MSc Epidemiology

Associations between mode of delivery and maternal sexual outcomes: a longitudinal study using the ALSPAC cohort

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Dissertation Declaration

I declare that the work in this report was carried out in accordance with the requirements of the University's Regulations and Code of Practice for Taught Programmes and that it has not been submitted for any other academic award. Except where indicated by specific reference in the text, this work is my own work. Work done in collaboration with, or with the assistance of others, is indicated as such. I have identified all material in this report which is not my own work through appropriate referencing and acknowledgement. Where I have quoted from the work of others, I have included the source in the references/bibliography. Any views expressed in the dissertation are those of the author.

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Summary

Background Sexual function is an important component of overall wellbeing. Studies investigating the association between mode of delivery and subsequent sexual function have produced evidence limited to the immediate postpartum period and outcomes such as dyspareunia (pain during sex) as opposed to sexual enjoyment. We aimed to use the Avon Longitudinal Study of Parents And Children (ALSPAC) cohort to explore the potential association between mode of delivery and sexual enjoyment and frequency at 18 years postpartum.

Methods We analysed data collected on ALSPAC mothers via a self-report questionnaire sent out at 18 years after the birth of the index child regarding their sexual enjoyment and frequency. Women were categorised based on their mode of delivery ascertained from linked medical records: types of vaginal delivery or caesarean section (CS). Sexual enjoyment and frequency were then binarized and investigated using multivariable logistic regression analysis.

Findings Of the 15 423 women in ALSPAC, 3 797 responded to one or both outcome-related questions at 18 years postpartum. Of the women who had delivered via CS, 91·2% reported that they enjoyed sex as opposed to 89·3% of women who experienced a vaginal delivery [adjusted odds ratio (aOR) =1·46 (95%CI: 0·91–2·34)]. There was no difference in sexual frequency between vaginal delivery and CS [aOR=1·04 (95%CI: 0·82–1·33)]. There was also no difference in either outcome between women who had an instrumental and non-instrumental vaginal delivery.

Interpretation There was weak evidence to suggest that mode of delivery was associated with sexual enjoyment at 18 years postpartum in the adjusted analysis. These findings provide a longer-term perspective using robust methods using UK data where sexual enjoyment was used as an outcome, rather than pain during sex.

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1 Introduction

Sexual health is an important part of a person's wellbeing, as defined by the World Health Organisation;[1] sexual function decline has been plausibly linked to vaginal delivery due to the potential for mechanistic harm to the perineum and pelvic floor.[2] Caesarean section (CS) has been increasing drastically in the UK, with rates as low as 9% in 1980 climbing to 24·6% in 2008–09.[3] One US study found that one perceived benefit of CS is reduced impact on sexual function[4] and a UK-based survey found that obstetricians would choose a CS for themselves in order to preserve sexual function.[5] Other studies have found that instrumental vaginal deliveries result in poorer sexual outcomes due to increased trauma of surrounding muscles than spontaneous vaginal deliveries.[6,7] It is essential to understand the impact of mode of delivery on subsequent maternal outcomes including sexual health.

Despite the qualitative evidence to support that CS is protective of sexual function compared with types of vaginal delivery, the observational evidence is sparse for long-term sexual enjoyment.[8,9] The majority of the literature focuses on sexual pain and uses short follow-up times or a cross-sectional design in the early postpartum period, meaning the long-term effects of mode of delivery on sexual outcomes are impossible to determine.

Here, the Avon Longitudinal Study of Parents and Children (ALSPAC) cohort was used to perform a longitudinal study of mode of delivery on sexual enjoyment and frequency at 18 years postpartum. Pregnant women in the county of Avon were recruited via engagement with various study promotional material in antenatal clinics (among others).[10] Questionnaires were subsequently sent out to participating women before and after the birth of their child to gather information on themselves and their families. Data collected on sexual enjoyment and frequency were abstracted from the questionnaire sent out at 18 years postpartum and women were categorised by their mode of delivery. The primary objective of this study was to explore the association between mode of delivery, vaginal delivery or CS, and sexual enjoyment and frequency. The secondary objective was to understand if an association exists between instrumental vaginal delivery and sexual outcomes, as compared with non-instrumental vaginal delivery.

