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Sexual violence and neonatal outcomes: a population-based cohort study

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TITLE PAGE

Title: Sexual violence and neonatal outcomes: a population-based cohort study

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ABSTRACT

Objective**:** The objective of this study was to explore the association between sexual violence and neonatal outcomes.
Design: National cohort study.
Setting: Women were recruited to the Norwegian Mother and Child Cohort Study (MoBa) when attending routine ultrasound examinations from 1999-2008.
Population: A total of 76 870 pregnant women.
Methods: Sexual violence and maternal characteristics were self-reported in postal questionnaires during pregnancy. Neonatal outcomes were retrieved from the Medical Birth Registry of Norway (MBRN). Risk estimations were performed with linear and logistic regression analysis.
Outcome Measures: Gestational age at birth, birth weight, preterm birth (PTB), low birth weight (LBW) and small for gestational age (SGA).
Results**:** Of 76 870 women, 18.4% reported a history of sexual violence. A total of 4.7% had a premature birth, 2.7% had children with a birth weight <2500 g and 8.1% children were small for gestational age. Women reporting both moderate and severe sexual violence (rape) had a significantly reduced gestational length (2 days) when the birth was provider-initiated in an analysis adjusted for age, parity, education, smoking, BMI and mental distress. Those exposed to severe sexual violence had a significantly reduced gestational length of 0.51 days with a spontaneous start of birth. Crude estimates showed that severe sexual violence was associated with PTB, LBW and SGA. When controlling for the above-mentioned socio-demographic and behavioural factors, the association was no longer significant.
Conclusions: Sexual violence was not associated with adverse neonatal outcomes. Moderate and severe violence had a small but significant effect on gestational age; however, the clinical influence of this finding is most likely limited. Women exposed to sexual violence in this study reported more of the socio-demographic and behavioural factors associated with PTB, LBW and SGA compared with non-abused women.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- This study was based on information from a large population-based study described as sufficient for large-scale epidemiologic studies.
- All outcomes were collected prospectively from a quality-assessed birth register.
- The setting, with small social and health inequalities, was suitable to isolate the effect of sexual violence on adverse neonatal outcomes.
- A non-validated instrument for measuring of the exposure variable was a limitation to this study.

INTRODUCTION

Preterm birth is a common and costly health problem.[1, 2] Approximately one in ten babies are born preterm worldwide, and prematurity is considered to be the leading cause of death for newborns.[2] Low birth weight (LBW) can be a consequence of preterm birth (PTB) or intra uterine growth restriction, the latter leading to the birth of small for gestational age (SGA) infants.[3] Research has identified some biological risk factors for PTB and LBW: ethnicity, multiple pregnancies, a previous preterm birth and uterine or placental abnormalities.[1, 3] Studies also emphasise behavioural and social factors as important but less understood factors for both PTB and LBW.[1] These factors can be maternal age, socio-economic status, maternal weight, substance abuse, stress, depression and violence.[1, 2, 4]

Violence against women is a significant public health problem, and a recent report from the World Health Organization (WHO) state that 35% of women worldwide have experienced either physical and/or sexual intimate partner violence or non-partner sexual violence.[5] A pregnancy does not protect women from violence, and the prevalence of physical or sexual violence during pregnancy ranges from 3.4-11% in high-income countries.[6] It is recognised that violence has an adverse impact on women's physical, sexual, reproductive, and mental health.[5, 7] A connection between PTB or LBW and violence against women has been reported, but the association is both supported and contradicted.[5, 8-20] Studies have primarily addressed physical abuse during pregnancy and PTB or LBW [8, 10, 11, 16-19, 21] or child sexual abuse and PTB/LBW.[9, 12] Results from a new meta-analysis published in the recent WHO report [5] have demonstrated an association between intimate partner violence, including both physical and sexual abuse, and PTB with an adjusted odds ratio (AOR) of 1.41 (95% CI 1.21-1.62) and AOR of 1.16 (95% CI: 1.02-1.29) with LBW.[5]

However, studies on sexual violence and neonatal outcomes are limited, and few population-based studies with large sample sizes that enable controlling for confounding variables have been conducted [5, 11] Thus, there is a need to study the potential effect of lifetime sexual violence on outcomes for newborns using a large cohort. The Norwegian Mother and Child Cohort Study (MoBa) is a population-based prospective cohort study of pregnant women that includes measurements of lifetime sexual violence and other relevant covariates. In this study, we assessed the relationship between sexual violence and gestational age at birth and birth weight. Additionally, we explored the associations between sexual violence and PTB, LBW and SGA.

