the information on risk factors is all recorded prospectively in obstetric case notes, before delivery or hysterectomy, so we are confident that any information bias caused by using case record review will be minimal.

Control selection is a further potential source of bias. All controls were checked to ensure that they had delivered before the case as per the selection instructions. We did not, however, undertake any further checking to ensure controls were being selected according to the instructions given, and we cannot therefore exclude the possibility of bias arising from incorrect control selection. However, it is unlikely that incorrect control selection will have introduced any systematic bias into the study because the majority of hospitals contributed only one case and her matched controls to the study. In addition, the features of the controls reflect the expected population characteristics of pregnant women in the United Kingdom, which suggests that they are an appropriate comparison group and that significant bias is unlikely to have occurred.

This study was undertaken in the setting of a country with a well-developed health care system. The results are, therefore, generalizable to all countries with similar population demographics and health care settings, including Europe, North America, and Australasia. The risks in countries with less developed health systems are likely to be different, and clinicians in those settings should interpret these results in the light of their individual circumstances.

Although fortunately a rare condition, peripartum hysterectomy nevertheless represents a catastrophic (and sometimes fatal) end to a pregnancy for any woman, regardless of whether she considers her family to be complete. This study reveals the extent of severe morbidity underlying the mortality associated with peripartum hysterectomy reported by the U.K. Confidential Enquiry into Maternal and Child Health.[1] In our study, for each woman who died after a peripartum hysterectomy, more than 150 women were managed with the same procedure. This illustrates the additional value of

systematically investigating "near-miss" events using systems such as the U.K. Obstetric Surveillance System to complement the in-depth confidential enquiry into deaths.

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