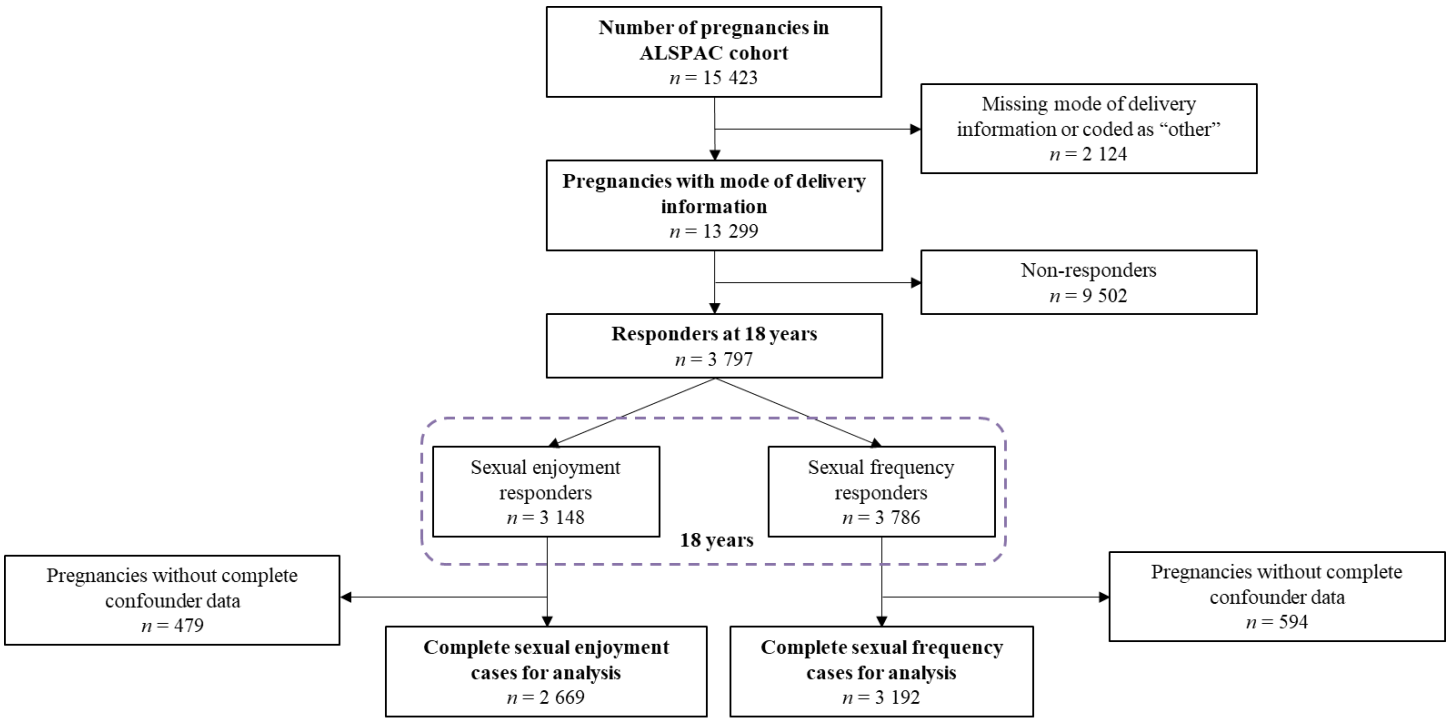
2 Methods

2.1 Participants and recruitment

ALSPAC is a large prospective cohort of women and their children and partners, recruited in the early nineties and followed up over the subsequent two decades. The study originally

recruited 14 541 women who were due to give birth between 1st April, 1991 and 21st December, 1992; a further 913 women who fitted the eligibility criteria have been recruited since. There have been previous publications describing the cohort in full,[11] as well as online resources via the ALSPAC website for exploring the data.[12] Of the 15 423 pregnant mothers' in this sample[1], 13 299 women had delivery information available who had not withdrawn from the study. The study population was then further restricted to women who had responded to either one of the questions relating to sex in the 18 years postpartum questionnaire. Women with missing mode of delivery or confounder data were excluded (Figure 1).

Figure 1 Flow diagram of participants through the study.



2.2 Ethics statement

Ethical approval for this study was obtained from the ALSPAC Ethics and Law Committee and the local Research Ethics Committee (North Somerset and South Bristol). The mothers enrolled in this cohort gave consent to approved researchers to use their answers to completed questionnaires in subsequent research. Permission was given on an individual basis for clinical, obstetric data to be obtained from Hospital Episode Statistics (HES) data. Mothers enrolled in ALSPAC had the right to withdraw from the cohort at any time during follow-up.

[1] This number differs from the ALSPAC publication checklist by $n = 31$ due to potential subsequent withdrawal of consent.

2.3 Measures

2.3.1 Mode of delivery

Mode of delivery was abstracted from routine antenatal records for women who had indicated at recruitment that they consented to having their medical records obtained for the ALSPAC dataset. Mode of delivery was categorised into spontaneous vaginal delivery (SVD), CS, assisted breech, breech extraction, forceps, vacuum extraction and other. Women with mode of delivery recorded as "other" were excluded (Figure 1), as categorisation into vaginal delivery or CS for analysis could not be determined by this label. For the primary objective, mode of delivery was dichotomised into vaginal delivery (SVD, breech extraction and assisted, forceps and vacuum) and CS. Further stratification of vaginal delivery into instrumental (forceps and vacuum deliveries) and non-instrumental (SVD and both breech deliveries) was performed for the secondary objective.

2.3.2 Maternal sexual outcomes

Maternal sexual outcomes were measured by self-report questionnaire sent out to participants at various timepoints. Originally, it had been proposed to examine outcomes at approximately 1, 5 and 20 years. Due to the paucity of literature regarding mode of delivery and sexual outcomes outside of the immediate postpartum period, I decided to focus solely on the 18-year timepoint.

Women were asked if they enjoyed sexual intercourse in a five-level categorical variable: "yes, very much", "yes, somewhat", "no, not a lot", "no, not at all", and "no sex at the moment". For women who gave the final response "no sex at the moment" it was uncertain as to why women were not having sex at that time: either they were not having sex because of lack of enjoyment or had not recently had sex so did not know if they enjoyed sex. Given the potential for outcome misclassification, these women were excluded from the analysis.

Sexual frequency was assessed using six categories: "not at all", "less than once a month", "1–3 times a month", "about once a week", "2–4 times a week", and "5 or more times a week".

Both categorical variables were dichotomised for use in multivariable logistic regression, as covered in the master's course. Sexual enjoyment was binarized, combining "yes very much" with "yes somewhat" and "no not a lot" with "no not at all". Sexual frequency was dichotomised *a priori* into less than once a week and once a week or more (halfway between categories); any method of defining a cut-off for this variable was deemed arbitrary. Further details discussed in supplementary material 7.1.

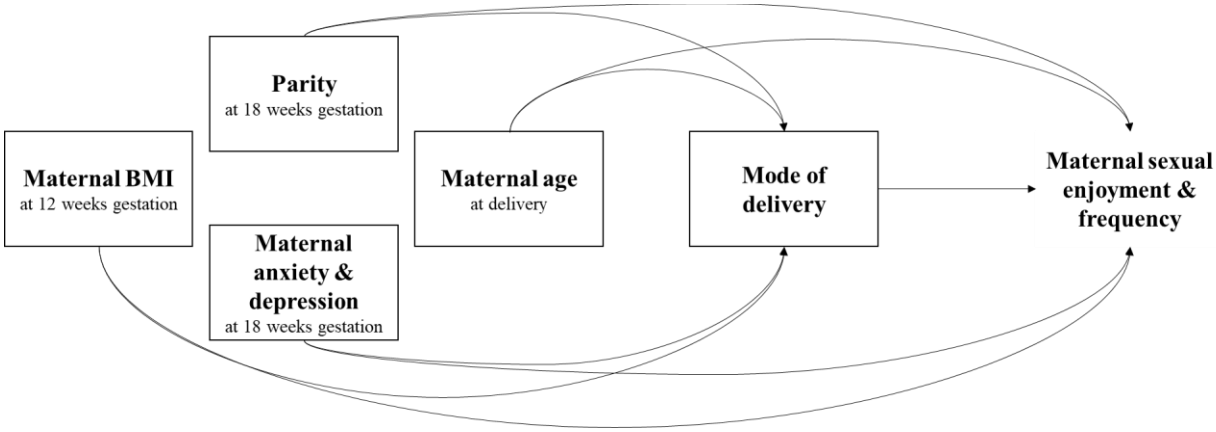
2.3.3 Other variables

Confounders were identified *a priori* from published literature as factors that may have affected both mode of delivery and subsequent sexual outcomes. Maternal health comprises a large proportion of the confounding structure in this study: maternal age, body mass index (BMI), parity and mental health problems (namely prenatal depression and anxiety) were identified as potential confounders.

