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Reproductive outcomes following induced abortion: a national register-based cohort study in Scotland

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ABSTRACT

Objective: To investigate reproductive outcomes in women following induced abortion (IA).

Design: Retrospective cohort study.

Setting: Hospital admissions between 1981 and 2007 in Scotland.

Participants: Data were extracted on all women who had an IA, a miscarriage or a live birth from the Scottish Morbidity Records. A total of 120 033, 457 477 and 47 355 women with a documented second pregnancy following an IA, live birth and miscarriage, respectively, were identified.

Outcomes: Obstetric and perinatal outcomes, especially preterm delivery in a second ongoing pregnancy following an IA, were compared with those in primigravidae, as well as those who had a miscarriage or live birth in their first pregnancy. Outcomes after surgical and medical termination as well as after one or more consecutive IAs were compared.

Results: IA in a first pregnancy increased the risk of spontaneous preterm birth compared with that in primigravidae (adjusted RR (adj. RR) 1.37, 95% CI 1.32 to 1.42) or women with an initial live birth (adj. RR 1.66, 95% CI 1.58 to 1.74) but not in comparison with women with a previous miscarriage (adj. RR 0.85, 95% CI 0.79 to 0.91). Surgical abortion increased the risk of spontaneous preterm birth compared with medical abortion (adj. RR 1.25, 95% CI 1.07 to 1.45). The adjusted RRs (95% CI) for spontaneous preterm delivery following two, three and four consecutive IAs were 0.94 (0.81 to 1.10), 1.06 (0.76 to 1.47) and 0.92 (0.53 to 1.61), respectively.

Conclusions: The risk of preterm birth after IA is lower than that after miscarriage but higher than that in a first pregnancy or after a previous live birth. This risk is not increased further in women who undergo two or more consecutive IAs. Surgical abortion appears to be associated with an increased risk of spontaneous preterm birth in comparison with medical termination of pregnancy. Medical termination was not associated with an increased risk of preterm delivery compared to primigravidae.

ARTICLE SUMMARY

Article focus

- Is an IA in a first pregnancy associated with spontaneous preterm birth or other adverse obstetric or perinatal outcomes in the second pregnancy?
- Is an IA performed after an initial singleton live birth associated with spontaneous preterm birth or adverse obstetric or perinatal outcomes in the next pregnancy?
- Do any of these associations differ by method of IA (ie, surgical vs medical)?
- Is the risk of adverse obstetric or perinatal outcomes associated with increasing number of terminations?

Key messages

- The risk of preterm birth after IA is lower than that after miscarriage but higher than that in a first pregnancy or after a previous live birth.
- This risk is not increased further in women who undergo two or more consecutive IAs.
- Surgical but not medical abortion appears to be associated with an increased risk of spontaneous preterm birth in comparison with primigravidae.

BACKGROUND

Many women start their reproductive careers with an abortion in their first pregnancy. In 2009, 13 005 abortions were performed in Scotland, with the highest rates in women aged 16–19 years.[1] What is not yet entirely clear is the effect these abortions may have on subsequent childbearing. It has been believed that infection, cervical trauma and endometrial curettage associated with induced abortion (IA) could lead to future infertility, ectopic pregnancy, preterm delivery and placenta praevia, but the data from existing observational studies are mixed.[2–18] Following the legalisation of abortion in 1967, initial research on the effects of an IA on subsequent pregnancies showed no evidence of an increased risk of miscarriage, preterm delivery or low birth weight.[19 20] Much of the work in the subject has been hampered by methodological limitations; randomised controlled studies are

ARTICLE SUMMARY

Strengths and limitations of this study

- Largest population-based study of reproductive outcomes following an IA generalisable to other populations with similar healthcare system.
- Compares outcomes after medical and surgical abortion and explores the dose-dependent effect of abortion on future preterm delivery. An added strength is use of national data and the ability to discriminate between spontaneous and overall preterm birth as an outcome.
- In acknowledgement of changes in clinical practice during the long study period, models are adjusted for year of pregnancy.
- Compares women with IA with those with a miscarriage, live birth and nulliparous women groups, adding validity to the results.
- Unrecorded and missing data in relation to certain potential confounding factors within the data set.
- Parity number was less reliable in the early years of data collection. This may reflect problems with coding and could potentially affect the quality of our results.
- In addition, the analysis of such a large population-based data set has the capacity to produce statistically significant differences, which may or may not be clinically relevant, although this has been minimised by our use of a 1% significance level throughout.

not feasible in this context and researchers have looked to observational studies. Many of the published studies have been limited by small sample sizes, self-reported outcomes and inability to adjust for many potential confounders. A recent review[21] reported that half of the 12 relevant studies found an association between IA and preterm birth as well as placenta praevia. More recently, a number of large studies found no increased risk of placenta praevia but supported an association with preterm[18 22 23] and very preterm delivery[24 25] The clinical implications of this are profound as reducing the incidence of preterm delivery, with its considerable associated problems, remains one of the most significant challenges in obstetrics.

Over a quarter of IAs in Scotland in 2005 were repeat procedures[1] (Information and Statistics Division (ISD), personal communication). While the reproductive sequelae of repeat abortions are unclear, the available literature suggests that the risk of preterm delivery is increased by multiple abortions.[18 22 24 26]

Changes in the technique of abortion have to be taken into account when assessing their impact on future reproduction. In 1992, 83.6% of terminations were carried out surgically, falling to 60.6% in 1998 and 40.7% in 2006, with the remainder being carried out medically.[1] A number of studies[27–29] have compared these methods in terms of safety, efficacy and short-term complications, but data on subsequent reproductive outcomes are scant. A recent study[30] found no difference in reproductive outcomes (ectopic pregnancy, miscarriage and preterm delivery) following medical and surgical IAs but was unable to adjust for known confounders, such as smoking.