METHODS

This study was a sub-project in the MoBa study that was conducted by the Norwegian Institute of Public health from 1999-2008.[22] All pregnant women in Norway were eligible to participate in MoBa, and they were recruited during their routine foetal ultrasound examination. Of the invited women, 40.6% consented to participate. Data were obtained through extensive self-administered questionnaires that contained demographic factors, general health, reproductive history and questions about maternal health status during pregnancy. Our analyses were based on questionnaire 1 (Q1), which was completed during (approximately) gestational week 17, and questionnaire 3 (Q3), which was completed during (approximately) gestational week 30. Data from MoBa were linked with data from the Medical Birth Registry of Norway (MBRN), which provided information on pregnancy and birth outcome. The current study is based on version VI of the quality-assured data files released for research in 2011. The MoBa study is described in detail elsewhere.[22]

Study population

This study included women who had a singleton birth between 22 and 44 weeks of gestation, who completed both Q1 and Q3, had MBRN data available and participated for the first time (79 363 women). While a pregnancy is the observation unit in the MoBa study, women are the observation unit in our study; hence, the exclusion of 13 475 pregnancies of women who participated more than once. We excluded 703 women who did not answer the questions on sexual violence. Further, we excluded records with missing data on gestational length (n= 297) and birth weight (n=41). We also excluded 6 children with birth weight <500 g and 4 children with birth weight >6000 g, leaving a study sample of 76 870 women (Figure 1).

Ethical statement

Informed consent was obtained from each women participating in the study. The Regional Committee for Medical Research Ethics (Ref.SAFH 95/313 RTL) and the Norwegian Data Inspectorate approved the study.

Variables

Exposure variable

The exposure variable was collected from Q1; here, the women were asked if they had been 1) pressured to perform sexual acts, 2) forced with violence or 3) raped. A positive answer was defined as having experienced sexual violence. Women with more than one positive answer were classified according to the most severe level reported. The answers were coded into three levels of severity for the sexual violence: 1) mild, 2) moderate and 3) severe, and by the timing of the abuse (previously or recent). Recent meant exposed to sexual violence in the current pregnancy or the last 6 or 12 months before pregnancy. More details about the exposure variable can be found in our previous studies.[23;24]

Outcome variables

All outcome variables were obtained from the MBRN. Gestational age at birth in days was based on ultrasound at (approximately) gestational week 18. For women with no ultrasound, the gestational age was based on the last menstrual period (1.7%). PTB was defined as a gestational age <37, LBW as a birth weight <2500 grams, and SGA was defined as birth weight below the 10th percentile for the gestational age at birth. SGA was calculated using Norwegian specific foetal growth tables by Skjerven et al.[25]

Adjusting variables

Maternal age, parity, socio-economical status, smoking and body mass index (BMI) were considered as possible confounding factors and were adjusted for. All adjusting variables were taken from the MoBa. In Q1, age was categorised into 5 groups: younger than 20 years, 20–24 years, 25–29 years, 30–34 years or 35 years and older. As a proxy for socio-economic status, we used the woman's education in years (categorised into 4 groups): primary (<12 years), secondary (12 years), higher ≤4 years (13–16 years and) and higher >4 years (≥17 years). Parity was dichotomised into nulli- and multiparous women. Smoking was categorised as no smoking or smoking, which included both daily and occasional smoking. BMI was grouped into 4 categories: <20, 20-24.9, 25.0-29.9 or ≥30.0 kg/m2. We also adjusted for mental distress because it is considered to be associated with both the exposure and the outcome.[4,5] Mental distress was measured using 5 items from The Hopkins symptoms checklist (SCL-5) with a cut-off at ≥2.0 points, as suggested by Strand [26] and obtained from Q3.

Because of the co-occurrence of different violence types,[7] we examined the effect of physical and emotional abuse as a child or as an adult in the multivariable statistical models.

Information on adult physical violence was taken from Q1 and consisted of a positive answer to whether women as an adult had experienced being slapped, hit, kicked or otherwise bothered in a physical manner. Child physical violence was taken from Q3 and consisted of a positive answer to the question "Have you experienced physical violence before the age of 18?" Emotional abuse as a child (<18) or as an adult (≥18) consisted of a positive answer to either, "Someone has over a long period of time systematically tried to subdue, degrade or humiliate you" or "Someone has threatened to hurt you or someone close to you" or both.

Previous preterm birth and inadequate antenatal care are considered to be associated with the exposure and the outcomes.[2, 3, 5] Because a previous preterm birth may be a result of sexual violence prior to the related pregnancy, we did not control for a previous preterm birth. In Norway, the majority of women attend antenatal care, a free and a well-integrated part of the public health system; therefore, we did not control for antenatal care. Ethnicity was not considered a relevant confounding factor in our study because the majority of the MoBa participants are ethnic Norwegian.