Maternal age has been shown to affect mode of delivery, with older mothers at increased risk of an operative delivery;[13] studies have also shown that sexual activity increases towards the end of the child-bearing window.[14] Maternal BMI is a strong determinant of mode of delivery, with overweight and obese expectant mothers more likely to experience a CS.[15] Evidence suggests obese women place less importance on their sexuality as part of their personal life balance.[16] Increasing parity has been shown in ALSPAC to be associated with a decreased risk of CS.[17] Pregnancy is a time in a woman's life when she is more vulnerable to mental health challenges due to somatic changes;[18] this can influence perception and sometimes practice of childbirth. Mental health problems, specifically depression and anxiety, were identified as potential confounders due to their association with lowered sexual desire and replacement of pleasure with feelings of fear.[19]

In ALSPAC, the patient characteristic data were collected over the course of the pregnancy at various timepoints, via questionnaire. Data were also abstracted from routine antenatal clinics. Maternal BMI at 12 weeks gestation and maternal age at delivery were used. Parity was obtained at 18 weeks gestation, as was maternal depression and anxiety status using the Edinburgh Postnatal Depression Scale[20] (EPDS) score and Crown Crisp Experimental Index[21] (CCEI) score, respectively. Other patient characteristics were obtained from ALSPAC for descriptive purposes: hypertensive disorder and diabetes status (abstracted from antenatal clinic data), as well as maternal education attainment at 32 weeks gestation (Section 7.1). These were not deemed confounders in this analysis due to the lack of evidence of an association with both the exposure and the outcome in this study.

Figure 2 Diagram showing the relationship between the outcomes (maternal sexual enjoyment and frequency), exposure (mode of delivery) and chosen measured confounders (maternal BMI measured at 12 weeks gestation), parity, maternal anxiety and depression (measured at 18 weeks gestation) and maternal age at delivery.



2.4 Data analysis

A complete case analysis (CCA) was used on pregnancies with complete data for chosen confounders; the analysis was restricted to women with complete information on variables included in the analysis, as defined by Hughes *et al.*[22] There were different women with complete confounder data for each outcome, thus the complete cases for each outcome were analysed separately. Complete cases in each outcome group were initially described in terms of their characteristics, stratified by vaginal delivery and CS, then compared using Chi-squared tests.

Multivariable logistic regressions were performed to assess whether enjoyable and frequent sexual intercourse was experienced by women who had undergone a CS, as compared with vaginal delivery, at 18 years postpartum. A crude analysis was performed, generating odds ratios (OR) for reporting to enjoy sex or have sex once or more per week in CS compared with vaginal delivery. Then, an adjusted model was run, including the covariates maternal age at delivery, maternal BMI recorded at 12 weeks gestation and parity, EPDS score and CCEI score all recorded at 18 weeks gestation, as defined *a priori* (Figure 2). For the secondary objective, both crude and adjusted analyses were performed comparing sexual enjoyment and frequency between instrumental and non-instrumental vaginal deliveries.

All analyses were completed in Stata (version 15·1) (StataCorp, College Station, TX USA).

3 Results

3.1 Study sample

Of the original cohort, 13 299 women had mode of delivery information and 3 797 (24·6% of the sample) had responded to either question at 18 years postpartum (Figure 1). Table 1 reports the characteristics of women with complete data for sexual enjoyment, stratified by either vaginal delivery or CS (see Table S1 for characteristics of complete cases for sexual frequency). Women who underwent a CS tended to be older, with an average age of 30·3 years (versus 29·2 in vaginal delivery); mothers who gave birth via CS also had a higher average BMI (24·2 in CS versus 22·5 in vaginal delivery). More women who underwent a CS had hypertension (34·9% in CS versus 15·8% in vaginal delivery) and diabetes (5·2% in CS versus 3·3% in vaginal delivery). Women who underwent a CS were more likely to be nulliparous at the time of their pregnancy with the index child (56·1% in CS vs 46·3% in vaginal delivery).

Participation rate at 18 years postpartum in ALSPAC was 28·6% for at least one response to a sexual outcome related question for women with delivery information available (n =13 299). In this cohort, responders were more likely to be older and have attained A-levels or above, as compared with non-responders. They were also less likely to be anxious or depressed and have more than one child (Table S2).

Table 1 Characteristics of complete case (for sexual enjoyment) mothers ($\boldsymbol{n}$ = 2 669) who gave birth via vaginal delivery and caesarean section.

	Vaginal delivery n (%) (unless otherwise specified)	**Caesarean section n (%)** (unless otherwise specified)	***p*-value**
Complete cases (sexual enjoyment)	**2 400**	**269**	
Maternal age at delivery			
Mean age, years (SD[1])	29·2 (4·2)	30·3 (4·3)	
Median age, years (IQR[2])	29 (26 – 32)	30 (27 – 33)	0·009
Maternal BMI[3] (12 weeks gestation)			
Mean BMI kg/m^2 (SD[1])	22·5 (3·4)	24·2 (4·5)	
Median BMI kg/m^2 (IQR[2])	21·9 (20·4 – 23·8)	23·1 (21·3 – 25·8)	<0·001
EPDS[4] score (18 weeks gestation)			
Probable depression (score ≥ 13)	234 (9·8)	26 (9·7)	0·965
CCEI[5] score (18 weeks gestation)			
Probable anxiety (score ≥ 8)	312 (13·0)	25 (9·3)	0·083
Parity (18 weeks gestation)			
0	1 111 (46·3)	151 (56·1)	
1	899 (37·5)	79 (29·4)	
2	304 (12·7)	28 (10·4)	
≥ 3	86 (3·6)	11 (4·1)	0·021
Maternal education (32 weeks gestation)			
CSE[6]	201 (8·4)	27 (10·0)	
Vocational	147 (6·1)	15 (5·6)	
O-level[6]	855 (35·6)	90 (33·5)	
A-level	697 (29·0)	88 (32·7)	
Degree	483 (20·1)	51 (19·0)	
Missing	17 (0·7)	<5[7]	0·631
Hypertensive disorder			
High blood pressure noted during pregnancy	379 (15·8)	94 (34·9)	
Missing	19 (0·8)	<5[7]	<0·001
Diabetes			
Diabetes or glycosuria noted during pregnancy	78 (3·3)	14 (5·2)	<0·001

[1] Standard deviation
[2] Interquartile range
[3] Body mass index
[4] Edinburgh postnatal depression scale (EPDS): threshold (≥ 13 for probable depression of varying degrees of severity) as determined by authors Cox *et al.* (1987) of the 10-item EPDS
[5] Crown Crisp Experimental Index (CCEI) for anxiety: threshold (≥ 8 for probable anxiety) as determined by authors Glover *et al*. (2004)
[6] CSEs (Certificate of Secondary Education) and O-levels were secondary school examinations taken by fifth year students in the UK between 1965 – 1987. These were subsequently replaced with GCSEs (General Certificate of Secondary Education) in 1988.
[7] This many include zero; denoted <5 as per the ALSPAC publication checklist.