The Scottish Morbidity Record (SMR) system in Scotland covers a national population and has captured data on medical and surgical abortion for many years. Over 99.3% of abortions in Scotland are carried out in NHS premises and are recorded in the SMR system. As these data are based on clinical records, any potential bias created by under-reporting will be removed. The availability of this large national data set provides an ideal opportunity to link records on abortion (SMR01) with maternity records (SMR02) in order to explore the risk of preterm delivery and other maternal and perinatal outcomes in women following one or more episodes of IA. The data would also allow a meaningful comparison of outcomes following alternative forms of IA (ie, medical vs surgical).

The primary aim of this study was to investigate the reproductive outcomes in women following IA. In particular, we wished to answer the following research questions: (1) Is an IA *in a first pregnancy* associated with spontaneous preterm birth or other adverse obstetric or perinatal outcomes in the second pregnancy? (2) Is an IA performed *after a singleton term first pregnancy* associated with spontaneous preterm birth or adverse obstetric or perinatal outcomes in the next pregnancy? (3) Do any of these associations differ by method of IA (ie, surgical vs medical)? (4) Is the risk of adverse obstetric or perinatal outcomes associated with increasing number of terminations?

METHODS

A retrospective cohort study design was used on routinely collected data extracted from the ISD database. Approval was obtained from the Privacy Advisory Committee of the NHS, Scotland.

Data were extracted from the ISD databases (SMR01 and SMR02) on women aged 15–55 years who had an IA, a miscarriage, a live birth or an ongoing pregnancy and live delivery in their first pregnancy between 1981 and 2007, followed by a second pregnancy event. Reproductive outcomes in the subsequent pregnancy of women who had an IA in their first pregnancy (exposed cohort) were compared with those in two unexposed groups: (1) women in their second pregnancy after a miscarriage in their first pregnancy and (2) women in their second pregnancy after a live birth in their first pregnancy. In addition to these two unexposed cohorts, obstetric and perinatal outcomes in the subsequent pregnancy of women who had an IA in their first pregnancy (exposed group) were also compared with those women in their first pregnancy.

To explore outcomes following early pregnancy loss after an initial live birth, data were extracted on all women (aged 15–55 years) who had an IA, a miscarriage or a live birth in their second pregnancy (following a live birth in their first pregnancy) between 1981 and 2007 from the ISD databases (SMR01 and SMR02) and followed up to identify a third pregnancy event. Reproductive, obstetric and perinatal outcomes in women who

had an IA after a singleton term first pregnancy (exposed group) were compared with those in two unexposed groups: (1) women in their third pregnancy following a singleton term delivery in the first pregnancy and a miscarriage in the second pregnancy and (2) women in their third pregnancy following two singleton term deliveries.

Women treated by different methods of IA (surgical or medical) in their first pregnancy were compared in terms of reproductive, obstetric and perinatal outcomes. Finally, to answer research question 4, reproductive and perinatal outcomes were compared between women who had one, two, three and four previous consecutive IAs and women with no previous abortions. Each group of women was independent of the others, for example, women who had three abortions were excluded from the group with two abortions. For each analysis, except research question 4, the women were matched on parity as the risk of adverse obstetric outcomes is dependent on parity, with primiparous women having the highest risk.

Data extracted

The following variables were identified by matching SMR01 and SMR02 data sets between the years 1981 and 2007.

Demographic details: Age at pregnancy events, smoking status and social class (assessed using Carstairs category of deprivation) in the exposed group were compared with each of the three unexposed cohorts.

IA details: Estimated gestation and method of termination (medical or surgical or both) were recorded for the exposed group.

Reproductive outcomes: Miscarriage, abortion, live birth, ectopic pregnancy, stillbirth in the exposed group were compared with the unexposed cohorts.

Obstetric and perinatal outcomes: The incidence of pre-eclampsia, placenta praevia, placental abruption, preterm delivery, very preterm delivery, low birth weight and the mode of delivery in the exposed cohort were compared with each of the three unexposed cohorts. Spontaneous delivery rates (including live birth and stillbirth) were calculated after excluding women who had induced labour and elective (planned) caesarean section.

Socioeconomic status was assessed using the Carstairs Index,[31] which was divided into quintiles for analysis.

Power calculation

Given the number of subgroups in the analysis coupled with multiple outcomes, a global sample size calculation was not feasible. Preliminary enquiries with ISD suggested that we could identify at least 260 000 terminations (1981–2007), of which 30% (n=69 000) were estimated to have had a subsequent live birth and 25.5% (n=66 223) were IAs in a first pregnancy.

Using a 1:1 ratio of women with IAs in a first pregnancy (exposed cohort) and unexposed women, we anticipated having over 90% power, at the two-sided 5% significance level, to detect a difference of 0.5% or more in the chances of a preterm birth (ie, an OR of 1.09), assuming that the prevalence of live births in the unexposed group was 6%.

Statistical analysis

In the absence of an ideal comparison group for women with a prior abortion, we used three unexposed cohorts, which could increase the chance of false-positive associations (type I error). To help minimise this, we used a stringent p value of ≤0.01 to denote statistical significance throughout the statistical analyses.

A generalised linear model was used with Poisson family and robust variance estimator to ascertain the relationship between exposure (first pregnancy IA) and various reproductive outcomes (stillbirth, miscarriage, ectopic pregnancy and IA), maternal and perinatal outcomes (pre-eclampsia, placenta praevia, placental abruption) after adjusting for potential confounders (maternal age, year of delivery, smoking and Carstairs at relevant pregnancy). For the outcome of induction of labour, pre-eclampsia, placenta praevia and placental abruption were also entered into the model. Similarly, the outcome low birth weight was also adjusted for gestational age. Stata V.11 was used for the analysis and a stringent p value of ≤0.01 was used to denote statistical significance throughout.