Statistical Analysis

Characteristics were presented as percentages within the entire sample and the different outcomes. Linear regression was performed to assess differences in birth weight and gestational age for children born to women with and without a history of mild, moderate and severe sexual violence. The association between sexual violence and PTB, LBW and SGA was estimated with crude and adjusted odds ratios using logistic regression analysis. All analyses were adjusted for maternal age, parity, education, smoking, BMI and mental distress in the first step. Birth weight was additionally adjusted for gestational age. We further adjusted for other types of violence in the second step. We initially tested the correlation

between other types of violence and sexual violence because of co-occurrence, and all Pearson's correlation coefficients were below the generally accepted cut-off of <0.4 for use as a covariate in the regression analyses.[27] Post protocol, we stratified the sample into spontaneous start of birth and provider-initiated start of birth (induced start of birth or elective caesarean section) for gestational age because a provider-initiated start could influence the time point of birth. Information on how the birth started was taken from MBRN. We additionally performed a sensitivity analysis in which we examined the association between sexual violence and SGA and LBW among women who had a spontaneous birth at term (≥37 weeks) because we wanted to examine the effect of violence in a group of women who were considered to be low risk according to gestational age and start of birth. When we examined the timing of the sexual violence, we compared women who were exposed to recent (sexual violence during pregnancy or the last 6 or 12 months) and those exposed to previous sexual violence to non-abused women. We also examined the timing among women reporting recent and previous severe sexual violence (rape) for all outcomes. The prevalence of missing data was generally low with 2.5% for BMI, 3.7% for education, and 0.7% for smoking during pregnancy. Because of this, no imputing methods for missing data were used,[28] except for the missing data for the SCL-5 (3.2%), which were replaced by the series mean. The results of the logistic regression analyses remained approximately the same when performed with the complete exclusion of missing data compared with using the imputed missing data for SCL-5.

The comparison group for all analyses was women not reporting any sexual violence. All analyses were performed with the statistical package SPSS for WINDOWS (SPSS Inc., Chicago, IL, USA) version 18. P-values <0.05 were considered statistically significant.

RESULTS

The mean gestational age at birth in the total sample was 279.6 days (standard deviation 11.9 days), and the mean birth weight was 3592.7 grams (standard deviation 547.1 g). Table 1 displays the characteristics in the total sample and by the different outcomes.

Table 1. Background characteristics in the total sample and by preterm birth (PTB): gestational age <week 37, low birth weight (LBW): weight <2500 g and small for gestational age (SGA) weight below the 10th percentile by gestational age at birth in the Mother and Child Cohort

	Total N=76870 %	**PTB** N=3620 %	**LBW** N=2107 %	**SGA** N=6257 %
Age				
<20	1.5	2.2	2.6	1.9
20–24	12.2	12.7	13.8	13.2
25–29	36.2	34.6	34.8	36.4
30–34	35.7	33.7	33.2	34.2
≥35	14.4	16.7	15.6	14.3
Education				
Primary	2.4	3.1	3.9	2.7
Secondary	34.8	38.5	38.8	35.0
Higher ≤4 years	37.8	35.6	37.3	36.1
Higher >4 years	21.3	19.2	20.5	22.2
Missing	3.7	3.6	3.7	3.9
Parity				
Nulliparous	54.9	61.7	68.2	70.7
Multiparous	45.1	38.3	31.8	29.3
Smoking				
No	90.9	89.3	85.8	85.6
Yes	8.5	10.1	13.6	13.6
Missing	0.7	0.6	0.6	0.7
Pre-pregnancy body mass index				
<20	12.4	12.8	15.6	19.1
20–24.9	54.9	49.9	50.8	55.6
25–29.9	21.0	22.0	19.0	15.2
≥30	9.2	12.6	11.8	7.6
Missing	2.5	2.7	2.9	2.4
Mental distress				

No	93.3	92.3	91.3	92.3
Yes	6.8	7.7	8.7	7.7
Adult physical violence				
No	85.5	83.9	83.6	84.7
Yes	14.5	16.1	16.4	15.3
Child physical violence				
No	94.5	94.4	94.1	94.3
Yes	5.5	5.6	5.9	5.5
Adult emotional abuse				
No	83.6	82.1	81.3	82.5
Yes	16.4	17.9	18.7	17. 5
Child emotional abuse				
No	86.2	85.1	84.7	85.5
Yes	13.8	14.9	15.3	14.5

The prevalence of adverse neonatal outcomes was generally highest in the youngest (<20 y) and the oldest age groups (≥35 y) among smokers and women with primary school education. A BMI ≥30 was associated with PTB and LBW and BMI <20 with SGA. Women who reported mental distress also reported more PTB, LBW and SGA.