3.2 Sexual enjoyment

Of the 2 669 women who answered the sexual enjoyment question at 18 years postpartum with complete data, 2 391 women (90%) reported that they enjoyed sexual intercourse. The overall prevalence of enjoying sex was 89% (n =2 143) and 91% (n =248) in vaginal delivery and CS, respectively.

Table 2 shows the crude and adjusted associations between mode of delivery and maternal sexual enjoyment at 18 years postpartum. In the crude analysis, women who underwent a CS were approximately 41% more likely to enjoy sex than women who had experienced a vaginal delivery, however the 95% confidence interval (CI) crossed one [OR=1·41 (95%CI: 0·89–2·25)].

In the multivariable analysis, having adjusted for maternal age (at delivery), maternal BMI (at 12 weeks gestation) and parity, depression and anxiety (at 18 weeks gestation), evidence for an association was weak. Delivering by CS conferred a 46% increase in odds of enjoying sex, compared with vaginal delivery, however the confidence interval spanned the null value [adjusted OR (aOR) =1·46 (95%CI: 0·91–2·34)] (Table 2).

3.3 Sexual frequency

Of the 3 192 women who answered the sexual frequency question at 18 years postpartum who had complete data on covariates, 1 318 women reported that they engaged in sexual intercourse ≥once per week. The overall prevalence of having sex ≥once a week was 42% (n =1 194) and 39% (n =124) in vaginal delivery and CS, respectively.

Table 2 shows the crude and adjusted associations between mode of delivery and maternal sexual frequency at 18 years postpartum. In the crude analysis, women who had undergone a CS were approximately 10% less likely to have sex ≥once a week compared with women who had experienced a vaginal delivery [OR=0·91 (95%CI: 0·71–1·15)].

This estimate was attenuated towards the null when adjusting for the confounding factors maternal age, BMI, parity, anxiety and depression, where no association was observed between mode of delivery and sexual frequency [aOR=1·04 (95%CI: 0·82–1·33)] (Table 2).

3.4 Instrumental vaginal delivery

In order to explore outcomes in instrumental vaginal delivery, the vaginal delivery group was stratified by forceps or vacuum deliveries and SVD or breech deliveries, for instrumental and non-instrumental, respectively. These two groups were then compared for both sexual enjoyment and frequency outcomes, using the model discussed above.

Table 3 shows the crude and adjusted associations between instrumental deliveries and outcomes. The overall prevalence of enjoying sexual intercourse in the instrumental delivery group was 90% (n =300), compared with 89% of non-instrumental deliveries (n =1 843). There was little evidence to support an association between instrumental delivery and sexual

enjoyment [OR=1·07 (95%CI: 0·73–1·56)]. This null finding was not changed by adjusting for covariates [aOR=1·02 (95%CI: 0·69–1·53)].

Sexual frequency is also shown in Table 3; 39% (n =160) of women who underwent an instrumental delivery had sexual intercourse ≥once a week, as opposed to 42% (n =1 034) of non-instrumental birth mothers. Similarly to sexual enjoyment, there was little evidence to support an association between type of vaginal delivery and sexual frequency, with the crude analysis providing a slight decrease in frequency in the instrumental group [OR=0·90 (95%CI: 0·73–1·11)]. Adjusting for covariates in this instance attenuated this finding towards the null [aOR=0·95 (95%CI: 0·76–1·19)].

Table 2 Odds ratios for associations between mode of delivery and maternal sexual enjoyment ($\boldsymbol{n} = 2\,669$) and frequency ($\boldsymbol{n} = 3\,192$) at 18 years postpartum.

Maternal outcome	**Mode of delivery**		**Crude model**		**Adjusted model[1]**	
	Vaginal delivery[2] *n* (%)	**Caesarean section *n* (%)**	**OR (95%CI)**	***p*-value**	**OR (95%CI)**	***p*-value**
Sexual enjoyment[3] – *n* complete cases	**2 400**	**269**	-	-	-	-
No	257 (10·7)	21 (7·8)	1·41 (0·891 to 2·25)	0·141	1·46 (0·909 to 2·34)	0·117
Yes	2 143 (89·3)	248 (92·2)				
Sexual frequency[4] – *n* complete cases	**2 875**	**317**	-	-	-	-
< once a week	1 681 (58·5)	193 (60·9)	0·905 (0·713 to 1·15)	0·408	1·04 (0·817 to 1·33)	0·703
≥ once a week	1 194 (41·5)	124 (39·1)				

Table 3 Odds ratios for associations between type of vaginal delivery and maternal sexual enjoyment ($\boldsymbol{n} = 2\,400$) and frequency ($\boldsymbol{n} = 2\,875$) at 18 years postpartum.

Maternal outcome	**Mode of delivery**		**Crude model**		**Adjusted model[1]**	
	Non-instrumental delivery[5] *n* (%)	**Instrumental delivery[6] *n* (%)**	**OR (95%CI)**	***p*-value**	**OR (95%CI)**	***p*-value**
Sexual enjoyment[3] – *n* complete cases	**2 066**	**334**	-	-	-	-
No	223 (10·8)	34 (10·2)	1·07 (0·729 to 1·56)	0·736	1·02 (0·685 to 1·53)	0·912
Yes	1 843 (89·2)	300 (89·8)				
Sexual frequency[4] – *n* complete cases	**2 468**	**407**	-	-	-	-
< once a week	1 434 (58·1)	247 (60·7)	0·898 (0·725 to 1·11)	0·327	0·950 (0·757 to 1·19)	0·658
≥ once a week	1 034 (41·9)	160 (39·3)				

[1] Adjusted for maternal age at delivery, maternal BMI at 12 weeks gestation and parity, EPDS score (depression) and CCEI score (anxiety) at 18 weeks gestation
[2] Spontaneous vaginal deliveries, breech deliveries, forceps and vacuum deliveries
[3] Sexual enjoyment was derived from a question "In general, do you enjoy it [sexual intercourse]?" measured on a Likert scale: "yes, very much", "yes, mostly", "no, not a lot", "no, not at all", and "no sex at the moment". This outcome was then dichotomised combining "yes, very much" with "yes, mostly" and "no, not a lot" with "no, not at all", for "yes" and "no" respectively. Women who responded "no sex at the moment" were excluded from the analysis.
[4] Sexual frequency was derived from a question "How often are you having sexual intercourse now?" measured on a Likert scare: "not at all", "less than once a month", "1-3 times a month", "about once a week", "2-4 times a week" and "5 or more times a week". This outcome was dichotomised into "less than once a week" and "once or more a week". This threshold was chosen as in between all categories, as any threshold for this outcome was deemed arbitrary.
[5] Spontaneous vaginal delivery and breech deliveries
[6] Forceps and vacuum deliveries

4 Discussion

These findings indicate little evidence to support an association between mode of delivery and sexual enjoyment at 18 years postpartum. Although an increase in odds of enjoying sex having had a CS was observed, the confidence limit crossed one at its lower bound, so that decreased odds cannot be ruled out with confidence.