As smoking data were not routinely collected in the maternity database (SMR02) before 1992 and rarely recorded for women having an IA or miscarriage. Thus, self-reported smoking status, collected at antenatal booking visit, though available for some women, was non-randomly missing for a high percentage of women. This sometimes led to non-convergence of the statistical models. Therefore, a sensitivity analysis was carried out by rerunning all the multivariate models, excluding the smoking variable to determine if the overall effect sizes remained of similar magnitude. This was found to be so.

RESULTS

Demographic characteristics of women who had an abortion in their first pregnancy were compared with those who had either a live birth or a miscarriage in their first pregnancy and with primigravida women (table 1). Women with a previous IA were significantly older, more socially deprived and more likely to be smokers than primigravida women or those who had a live birth or a miscarriage in a previous pregnancy.

Table 2 presents reproductive outcomes in a subsequent pregnancy following IA, live birth and miscarriage in the first pregnancy. As table 2 shows, women with an IA in the first pregnancy were more at risk of having a stillbirth or an IA in the second pregnancy compared with an initial live birth. Compared with those who had an initial miscarriage, women who had an IA in their first pregnancy were less likely to have a subsequent miscarriage or ectopic pregnancy, but more likely to have another IA.

Perinatal outcomes in the next ongoing pregnancy following IA are also compared with those in

Table 1 Demographic characteristics at first pregnancy of women who had induced abortion, live birth or miscarriage in their first pregnancy

	Outcome in first pregnancy				
	Induced abortion (N=120 033)	Live birth (N=457 477)	p Value	Miscarriage (N=47 355)	p Value
Mean age (SD)	24.68 (7.56)	24.89 (5.11)	<0.001	26.26 (6.13)	<0.001
Carstairs category* †					
1	17 265 (17.1)	79 705 (18.0)	<0.001	8403 (18.8)	<0.001
2	18 538 (18.3)	81 661 (18.4)		8206 (18.4)	
3	19 530 (19.3)	84 559 (19.1)		8794 (19.7)	
4	21 135 (20.9)	92 504 (20.9)		9426 (21.1)	
5	24 615 (24.4)	105 313 (23.7)		9788 (21.9)	
Smoking status†					
Never	1014 (42.3)	112 744 (48.4)	<0.001	4892 (39.8)	<0.001
Current	676 (28.2)	72 182 (31.0)		2044 (16.6)	
Former	85 (3.5)	22 140 (9.5)		533 (4.3)	
Not known	622 (26.0)	26 088 (11.2)		4818 (39.2)	
Total	2397	233 154		12 287	
Missing	117 636 (98.0)	224 323 (49.0)		35 068 (74.1)	
Interpregnancy interval in weeks					
Median (IQR)	165 (78–321)	139 (95–213)	<0.001	65 (47–104)	<0.001

Values are n (%) unless otherwise specified.
*Carstairs categories: 1= least deprived, 5= most deprived.
†Percentage based on available information for each group.

primigravida and women who have had a live birth or miscarriage (table 2). Compared with women having a previous live birth, women who had an IA were at higher risk of pre-eclampsia; abruptio placenta; induction of labour; spontaneous preterm, very preterm (<32 weeks) and extremely preterm (<28 weeks) delivery and delivery of a low birthweight baby (<2500 g) but not placenta praevia.

In comparison with women with a previous miscarriage, a history of IA was associated with a lower risk of developing pre-eclampsia and spontaneous preterm and very preterm delivery. Risks of pre-eclampsia, placental abruption (but not placenta praevia), delivery of a low birthweight baby and spontaneous preterm, very preterm and extremely preterm birth were significantly higher following IA than in primigravid women. The risk of pre-eclampsia in women with a previous IA was higher than that in primigravid women but lower than that in women with a previous miscarriage (table 2).

The demographic characteristics of women who had a live birth in their first pregnancy and then went on to have an IA, a live birth or a miscarriage in their second pregnancy are shown in table 3. Women with an IA in their second pregnancy were younger, belonged to a more deprived social group and were more likely to be smokers than women who had a live birth in their second pregnancy. Compared with women who had a miscarriage in their second pregnancy, women with a previous IA were older, belonged to more deprived social classes and were more likely to smoke.

As table 4 shows, IA in the second pregnancy was associated with a higher risk of an ectopic pregnancy or an IA in the third pregnancy compared with an initial live birth. The risk of miscarriage in a third pregnancy was lower in women who had an IA in their second pregnancy, but the risks of another IA were higher than in women with a previous miscarriage.

Compared with women with two previous live births, women with a live birth followed by an IA were more likely to have pre-eclampsia, placenta praevia, induced labour, low birth weight and spontaneous preterm, very preterm and extremely preterm birth (table 4). Women with an IA in their second pregnancy were not at any significantly higher risk of perinatal complications in comparison with women with a previous miscarriage.

In records where the method of IA was clearly recorded, 52 560 women were noted to have had surgical and 16 702, medical abortions. As table 5 shows, reproductive outcomes were comparable in the two groups except for a lower risk of a second IA following surgical termination of pregnancy. The adjusted RR of miscarriage, ectopic pregnancy, placenta praevia and spontaneous preterm delivery (<37 weeks) were significantly higher after surgical termination. In comparison with primigravid women, that is, no previous abortion, women with a medical abortion had an increased risk of placental abruption but not spontaneous preterm, very preterm or extremely preterm delivery. In contrast, women with a surgical abortion had higher risks of all three types of spontaneous preterm delivery. They also had an increased risk of pre-eclampsia, placenta praevia, placental abruption and low birthweight babies. More women had repeat abortion following surgical termination of pregnancy, and fewer went on to have a live birth in comparison with primigravid women and those who had medical terminations.