Among the 76 870 women enrolled, 9263 (12.1%) reported a history of mild sexual violence, 2102 (2.8%) moderate and 2746 (3.5%) severe. Women with a history of sexual violence were significantly younger and they were more likely to have primary school education. Additionally, these women more frequently reported smoking, a BMI ≥30 and mental distress. These women more often experienced other types of violence both as children and adults (data not provided in tables).

A lower gestational age at birth was observed for newborns from women who reported moderate and severe sexual violence with approximately two days when birth was provider-initiated (Table 2).

Table 2. Differences in gestational age for spontaneous and provider-initiated start of birth and birth weight for non-exposed women and women exposed to mild, moderate and severe sexual violence

	N= 76 870 (%)	Mean	Crude estimate β (95% CI)	Adjusted estimate β (95% CI)*
Gestational age				
No sexual violence	62 699 (81.6)	279.7 days	1	1
Mild sexual violence	9263 (12.1)			
Spontaneous start	7323 (11.5)	279.9 days	0.09 (-0.16; 0.33)	0.22 (-0.04; -0.48)
Provider-initiated start	1940 (12.5)	280.3 days	0.36 (-0.37; 1.08)	0.64 (-0.11; 1.39)
Moderate sexual violence	2102 (2.8)			
Spontaneous start	1670 (2.7)	279.3 days	-0.40 (-0.87; 0.06)	-0.28 (-0.78; 0.21)
Provider-initiated start	492 (3.2)	277.6 days	-2.13 (-3.41; -0.84)	-2.02 (-3.39; -0.67)
Severe sexual violence	2746 (3.6)			
Spontaneous start	2048 (3.3)	278.7 days	-0.91 (-1.37; -0.44)	-0.65 (-1.15; -0.16)
Provider-initiated start	698 (4.5)	277.5 days	-2.24 (-3.47; -1.01)	-1.92 (-3.22; -0.62)
Birth weight				
No sexual violence	62 699 (81.6)	3594 g	1	1
Mild sexual violence	9263 (12.1)	3597 g	2.03 (-9.26; 13.32)	0.04 (-9.16; 9.23)**
Moderate sexual violence	2102 (2.8)	3582 g	-13.61 (-34.74; 7.51)	6.11 (-11.30; 23.52)**
Severe sexual violence	2746 (3.6)	3556 g	-38.33 (-59.17; -17.49)	-0.76 (-18.05; 16.53)**

*Adjusted for maternal age, parity, education, smoking, body mass index and mental distress
**Additional adjustment for gestational age

Among women with a spontaneous start of birth, the gestational age was approximately one half of a day shorter when women reported severe sexual violence. These findings were significant in an adjusted analysis. A crude analysis showed that women who reported a history of severe violence delivered on average 38.3 g lighter children, a difference that disappeared when controlling for gestational age, mother's age, parity, education, smoking, BMI and mental distress. There were no differences regarding birth weight between women with a history of mild or moderate sexual violence compared with non-abused women.

Results from the logistic regression analysis are presented in Table 3.

Table 3. Odds of preterm birth (PTB), low birth weight (LBW) and small for gestational age (SGA) with 95% confidence intervals (CI) according to the different levels of sexual violence

	N (%)	Prevalence (%)	Crude odds ratio (95% CI)	Adjusted odds ratio (95% CI)*
PTB		**3620 (4.7)**		

No sexual violence	62 699 (81.6)	2931 (4.7)	1	1
Mild sexual violence	9263 (12.1)	412 (4.4)	0.95 (0.85-1.06)	0.93 (0.83-1.03)
Moderate sexual violence	2102 (2.8)	115 (5.3)	1.15 (0.95-1.39)	1.14 (0.93-1.39)
Severe sexual violence	2746 (3.6)	162 (5.9)	1.28 (1.08-1.51)	1.15 (0.97-1.37)
LBW		**2107 (2.7)**		
No sexual violence	62 699 (81.6)	1681 (2.7)	1	1
Mild sexual violence	9263 (12.1)	257 (2.8)	1.04 (0.91-1.18)	0.98 (0.85-1.12)
Moderate sexual violence	2102 (2.8)	75 (3.5)	1.30 (1.03-1.65)	1.19 (0.93-1.53)
Severe sexual violence	2746 (3.6)	94 (3.4)	1.29 (1.04-1.59)	1.07 (0.85-1.34)
SGA		**6257 (8.1)**		
No sexual violence	62 699 (81.6)	5061 (8.1)	1	1
Mild sexual violence	9263 (12.1)	768 (8.3)	1.03 (0.95-1.12)	1.00 (0.91-1.08)
Moderate sexual violence	2102 (2.8)	178 (8.3)	1.02 (0.87-1.19)	0.95 (0.80-1.12)
Severe sexual violence	2746 (3.6)	250 (9.1)	1.14 (1.00-1.30)	1.05 (0.91-1.21)