The current body of literature addressing this relationship is inconsistent, with follow-ups rarely extending past the first year postpartum. Additionally, studies using a cross-sectional design soon after the birth make it difficult to disentangle the transient effects of mode of delivery from the potential permanent effects. A UK-based study in 2005 carried out by Barrett *et al*. used a cross-sectional postal survey of 796 women at six months postpartum to investigate postnatal sexual health at three and six months postpartum. They found that women who had experienced a CS were less likely to report dyspareunia in the first 3 months postpartum than women who delivered vaginally.[9] The opportunity to use data collected at 18 years postpartum allows a clearer understanding of the potential permanent effects of mode of delivery on sexual outcomes.

In studies where the relationship between mode of delivery and sexual-related outcomes was explored, very few adjust for mental health problems[9,23,24] which were evidently strong confounding factors from this analysis and surrounding literature. An Australian study of 1 295 women found that instrumental vaginal delivery was associated with increased risk of sexual problems compared with SVD and CS. However, the study authors only adjusted for parity, perineal trauma and length of labour in individual analyses.[24] It is clear from the literature that the confounding structure surrounding this relationship is more complex than these covariates.

Often, only dyspareunia and other pain-related outcomes are explored when comparing modes of delivery.[25] There is little research into enjoyment of sexual intercourse, and it is inappropriate to proxy sexual enjoyment by absence or presence of pain. Last year, a Danish cohort study found that women who had given birth via CS exclusively were more likely to experience one or more sexual problems than women who had experienced only SVDs: insufficient lubrication and dyspareunia, both deep and entry.[26] These outcomes were measured via a questionnaire sent to women enrolled in the Danish National Birth Cohort between 11 and 18 years postpartum. In ALSPAC, although not discussed here, women who underwent a CS were 69% more likely to report that they experienced pain in the vagina during sex [OR=1·69 (95%CI: 1·40–2·04)]. This effect persisted after adjustment [aOR=1·72 (95%CI:

1·41–2·10)] at 11 years postpartum (Table S4). These findings are consistent with the existing literature on long-term sexual pain following CS[27] and, alongside the null findings of this study, highlight the importance of separating sexual pain and enjoyment, as increased sexual pain does not predict decreased sexual enjoyment in ALSPAC.

The strengths of this study included its long-term follow-up with linkage to clinical antenatal records. This allowed for limited recall bias of the outcome measures and an accurate measurement of the exposure. It is the first UK-based study of its kind, improving generalisability of the study to women living in the UK. It is also one of the few studies that addresses sexual enjoyment as an outcome, contrary to sexual pain.

Limitations of this study include the inability to investigate episiotomy and perineal tear, reducing detail in the definition of mode of delivery. Both of these have been identified frequently in the literature as potentially damaging to sexual function postpartum;[28,29] information was only available for certain women due to the selective abstraction of these variables for previous studies. This meant that episiotomy and perineal tear could not be used in the exposure definition, thus damage to the perineum could not be explored as a potential causative mechanism in sexual dysfunction. Residual confounding cannot be ruled out, particularly given the time-varying nature of the confounders over the course of 18 years postpartum. Also, participating mothers may have gone on to have subsequent children after the index child which might have led to misclassification of the exposure. Selection bias in the initial recruitment and participants retention in ALSPAC may have limited the representativeness of this study to the rest of the UK.

The use of CCA was appropriate so that the crude and adjusted analyses were comparable with one another by including the same women. Missing data was a problem in this study and although inappropriate use of methods to deal with missing data can lead to bias,[22] these were outside the scope of this course and will be the focus of future work. When comparing complete cases with those who were not, little difference was observed (Table S3): complete cases were older, more likely to have fewer children and a higher educational attainment. Although complete cases are mostly representative of all the responders at 18 years postpartum, by only using complete cases, power was significantly reduced and ability to detect an effect was lessened.

Our study suggests that mode of delivery is not associated with sexual enjoyment or frequency at 18 years postpartum. Going forward, we will accommodate missing data appropriately using

multiple imputation to investigate episiotomy and perineal tear, as well as dyspareunia and other pain outcomes.

5 Acknowledgements

HF and AF were responsible for the conception of the study and designed with FM. FM carried out all statistical analysis and the final draft was written by FM.

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7 Supplementary Material

7.1 Data collection

Additional information is provided here regarding exposure, outcome and other variables. The exposure variable, mode of delivery, and covariates hypertensive disorder and diabetes were abstracted from antenatal medical records for women who gave their consent at recruitment. Maternal high blood pressure was coded in ALSPAC as preeclampsia, gestational hypertension and pre-existing hypertension; these were pooled for the purpose of the descriptive analysis due to small numbers (<5) in individual categories. Maternal diabetes was coded in ALSPAC as existing diabetes, gestational diabetes and glycosuria noted during pregnancy; similarly to hypertensive disorder, categories of diabetes were pooled for descriptive analyses.

Outcome variables, sexual enjoyment and frequency, and the other covariates, maternal age and body mass index, Edinburgh Postnatal Depression Scale and Crown Crisp Experimental Index scores, parity and maternal education were derived from self-report questionnaires sent out at various timepoints for ALSPAC. All questions for deriving these variables are shown below.

Maternal age at delivery was derived by ALSPAC authors from date of birth given at collection of pregnancy baseline data.