Table 2 Reproductive and perinatal outcomes following induced abortion, miscarriage or live birth in first pregnancy

	Outcome in first pregnancy			Crude and adjusted (Adj.) RR (99% CI)*	
	Induced abortion	**Live birth**	**Miscarriage**	**Induced abortion versus live birth**	**Induced abortion versus miscarriage**
Outcome of second pregnancy	N=120 033	N=457 477	N=47 355		
Live birth	67 336 (56.1)	355 674 (77.7)	36 479 (77.0)	Crude 0.72 (0.71 to 0.73) Adj. 0.74 (0.73 to 0.74)	Crude 0.72 (0.72 to 0.73) Adj. 0.69 (0.69 to 0.70)
Stillbirth	409 (0.34)	1406 (0.31)	247 (0.52)	Crude 1.11 (0.96 to 1.28) Adj. 1.06 (0.91 to 1.24)	Crude 0.65 (0.53 to 0.80) Adj. **0.58 (0.46 to 0.74)**
Miscarriage	7965 (6.6)	30 669 (6.7)	6197 (13.1)	Crude 0.99 (0.96 to 1.02) Adj. **1.05(1.01 to 1.08)**	Crude 0.51 (0.49 to 0.53) Adj. **0.56 (0.54 to 0.59)**
Ectopic pregnancy	1115 (0.9)	2939 (0.6)	499 (1.1)	Crude 1.45 (1.32 to 1.58) Adj. **1.36 (1.23 to 1.50)**	Crude 0.88 (0.77 to 1.01) Adj. **0.83 (0.71 to 0.97)**
Induced abortion	43 208 (36.0)	66 789 (14.6)	3933 (8.3)	Crude 2.47 (2.43 to 2.50) Adj. **2.30 (2.27 to 2.33)**	Crude 4.33 (4.16 to 4.51) Adj. **4.64 (4.44 to 4.85)**

	Outcome in first pregnancy				Crude and adjusted (Adj.) RR (99% CI)*		
	Induced abortion	**Live birth**	**Miscarriage**	**Primigravida**	**Induced abortion versus live birth**	**Induced abortion versus miscarriage**	**Induced abortion versus primigravida**
Outcomes in ongoing pregnancies	N=67 745	N=357 080	N=36 726	N=457 477			
Pre-eclampsia	1583 (2.3)	2982 (0.8)	922 (2.5)	8649 (1.9)	Crude 2.80 (2.58 to 3.03) Adj. **2.42 (2.21 to 2.65)**	Crude 0.93 (0.84 to 1.03) Adj. **0.83 (0.73 to 0.94)**	Crude 1.24 (1.15 to 1.32) Adj. **1.26 (1.17 to 1.35)**
Placenta praevia	385 (0.6)	1919 (0.5)	289 (0.8)	2042 (0.5)	Crude 1.06 (0.92 to 1.22) Adj. 1.09 (0.93 to 1.28)	Crude 0.72 (0.59 to 0.88) Adj. 0.79 (0.62 to 1.01)	Crude 1.27 (1.10 to 1.47) Adj. 1.05 (0.91 to 1.22)
Abruptio placenta	339 (0.5)	1197 (0.3)	173 (0.5)	1770 (0.4)	Crude 1.49 (1.27 to 1.75) Adj. **1.49 (1.25 to 1.77)**	Crude 1.06 (0.84 to 1.35) Adj. 1.00 (0.76 to 1.32)	Crude 1.30 (1.11 to 1.51) Adj. **1.28 (1.10 to 1.50)**
Induction of labour†	18 044 (26.6)	69 482 (19.5)	10 347 (28.2)	120 080 (26.3)	Crude 1.37 (1.34 to 1.39) Adj. **1.33 (1.30 to 1.35)**	Crude 0.95 (0.92 to 0.97) Adj. 0.98 (0.95 to 1.01)	Crude 1.01 (1.00 to 1.03) Adj. 1.00 (0.99 to 1.02)
Low birth weight <2500 g‡	5385 (8.0)	16 309 (4.6)	3101 (8.5)	28 735 (6.3)	Crude 1.74 (1.67 to 1.81) Adj. **1.24 (1.17 to 1.31)**	Crude 0.94 (0.89 to 1.00) Adj. 0.96 (0.90 to 1.03)	Crude 1.27 (1.22 to 1.31) Adj. **1.08 (1.04 to 1.13)**
Outcomes in spontaneous births	N=45 656	N=255 220	N=23 751	N=318 217			
Spontaneous preterm birth <37 weeks	4224 (9.3)	13 453 (5.3)	2376 (10.0)	21 891 (6.9)	Crude 1.76 (1.68 to 1.83) Adj. **1.66 (1.58 to 1.74)**	Crude 0.92 (0.86 to 0.97) Adj. **0.85 (0.79 to 0.91)**	Crude 1.35 (1.29 to 1.40) Adj. **1.37 (1.32 to 1.42)**
Spontaneous very preterm birth <32 weeks	878 (1.9)	2157 (0.9)	513 (2.2)	4051 (1.3)	Crude 2.28 (2.05 to 2.52) Adj. **2.20 (1.96 to 2.47)**	Crude 0.89 (0.77 to 1.03) Adj. **0.83 (0.70 to 0.99)**	Crude 1.51 (1.37 to 1.66) Adj. **1.57 (1.43 to 1.72)**

Values are n (%) unless otherwise specified. Statistically significant relative risks are shown as bold.
*Adjusted for maternal age, year of delivery, Carstairs at first pregnancy and interpregnancy interval.
†Further adjusted for pre-eclampsia, placenta praevia and abruptio placenta.
‡Low birth weight also adjusted for gestational age.

Table 3 Demographic characteristics of women who had induced abortion, live birth or miscarriage after an initial live birth

	Outcome in second pregnancy following an initial live birth				
	Induced abortion (N=30 527)	Live birth (N=125 855)	p Value	Miscarriage (N=22 404)	p Value
Mean age (SD)	26.04 (5.85)	26.15 (4.68)	<0.001	28.41 (5.42)	0.001
Carstairs category* †					
1	3523 (12.8)	20 264 (16.5)	<0.001	4498 (20.9)	<0.001
2	4304 (15.6)	21 985 (17.9)		4079 (18.9)	
3	5186 (18.8)	23 425 (19.0)		4312 (20.0)	
4	6243 (22.6)	25 979 (21.1)		4447 (20.6)	
5	8370 (30.3)	31 395 (25.5)		4235 (19.6)	
Smoking status†					
Never	393 (39.7)	32 464 (48.5)	<0.001	3165 (46.1)	0.001
Current	313 (31.6)	20 658 (30.9)		1169 (17.0)	
Former	43 (4.3)	5359 (8.0)		282 (4.1)	
Not known	241 (24.3)	8482 (12.7)		2243 (32.7)	
Total	990	66 963		6859	
Missing	29 537 (96.8)	58 892 (46.8)		15 545 (69.4)	
Interpregnancy interval					
Median (IQR)	108 (61–209)	152 (96–256)	<0.001	60 (48–87)	<0.001

Values are n (%) unless otherwise specified.
*Carstairs categories: 1= least deprived, 5= most deprived.
†Percentage based on available information for each group.

Table 6 summarises the risk of spontaneous preterm delivery in subsequent pregnancies following one or more consecutive IAs in comparison with those with no previous abortions (primigravid women). The adjusted RRs of spontaneous preterm birth (<37 weeks) was incrementally higher in women undergoing one, two, three and four IAs. The adjusted RRs of spontaneous very preterm delivery (<32 weeks) was higher after one and four IAs, while the adjusted RRs of spontaneous extremely preterm delivery (<28 weeks) was higher following two and four previous IAs. Additional IAs were not associated with increased adjusted RRs of any type of spontaneous preterm birth.

DISCUSSION

Principal findings

Our results suggest that women who had an IA in the first pregnancy were more at risk of maternal and perinatal risks in comparison with women with a previous live birth. Compared with an initial miscarriage, an IA in a first pregnancy was associated with a higher subsequent risk of miscarriage or ectopic pregnancy, IA and pre-eclampsia. Women with a previous IA face increased risks of antepartum haemorrhage and spontaneous preterm birth than women in their first pregnancy.

A live birth prior to an IA does not appear to be associated with reduced perinatal complications in women who are at higher risk of spontaneous preterm birth than primigravida. Surgical termination appears to be associated with a higher chance of spontaneous preterm birth than medical IA. There does not appear to be a dose-dependent effect of IA on future adverse perinatal outcomes. Women with three or four consecutive IAs were not at significantly higher risk of spontaneous preterm birth in comparison with women who have had one termination of pregnancy.

Strengths

To our knowledge, this is the largest population-based study of reproductive outcomes following an IA. Registry-based previous studies reporting preterm birth rates as an outcome have been unable to discriminate between spontaneous and induced preterm delivery; this is one of the first papers to be able to calculate and report spontaneous preterm birth rates after IA.

We have acknowledged changes in clinical practice over the years during which data were collected and have adjusted for year of pregnancy in the regression models. The choice of an appropriate comparison group to women with a history of IA is problematic. Women who are pregnant again after having undergone an IA in a previous (first) pregnancy are gravida 2 and parity 0. It is impossible to control for both gravidity and parity unless the unexposed cohort have had a prior pregnancy, which did not lead to a delivery. Other comparison groups can be either women in their first ongoing pregnancies (gravidity 1 parity 0) or in their second ongoing pregnancies after a previous delivery (gravidity 2 parity 1). We feel that our strategy comparing the exposed cohort with all three of the above groups adds validity to our results.

Limitations

The main limitations of this study stem from unrecorded and missing data in relation to certain potential confounding factors within the data set. For example, smoking data were only available for 50% of women;

Table 4 Reproductive and perinatal outcomes in women who had induced abortion, live birth or miscarriage following a live birth in the first pregnancy