Maternal BMI at 12 weeks gestation was used in this analysis; it was derived by ALSPAC staff using height and weight obtained from the "About Yourself" questionnaire, in the section "Your Medical History".

a) What was your weight before you started this pregnancy? (please indicate whether stones, pounds or kilos)
……

b) How tall are you? (please indicate whether feet, inches or metres)
……

Maternal depression was derived as a score on the Edinburgh Postnatal Depression Scale from the "Having A Baby" questionnaire sent at 18 weeks gestation, in the section "Your Feelings".

a) I have been able to laugh and see the funny side of things:

As much as I always could	1
Not quite as much now	2
Definitely not so much now	3
Not at all	4

b) I have looked forward with enjoyment to things:

As much as I ever did	1
Rather less than I used to	2

Definitely less than I used to 3

Hardly at all 4

c) I have blamed myself unnecessarily when things went wrong:

Yes, most of the time 1

Yes, some of the time 2

Not very often 3

No never 4

d) I have been anxious or worried for no good reason:

No, not at all 1

Hardly ever 2

Yes, sometimes 3

Yes, often 4

e) I have felt scared or panicky for no very good reason:

Yes, quite a lot 1

Yes, sometimes 2

No, not much 3

No, not at all 4

f) Things have been getting on top of me:

Yes, most of the time 1

Yes, sometimes 2

No, hardly ever 3

No, not at all 4

g) I have been so unhappy that I have had difficulty sleeping:

Yes, most of the time 1

Yes, sometimes 2

Not very often 3

No, not at all 4

h) I have felt sad or miserable:

Yes, most of the time 1

Yes, quite often 2

Not very often 3

No, not at all 4

i) I have been so unhappy that I have been crying:

Yes, most of the time 1

Yes, quite often 2

Only occasionally 3

No, never 4

j) The thought of harming myself has occurred to me:

Yes, quite often 1

Sometimes 2

Hardly ever	3
Never	4

Maternal parity was also collected at 18 weeks gestation via the "Having A Baby" questionnaire, in the section "Your Previous Pregnancies".

a) How many children still living, of your own do you have?
……

Maternal anxiety was derived as a score on the Crown Crisp Experimental Index for anxiety, also from the "Having A Baby" questionnaire sent at 18 weeks gestation (section "Your Feelings"). The variable was recorded in the sample as an overall score.

	Very often	**Often**	**Not very often**	**Never**
Do you feel upset for no obvious reason?	1	2	3	4
Do you get troubled by dizziness or shortness of breath?	1	2	3	4
Have you felt as though you might faint?	1	2	3	4
Do you feel sick or have indigestion?	1	2	3	4
Do you feel that life is too much effort?	1	2	3	4
Do you feel uneasy and restless?	1	2	3	4
Do you feel tingling or prickling sensations in your body, arms or legs?	1	2	3	4
Do you regret much of your past behaviour?	1	2	3	4
Do you sometimes feel panicky?	1	2	3	4
Do you find that you have little or no appetite?	1	2	3	4
Do you wake unusually early in the morning?	1	2	3	4
Do you worry a lot?	1	2	3	4
Do you feel tired or exhausted?	1	2	3	4
Do you experience long periods of sadness?	1	2	3	4
Do you feel strung-up inside?	1	2	3	4
Can you get off to sleep alright?	1	2	3	4
Do you ever have the feeling you are going to pieces?	1	2	3	4

Do you often have excessive sweating or fluttering of the heart?	1	2	3	4
Do you find yourself needing to cry?	1	2	3	4
Do you have bad dreams which upset you when you wake up?	1	2	3	4
Do you lose the ability to feel sympathy for others?	1	2	3	4
Can you think quickly?	1	2	3	4
Do you have to make effort to face up to crisis or difficulty?	1	2	3	4

Maternal education was derived from responses to the questionnaire "Your Pregnancy" sent at 32 weeks gestation (section "Education And Occupation"). Women were asked to list any educational qualifications they had achieved to date, as well as their partner, mother and father (these were not used in this analysis so not shown here).

	Your self
CSE or GCSE (D, E, F or G)	1
O-level or GCSE (A, B or C)	1
A level	1
Qualifications in shorthand/typing/or other skills, e g hairdressing	1
Apprenticeship	1
State enrolled nurse	1
State registered nurse	1
City & Guilds intermediate technical	1
City & Guilds final technical	1
Teaching qualification	1
University degree	1
No qualifications	1
Qualifications not known	1
Other (please describe)	1

Information contained in this variable were categorised in the dataset upon generation as: CSE, Vocational, O-level, A-level, and Degree.

The outcome variables, sexual enjoyment and frequency, were obtained at a questionnaire sent at around 18 years postpartum, called "You And Your Life". They were both measured on a Likert scale and the questions were placed in the "Sexual and Reproductive Health" section.

a) How often are you having sexual intercourse now?

Not at all	1 ☐	Less than once a month	2 ☐	1-3 times a month	3 ☐
About once a week	4 ☐	2-4 times a week	5 ☐	5 or more times a week	6 ☐

b) In general, do you enjoy it?

Yes, very much	1 ☐	Yes, somewhat	2 ☐	No, not a lot	3 ☐
Not at all	4 ☐	No sex at the moment	5 ☐		

The categorical outcome variables were then dichotomised as described in Section 2.3.2.

Two other outcomes were preliminarily explored in this dataset: pain in the vagina during sexual intercourse (dyspareunia) and pain elsewhere after sexual intercourse. These variables were obtained from the questionnaire "Lifestyle And Health Of Mother" sent out at 11 years postpartum in the section "A Bit About Sexual Matters". These variables were also measured on a Likert scale.

b) Do you ever have pain or soreness in the vagina when you have sexual intercourse?

Not at all	1 ☐
A little	2 ☐
Moderate	3 ☐
A lot	4 ☐

c) How often do you have pain elsewhere after sexual intercourse?

Never	1 ☐
Occasionally	2 ☐
Often	3 ☐
Always	4 ☐
Don't have sex	5 ☐

These variables were dichotomised for analysis. For dyspareunia, "not at all" was combined with "a little" and "moderate" was combined with "a lot" for "no" and "yes", respectively. Pain elsewhere was dichotomised by combining "occasionally", "often", "always" for "yes" and "never" comprised the "no" category. Women who responded "don't have sex" were excluded

so as to not misclassify the outcome; women may have not been having sex because of pain or weren't having sex therefore would not know whether they had pain or not.

7.2 Characteristics

Further information on characteristics of different participant groups is provided. Categories with less than five participants were denoted "<5" as per the ALSPAC Publication Checklist.

Table S1 Characteristics of complete case (for sexual frequency) mothers ($\boldsymbol{n}$ = 3 192) who gave birth via vaginal delivery and caesarean section.