	Outcome of second pregnancy			Induced abortion versus live birth	Induced abortion versus miscarriage
	Induced abortion	Live birth	Miscarriage		
Outcome of third pregnancy	N=30 527	N=125 855	N=22 404	Crude and adjusted (Adj.) RR (99% CI)*	
Live birth	18 562 (60.8)	85 014 (67.5)	17 745 (79.2)	Crude 0.90 (0.89 to 0.91)	Crude 0.77 (0.76 to 0.78)
				Adj. 0.88 (0.87 to 0.89)	Adj. 0.77 (0.76 to 0.78)
Stillbirth	84 (0.3)	426 (0.3)	69 (0.3)	Crude 0.81 (0.60 to 1.11)	Crude 0.89 (0.59 to 1.36)
				Adj. 0.76 (0.55 to 1.06)	Adj. 0.86 (0.54 to 1.37)
Miscarriage	2005 (6.6)	8778 (7.0)	2869 (12.8)	Crude 0.94 (0.89 to 1.00)	Crude 0.51 (0.48 to 0.55)
				Adj. **0.93 (0.88 to 1.00)**	Adj. **0.67 (0.62 to 0.72)**
Ectopic pregnancy	339 (1.1)	1064 (0.9)	181 (0.8)	Crude 1.31 (1.12 to 1.54)	Crude 1.38 (1.09 to 1.74)
				Adj. **1.31 (1.11 to 1.56)**	Adj. 1.16 (0.90 **to** 1.50)
Induced abortion	9537 (31.2)	30 573 (24.3)	1540 (6.9)	Crude 1.29 (1.25 to 1.32)	Crude 4.55 (4.25 to 4.86)
				Adj. **1.33 (1.30 to 1.37)**	Adj. **4.37 (4.06 to 4.70)**
Outcomes in ongoing pregnancies	N=18 646	N=85 440	N=17 814	Crude and adjusted (Adj.) RR (99% CI)†	
Pre-eclampsia	144 (0.8)	567 (0.7)	165 (0.9)	Crude 1.16 (0.92 to 1.48)	Crude 0.83 (0.62 to 1.12)
				Adj. **1.40 (1.10 to 1.79)**	Adj. 0.91 (0.66 to 1.27)
Placenta praevia	183 (1.0)	473 (0.6)	133 (0.8)	Crude 1.77 (1.42 to 2.22)	Crude 1.32 (0.98 to 1.76)
				Adj. **1.78 (1.40 to 2.25)**	Adj. 1.34 (0.97 to 1.84)
Abruptio placenta	91 (0.5)	325 (0.4)	66 (0.4)	Crude 1.28 (0.95 to 1.74)	Crude 1.32 (0.87 to 2.00)
				Adj. 1.28 (0.93 to 1.77)	Adj. 1.32 (0.83 to 2.10)
Induction of labour‡	4298 (23.1)	18 239 (21.4)	3968 (22.3)	Crude 1.08 (1.04 to 1.12)	Crude 1.03 (0.98 to 1.09)
				Adj. **1.11 (1.07 to 1.16)**	Adj. 1.01 (0.96 to 1.07)
Low birth weight <2500§	1086 (5.8)	3905 (4.6)	784 (4.4)	Crude 1.28 (1.17 to 1.39)	Crude 1.32 (1.17 to 1.49)
				Adj. **1.36 (1.21 to 1.51)**	Adj. 1.04 (0.90 to 1.21)
Outcomes in spontaneous births	N=12 868	N=59 220	N=12 056		
Spontaneous preterm birth <37 weeks	859 (6.7)	3035 (5.1)	644 (5.3)	Crude 1.30 (1.18 to 1.43)	Crude 1.25 (1.10 to 1.42)
				Adj. **1.27 (1.14 to 1.40)**	Adj. 1.14 (0.99 to 1.32)
Spontaneous very preterm birth <32 weeks	162 (1.3)	495 (0.8)	104 (0.9)	Crude 1.51 (1.19 to 1.90)	Crude 1.46 (1.06 to 2.01)
				Adj. **1.44 (1.12 to 1.84)**	Adj. **1.35 (0.93 to 1.96)**

Values are n (%) unless otherwise specified. Statistically significant relative risks are shown in bold.
*Adjusted for age, year of delivery, Carstairs at second pregnancy and interpregnancy interval.
†Adjusted for maternal age, year of pregnancy, Carstairs category at second pregnancy and interpregnancy interval.
‡Further adjusted for pre-eclampsia, placenta praevia and abruptio placenta.
§Low birth weight also adjusted for gestational age.

Table 5 Reproductive outcomes following medical and surgical abortion

Reproductive outcomes in next (2nd) pregnancy	Primigravida N=457 477	Medical termination in first pregnancy N=16 702	Surgical termination in first pregnancy N=52 560	RR	Medical vs Primigravida crude and adjusted (Adj.) RR (99% CI)*	Surgical vs Primigravida crude and adjusted (Adj.) RR (99% CI)*	Surgical vs medical induced abortion crude and adjusted (Adj.) RR (99% CI)*
Live birth	355 674 (77.7)	9785 (58.6)	28 285 (53.8)	Crude	0.75 (0.74 to 0.77)	0.69 (0.69 to 0.70)	0.92 (0.90 to 0.94)
				Adj.	**0.71 (0.70 to 0.73)**	**0.76 (0.75 to 0.77)**	**1.44 (1.41 to 1.48)**
Still birth	1406 (0.3)	57 (0.3)	151 (0.3)	Crude	1.11 (0.79 to 1.57)	0.93 (0.75 to 1.17)	0.84 (0.56 to 1.26)
				Adj.	1.15 (0.80 to 1.64)	0.95 (0.73 to 1.23)	0.98 (0.57 to 1.69)
Miscarriage	30 669 (6.7)	1200 (7.2)	3723 (7.1)	Crude	1.07 (1.00 to 1.15)	1.06 (1.01 to 1.10)	0.99 (0.91 to 1.07)
				Adj.	0.98 (0.91 to 1.06)	1.03 (0.98 to 1.08)	**1.45 (1.30 to 1.62)**
Ectopic	2939 (0.6)	120 (0.7)	599 (1.1)	Crude	1.12 (0.88 to 1.42)	1.77 (1.58 to 1.99)	1.59 (1.23 to 2.05)
				Adj.	0.99 (0.78 to 1.28)	**1.80 (1.58 to 2.06)**	**1.78 (1.29 to 2.45)**
Induced abortion	66 789 (14.6)	5540 (33.2)	19 802 (37.7)	Crude	2.27 (2.21 to 2.34)	2.58 (2.54 to 2.63)	1.14 (1.10 to 1.17)
				Adj.	**3.01 (2.91 to 3.12)**	**2.00 (1.96 to 2.04)**	**0.44 (0.42 to 0.46)**
Outcome in ongoing pregnancy§	N=457 477	N=9842	N=28 436				
Pre-eclampsia	8649 (1.9)	316 (3.2)	688 (2.4)	Crude	1.70 (1.47 to 1.96)	1.28 (1.16 to 1.42)	0.75 (0.63 to 0.90)
				Adj.	1.01 (0.86 to 1.17)	**1.14 (1.03 to 1.27)**	1.12 (0.90 to 1.39)
Placenta praevia	2042 (0.5)	23 (0.2)	248 (0.9)	Crude	0.52 (0.31 to 0.90)	1.95 (1.64 to 2.32)	3.73 (2.13 to 6.54)
				Adj.	0.81 (0.47 to 1.40)	**1.63 (1.36 to 1.95)**	**2.23 (1.17 to 4.26)**
Abruptio placentae	1770 (0.4)	40 (0.4)	160 (0.6)	Crude	1.05 (0.70 to 1.58)	1.45 (1.18 to 1.80)	1.38 (0.88 to 2.18)
				Adj.	**1.65 (1.08 to 2.52)**	**1.54 (1.24 to 1.91)**	1.09 (0.63 to 1.88)
Birth weight† <2500 g	28 735 (6.3)	697 (7.1)	2407 (8.5)	Crude	1.13 (1.03 to 1.24)	1.35 (1.28 to 1.42)	1.19 (1.07 to 1.33)
				Adj.	1.05 (0.94 to 1.17)	**1.16 (1.08 to 1.23)**	1.12 (0.97 to 1.28)
Spontaneous births§	**N=318 217‡**	**N=6474‡**	**N=18 126‡**				
Preterm <37 weeks	21891 (6.9)	533 (8.2)	1768 (9.8)	Crude	1.20 (1.07 to 1.33)	1.42 (1.34 to 1.51)	1.18 (1.05 to 1.34)
				Adj.	1.11 (0.99 to 1.24)	**1.45 (1.37 to 1.55)**	**1.25 (1.07 to 1.45)**
Very preterm <32 weeks	4051 (1.3)	123 (1.9)	363 (2.0)	Crude	1.49 (1.18 to 1.89)	1.57 (1.37 to 1.81)	1.05 (0.81 to 1.38)
				Adj.	1.25 (0.98 to 1.60)	**1.62 (1.41 to 1.87)**	1.13 (0.81 to 1.58)
Very preterm <28 weeks	1349 (0.4)	35 (0.5)	120 (0.7)	Crude	1.27 (0.82 to 2.00)	1.56 (1.22 to 2.00)	1.23 (0.75 to 2.01)
				Adj.	0.91 (0.58 to 1.44)	**1.62 (1.27 to 2.07)**	1.38 (0.73 to 2.61)

Values are n (%) unless otherwise specified. Statistically significant relative risks are shown as bold.
*All relative risks comparing medical vs surgical have been adjusted for maternal age, year of event, Carstairs category at the previous & interpregnancy interval.
†Low birth weight also adjusted for gestational age.
‡Only spontaneous delivery considered among live & still birth.
§All relative risks comparing primigravida vs medical/surgical have been adjusted for maternal age, year of event, Carstairs category at the ongoing pregnancy.

Table 6 Risk of spontaneous preterm delivery following increasing number of induced abortions

	PTD <37 weeks		PTD <32 weeks		PTD <28 weeks	
	Crude RR (99% CI)	Adj.RR (99% CI)*	Crude RR (99% CI)	Adj RR (99% CI)	Crude RR (99% CI)	Adj RR (99% CI)
1 Previous abortion vs 0	1.50 (1.41 to 1.59)	**1.47 (1.38 to 1.57)**	1.70 (1.47 to 1.96)	**1.59 (1.37 to 1.84)**	1.44 (1.09 to 1.87)	1.24 (0.94 to 1.64)
2 Previous abortions vs 0	1.55 (1.32 to 1.81)	**1.51 (1.29 to 1.77)**	1.48 (1.00 to 2.19)	1.34 (0.91 to 2.00)	2.27 (1.31 to 3.94)	**1.89 (1.08 to 3.31)**
3 Previous abortions vs 0	1.55 (1.04 to 2.31)	**1.52 (1.01 to 2.27)**	1.81 (0.74 to 4.46)	1.64 (0.67 to 4.06)	1.36 (0.22 to 8.37)	**1.12 (0.18 to 6.96)**
4 Previous abortions vs 0	2.13 (1.26 to 3.64)	**2.10 (1.23 to 3.59)**	4.62 (1.91 to 11.19)	**4.27 (1.76 to 10.37)**	6.94 (1.95 to 24.72)	**5.96 (1.65 to 21.37)**
2 Previous abortions vs 1	1.03 (0.87 to 1.22)	1.02 (0.86 to 1.21)	0.87 (0.57 to 1.31)	0.84 (0.56 to 1.28)	1.58 (0.86 to 2.89)	1.52 (0.83 to 2.78)
3 Previous abortions vs 2	1.00 (0.65 to 1.54)	1.01 (0.66 to 1.55)	1.23 (0.46 to 3.27)	1.22 (0.46 to 3.26)	0.60 (0.09 to 3.99)	0.60 (0.09 to 3.97)
4 Previous abortions vs 3	1.38 (0.71 to 2.68)	1.38 (0.71 to 2.70)	2.55 (0.72 to 9.01)	2.60 (0.74 to 9.18)	5.10 (0.56 to 46.78)	5.29 (0.58 to 48.70)

Statistically significant relative risks are shown as bold.
PTD, preterm delivery.
*Adjusted for maternal age, year of delivery, Carstairs at first pregnancy and interpregnancy interval.

data on body mass index were unavailable, while data on gestational age at termination was missing in the majority of cases. The actual method of termination (medical vs surgical) was unrecorded in around 25% of all cases, while a large number of women appeared to have both medical and surgical treatment. Parity number was less reliable in the early years of data collection. This may reflect problems with coding and could potentially affect the quality of our results. In addition, the analysis of such a large population-based data set has the capacity to produce statistically significant differences, which may or may not be clinically relevant, although this has been minimised by our use of a stringent 1% significance level throughout.