	Vaginal delivery n (%) (unless otherwise specified)	**Caesarean section n (%)** (unless otherwise specified)	***p*-value**
Complete cases (sexual frequency)	**2 875**	**317**	
Maternal age at delivery			
Mean age, years (SD[1])	29·5 (4·4)	30·6 (4·6)	
Median age, years (IQR[2])	29 (27 – 32)	30 (27 – 34)	0·013
Maternal BMI[3] (12 weeks gestation)			
Mean BMI kg/m^2 (SD[1])	22·6 (3·4)	24·0 (4·3)	
Median BMI kg/m^2 (IQR[2])	22·0 (20·4 – 23·9)	23·1 (21·3 – 25·6)	<0·001
EPDS[4] score (18 weeks gestation)			
Probable depression (score ≥ 13)	288 (10·0)	31 (9·8)	0·893
CCEI[5] score (18 weeks gestation)			
Probable anxiety (score ≥ 8)	381 (13·3)	35 (11·0)	0·267
Parity (18 weeks gestation)			
0	1 336 (46·5)	177 (55·8)	
1	1 065 (37·0)	92 (29·0)	
2	363 (12·6)	34 (10·7)	
≥ 3	111 (3·9)	14 (4·4)	0·017
Maternal education (32 weeks gestation)			
CSE[6]	245 (8·5)	30 (9·5)	
Vocational	184 (6·4)	20 (6·3)	
O-level[6]	1 004 (34·9)	97 (30·6)	
A-level	836 (29·1)	105 (33·1)	
Degree	585 (20·4)	61 (19·2)	
Missing	21 (0·7)	<5[7]	0·462
Hypertensive disorder			
High blood pressure noted during pregnancy	457 (15·9)	105 (33·1)	
Missing	21 (0·7)	<5[7]	<0·001
Diabetes			
Diabetes or glycosuria noted during pregnancy	97 (3·4)	16 (5·1)	<0·001

[1] Standard deviation
[2] Interquartile range
[3] Body mass index
[4] Edinburgh postnatal depression scale (EPDS): threshold (≥ 13 for probable depression of varying degrees of severity) as determined by authors Cox *et al.* (1987) of the 10-item EPDS
[5] Crown Crisp Experimental Index (CCEI) for anxiety: threshold (≥ 8 for probable anxiety) as determined by authors Glover *et al*. (2004)
[6] CSEs (Certificate of Secondary Education) and O-levels were secondary school examinations taken by fifth year students in the UK between 1965 – 1987. These were subsequently replaced with GCSEs (General Certificate of Secondary Education) in 1988.
[7] This many include zero

Table S2 Characteristics of non-responders and responders from the total mothers with delivery information ($\boldsymbol{n} = 13\,299$) at 18 years postpartum.

	Non-responders n (%) (unless otherwise specified)	**Responders n (%)** (unless otherwise specified)	***p*-value**
Total mothers (with delivery information)	**9 502**	**3 797**	
Maternal age at delivery			
Mean age, years (SD[1])	27·3 (5·0)	29·6 (4·5)	
Median age, years (IQR[2])	27 (24 – 31)	29 (26 – 32)	
Missing	<5[3]	<5[3]	<0·001
Maternal BMI[4] (12 weeks gestation)			
Mean BMI kg/m^2 (SD[1])	23·0 (4·0)	22·8 (3·5)	
Median BMI kg/m^2 (IQR[2])	22·2 (20·5 – 24·6)	22·0 (20·5 – 24·1)	
Missing	1 998 (21·0)	249 (6·6)	<0·001
EPDS[5] score (18 weeks gestation)			
Probable depression (score ≥ 13)	1 233 (12·9)	356 (9·4)	
Missing	1 540 (16·2)	300 (7·9)	<0·001
CCEI[6] score (18 weeks gestation)			
Probable anxiety (score ≥ 8)	1 413 (14·9)	455 (12·0)	
Missing	1 686 (17·7)	358 (9·1)	<0·001
Parity (18 weeks gestation)			
0	3 731 (39·3)	1 754 (46·2)	
1	3 021 (31·8)	1 312 (34·6)	
2	1 288 (13·6)	489 (12·9)	
≥ 3	585 (6·2)	150 (4·0)	
Missing	853 (9·0)	95 (2·4)	<0·001
Maternal education (32 weeks gestation)			
CSE[7]	2 078 (21·9)	347 (9·1)	
Vocational	933 (9·8)	248 (6·5)	
O-level[7]	2 831 (29·8)	1 296 (34·1)	
A-level	1 570 (16·5)	1 076 (28·3)	
Degree	736 (7·8)	777 (20·5)	
Missing	1 354 (14·3)	53 (1·4)	<0·001
Hypertensive disorder			
High blood pressure noted during pregnancy	1 692 (17·8)	678 (17·9)	
Missing	88 (0·9)	28 (0·7)	0·190
Diabetes			
Diabetes or glycosuria noted during pregnancy	358 (3·8)	136 (3·6)	
Missing	1 328 (14·0)	56 (1·5)	0·298

[1] Standard deviation
[2] Interquartile range
[3] This many include zero
[4] Body mass index
[5] Edinburgh postnatal depression scale (EPDS): threshold (≥ 13 for probable depression of varying degrees of severity) as determined by authors Cox *et al.* (1987) of the 10-item EPDS
[6] Crown Crisp Experimental Index (CCEI) for anxiety: threshold (≥ 8 for probable anxiety) as determined by authors Glover *et al.* (2004)
[7] CSEs (Certificate of Secondary Education) and O-levels were secondary school examinations taken by fifth year students in the UK between 1965 – 1987. These were subsequently replaced with GCSEs (General Certificate of Secondary Education) in 1988.

Table S3 Characteristics of incomplete cases (thus excluded from each analysis) and complete cases of responders at 18 years postpartum with delivery data ($\boldsymbol{n} = 3\,797$).