Defining an ideal reference group is a challenge in studies exploring outcomes after IA. While we have partially addressed this issue by using more than one unexposed cohort, our data do not allow us to adjust for potential differences in pregnancy intentions between groups, which can impact on antenatal care and perinatal outcomes.

Unrecorded data relating to key potential confounders cannot exclude the possibility that some associations are not explained by abortion itself but by special circumstances of women seeking abortion, which also increases their risk of complications in pregnancy. We ran a separate analysis to identify previous pregnancy complications in women who had an IA, a miscarriage or a live birth in their second pregnancy. As supplementary table A shows, IA in the second pregnancy was not significantly associated with increased RR (99% CI) of pre-eclampsia, placenta praevia, placental abruption and low birth weight, respectively, compared with live birth (0.99 (0.85 to 1.16), 1.29 (0.99 to 1.67), 1.32 (0.96 to 1.82) and 1.08 (0.98, 1.18)) or miscarriage (0.79 (0.65 to 0.96), 1.17 (0.81 to 1.69), 1.08 (0.70 to 1.68) and 1.14 (1.00 to 1.30)).

Comparison with previous studies

The association between IA and preterm birth found in this study is consistent with previously published work.[32] Two recent meta-analyses suggest that women who have had an IA are at higher risk of preterm birth in subsequent pregnancies.[33 34] Our study shows that after adjustment women with a previous abortion have an increased chance of a subsequent preterm birth and very preterm birth compared with primigravidae or those who have had a previous live birth, but at no significantly greater risk compared with women who have had a previous miscarriage. Women who had a live birth before an IA are more likely to have a preterm birth compared with women with two previous live births.

Our results did not suggest a significant increased risk of miscarriage after an IA, which is in keeping with a review of literature.[21] In contrast, Sun et al (2003)[35] demonstrated an association between surgical abortion and miscarriage in a subsequent pregnancy. Literature on the association between IA and miscarriage or ectopic pregnancy is sparse and conflicting. The increased risk

of having a second termination following IA in a first pregnancy highlighted in our study has been reported elsewhere.[36–38] While women who had an abortion were more likely to have a subsequent abortion, but they may also be more likely to have an unintended pregnancy. This should be seen a potential risk factor, which should be explored in future studies.

Available literature suggests that there is an association between IA and placenta praevia,[39 40] but no association with abruptio placenta.[41 42] This study found that women in their second pregnancy after an initial IA in the first were at higher odds of both placenta praevia and abruptio placenta; women in their third pregnancy after an IA in their second pregnancy had higher odds of placenta praevia but not abruptio placenta. Published evidence supports a decreased risk of pre-eclampsia after an IA.[43 44] Our results suggest a risk of developing pre-eclampsia, which is on par with primigravid women, but lower than women with a previous miscarriage. The reasons for these associations are unclear, and hence any explanations can only be speculative. Problems with placental position and function could occur due to disruption of the endometrium by vigorous curettage. The quality of placental function in a previous pregnancy could influence susceptibility to future pre-eclampsia.

Since the introduction of medical abortion, there has been much speculation about the rival merits of medical and surgical techniques, especially in terms of future reproductive outcomes. Analysis of Danish data has failed to demonstrate a difference in key outcomes, such as preterm birth between medical and surgical abortion, but this study was unable to identify spontaneous versus induced preterm birth.[30] With our ability to identify spontaneous preterm births we have shown a clear association with surgical abortion. However, since we were unable to adjust for gestational age, we cannot rule out the possibility that surgical abortions may have been performed at a more advanced stage of pregnancy requiring a greater degree of cervical dilatation, thus leading to future preterm labour. Our results are supported by a recent publication showing that the risk of preterm birth after one or more surgical abortions is higher than after medical abortion and comparable to that in primigravid women.[11]

A dose-dependent relationship between the number of IAs and future PTB has been shown in a number of previous studies.[32] The results of our analysis do not support this. Given our inability to adjust for a number of potential confounders, this needs to be investigated further.

Our data suggest that medical and surgical terminations may impact differently on future reproductive outcomes, with a higher risk of spontaneous preterm birth after surgery. We were unable to disentangle the separate effects of repeated medical and surgical abortion due to a relative paucity of numbers.

A recent publication[11] found an increased risk of premature delivery following multiple surgical, but not first trimester, medical IAs. While this could reflect the effect of repeated surgical trauma to the cervix, this needs further exploration in future studies with long-term periods of follow-up.

A key challenge in studying health sequelae after IA is to deal with potential differences in pregnancy intentions between comparison groups. While women who had an abortion were more likely to have a subsequent abortion, they may also be more likely to have an unintended pregnancy, which needs to be acknowledged as a potential risk factor in future studies.

CONCLUSIONS

IA in a first pregnancy is associated with a higher risk of spontaneous preterm birth in a subsequent pregnancy in comparison with primigravid women but not in women with a previous miscarriage. A successful pregnancy leading to a live birth prior to an IA does not appear to ameliorate this risk, while more than one abortion does not significantly increase it. Surgical, but not medical abortion appears to be associated with an increased risk of spontaneous very preterm birth in comparison with primigravid women. The results of this study should help provide women as well as health professionals with accurate information to inform clinical decision-making and tailor antenatal care to address women's risk profiles.

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Contributors AT conceived the idea for the study. SB was the principal investigator. He designed the study along with SohB, AT, AJL and TM, led the funding application, managed the project, interpreted the results and wrote the first draft of the paper. AL cleaned the data and performed some of the initial analyses. SohB cowrote the funding application, facilitated data manipulation, interpreted the results and helped to draft the paper. EAR performed the statistical analysis and interpreted the results with input from AJL. All authors commented on, and contributed to the final draft of the paper.

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Reproductive outcomes following induced abortion: a national register-based cohort study in Scotland

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