	Incomplete Cases n (%) (unless otherwise specified)	**Complete Cases n (%)** (unless otherwise specified)	***p*-value**
Total responders (at 18 year postpartum)	**595**	**3 202**	
Maternal age at delivery			
Mean age, years (SD[1])	29·1 (4·9)	29·6 (4·4)	
Median age, years (IQR[2])	29 (26 – 32)	30 (27 – 33)	0·002
Maternal BMI[3] (12 weeks gestation)			
Mean BMI kg/m^2 (SD[1])	22·7 (3·5)	22·8 (3·5)	
Median BMI kg/m^2 (IQR[2])	22·2 (20·4 – 24·1)	22·0 (20·5 – 24·1)	
Missing	249 (41·8)	<5[4]	0·415
EPDS[5] score (18 weeks gestation)			
Probable depression (score ≥ 13)	37 (6·2)	319 (10·0)	
Missing	300 (50·4)	<5[4]	0·161
CCEI[6] score (18 weeks gestation)			
Probable anxiety (score ≥ 8)	38 (6·2)	417 (13·0)	
Missing	345 (58·0)	<5[4]	0·327
Parity (18 weeks gestation)			
0	238 (40·0)	1 516 (47·3)	
1	150 (25·2)	1 162 (36·3)	
2	91 (15·3)	398 (12·4)	
≥ 3	24 (4·0)	126 (3·9)	
Missing	92 (15·5)	<5[4]	0·001
Maternal education (32 weeks gestation)			
CSE[7]	71 (11·9)	276 (8·6)	
Vocational	43 (7·2)	205 (6·4)	
O-level[7]	192 (32·3)	1 104 (34·5)	
A-level	132 (22·2)	944 (29·5)	
Degree	129 (21·7)	648 (20·2)	
Missing	28 (4·7)	25 (0·8)	0·002
Hypertensive disorder			
High blood pressure noted during pregnancy	115 (19·3)	563 (17·6)	
Missing	6 (1·0)	22 (0·7)	0·661
Diabetes			
Diabetes or glycosuria noted during pregnancy	23 (3·9)	113 (3·6)	
Missing	56 (9·4)	<5[4]	0·327

[1] Standard deviation
[2] Interquartile range
[3] Body mass index
[4] This many include zero
[5] Edinburgh postnatal depression scale (EPDS): threshold (≥ 13 for probable depression of varying degrees of severity) as determined by authors Cox *et al.* (1987) of the 10-item EPDS
[6] Crown Crisp Experimental Index (CCEI) for anxiety: threshold (≥ 8 for probable anxiety) as determined by authors Glover *et al.* (2004)
[7] CSEs (Certificate of Secondary Education) and O-levels were secondary school examinations taken by fifth year students in the UK between 1965 – 1987. These were subsequently replaced with GCSEs (General Certificate of Secondary Education) in 1988.

7.3 Additional results

A preliminary analysis was performed on dyspareunia and pain elsewhere after sex. A complete case analysis was utilised, where participants with complete data on covariates (maternal age and BMI, parity, anxiety and depression) were described and compared using multivariable logistic regression

As shown in Table S4, women who had delivered via caesarean section were 68% more likely to report that they experienced pain in the vagina during sexual intercourse than women who gave birth vaginally [OR = 1·68 (95%CI: 1·40 to 2·04)]. This effect persisted following adjustment for chosen covariates [aOR = 1·72 (95%CI: 1·41 to 2·10)]. Similarly, women who gave birth via caesarean section were more likely to report pain elsewhere after sexual intercourse [OR = 1·47 (95%CI: 1·11 to 1·96)]. The confidence interval did not cross one after adjustment [aOR = 1·61 (95%CI: 1·21 to 2·17)] (Table S4).

Interestingly, when stratifying vaginal deliveries by instrumental and non-instrumental, no difference is observed between the groups for either pain outcome (Table S5). The findings suggest there is no association between instrumental delivery and dyspareunia [aOR = 1·14 (95%CI: 0·925 to 1·40)] or pain elsewhere after sexual intercourse [aOR = 1·11 (95%CI: 0·803 to 1·53)].

Given these findings, exploring dyspareunia and pain elsewhere after sexual intercourse will be a focus of future work to add to the body of literature regarding these outcomes with relation to mode of delivery.

Table S4 Odds ratios for associations between mode of delivery and pain in the vagina during sexual intercourse (dyspareunia) ($\boldsymbol{n} = 5\,640$) and pain elsewhere after sexual intercourse ($\boldsymbol{n} = 5\,307$) at 11 years postpartum

Maternal outcome	**Mode of delivery**		**Crude model**		**Adjusted model[1]**	
	Vaginal delivery[2] *n* (%)	**Caesarean section *n* (%)**	**OR (95%CI)**	***p*-value**	**OR (95%CI)**	***p*-value**
Dyspareunia[3] – *n* complete cases	**4 887**	**573**	-	-	-	-
No	3 877 (79·3)	398 (69·5)	1·68 (1·40 to 2·04)	<0·001	1·72 (1·41 to 2·10)	<0·001
Yes	1 010 (20·7)	175 (30·5)				
Pain elsewhere[4] – *n* complete cases	**4 751**	**556**	-	-	-	-
No	4 378 (92·2)	494 (88·9)	1·47 (1·11 to 1·96)	<0·001	1·61 (1·21 to 2·17)	<0·001
Yes	373 (7·9)	62 (11·2)				

Table S5 Odds ratios for associations between types of vaginal delivery and pain in the vagina during sexual intercourse (dyspareunia) ($\boldsymbol{n} = 4\,887$) and pain elsewhere after sexual intercourse ($\boldsymbol{n} = 4\,751$) at 11 years postpartum

Maternal outcome	**Mode of delivery**		**Crude model**		**Adjusted model[1]**	
	Non-instrumental delivery[5] *n* (%)	**Instrumental delivery[6] *n* (%)**	**OR (95%CI)**	***p*-value**	**OR (95%CI)**	***p*-value**
Dyspareunia[3] – *n* complete cases	**4 215**	**672**	-	-	-	-
No	3 358 (79·7)	519 (77·2)	1·16 (0·950 to 1·40)	0·148	1·14 (0·925 to 1·40)	0·220
Yes	857 (20·3)	153 (22·8)				
Pain elsewhere[4] – *n* complete cases	**4 095**	**656**	-	-	-	-
No	3 774 (92·2)	604 (92·1)	1·01 (0·746 to 1·37)	0·938	1·11 (0·803 to 1·53)	0·535
Yes	321 (7·8)	52 (7·9)				

[1] Adjusted for maternal age at delivery, maternal BMI at 12 weeks gestation and parity, EPDS score (depression) and CCEI score (anxiety) at 18 weeks gestation
[2] Spontaneous vaginal deliveries, breech deliveries, forceps and vacuum deliveries
[3] Dyspareunia was derived from a question "Do you have pain or soreness in the vagina when you have sexual intercourse?" measured on a Likert scale: "not at all", "a little", "moderate", and "a lot". These categories were then dichotomised, combining "not at all" with "a little" and "moderate" with "a lot", for "no" and "yes", respectively
[4] Pain elsewhere after sexual intercourse was derived from a question "How often do you have pain elsewhere after sexual intercourse" measured on a Likert scale: "never", "occasionally", "often", "always", and "don't have sex". This variable was dichotomised, combining "occasionally", "often", and "always" for "yes"; those who responded "never" were coded as "no". Women who responded "don't have sex" were excluded due to potential misclassification of the outcome.
[5] Spontaneous vaginal delivery and breech deliveries
[6] Forceps and vacuum deliveries