*Adjusted for maternal age, parity, education, smoking, body mass index and mental distress

Women who reported severe sexual violence had higher odds of PTB, LBW and SGA in a crude analysis, an association that was attenuated and no longer significant when adjusted for maternal age, parity, education, smoking, BMI and mental distress. Other types of violence, both as a child and adult, had small attenuating effects on the odds ratios and were not included in the final models.

The sensitivity analysis, in which we examined the association between a history of sexual violence and SGA and LBW in a sub-sample of women who had a spontaneous term birth, showed the same pattern as in the total sample reported in Table 3. Women who reported severe sexual violence had higher odds of LBW and SGA in a crude analysis but not in the adjusted analysis (Data not provided in tables).

A crude analysis was used to examine if the timing of the violence was associated with adverse outcome. Women who reported recent sexual violence had a higher risk for LBW (OR 1.60 95% CI 1.04-2.17) compared with non-abused women. The association was no longer significant in the adjusted analysis. In our study, 684 (0.9%) women reported recent

sexual violence (mild, moderate and severe) and 13 487 (17.5%) previous sexual violence (Supplementary Table S1). There was no association between recent severe sexual violence (rape) and adverse neonatal outcome (Supplementary Table S2). There were 66 (0.1%) women who reported rape during pregnancy or the last 6 or 12 months in this study.

DISCUSSION

Main outcome

We found that moderate and severe sexual violence were associated with a reduction in gestational age at birth. The largest effect was observed when birth was provider-initiated among women exposed to moderate or severe violence. These women had an approximately two-day reduction in gestational age. There was no significant association between sexual violence and PTB, LBW or SGA in the adjusted analysis.

Strength

This study, based on information from a large population-based study, the Norwegian Mother and Child Cohort study (MoBa), which is linked to the Medical Birth Registry (MBRN), gave a unique opportunity to assess the association between sexual violence and outcome for newborns. The validity of the data in the MoBa has in earlier research been described as sufficient for large-scale epidemiologic studies.[29, 30] Our study was strengthened by the fact that the information on the different outcome variables was collected prospectively from the quality-assessed MBRN.[31] The outcomes in this study are part of a complex phenomenon that has several different risk factors. [2] The setting in this study, with small social and health inequalities, may therefore be suitable to isolate the effect of sexual violence on adverse neonatal outcomes.

Limitations

There are also limitations to our study. The participation rate of 40.6% in MoBa is low, and MoBa suffers to some extent from selection bias. The women included in the study are older, have more education, smoke less and are less likely to be of a non-Norwegian origin than the Norwegian population. A recent study has found that this may affect the prevalence estimates, but there was no evidence that the exposure-outcome associations were affected by selection bias.[32] Furthermore, as preterm birth is associated with ethnicity, the ethnic homogeneous sample in MoBa may limit the generalisability of our findings. The lack of a validated instrument for measuring the exposure is a limitation to this study, and violence measured in modules as part of a larger questionnaire, as that in MoBa, may achieve a lower disclosure rate.[5] However, a similar prevalence to that found in our study was reported in a Nordic study examining sexual violence and health.[33]

To our knowledge, no studies have examined the influence of lifetime sexual violence reported during pregnancy on the gestational age at birth for newborns. There were minor differences in the gestational age between abused and non-abused women in this study, and the clinical importance of our findings for the health of the newborn is most likely limited. However, the difference between the provider-initiated and spontaneous initiation of birth may be of interest. Shorter provider-initiated pregnancies may suggest an increase in elective inductions and elective caesarean sections for those exposed to violence. This is supported by others [34, 35] and in our previous study on sexual violence and maternal outcome.[36] Studies have emphasised the meaning of control for abused women when giving birth,[37] and choosing a planned start of birth may help the abused women remain in control.

Unlike the current meta-analysis mentioned in a WHO report (not yet published),[5] we did not find sexual violence to be associated with PTB and LBW in adjusted analysis. To our knowledge, no study has found an association between violence and SGA. The studies included in the meta-analysis investigated both sexual and physical intimate partner violence, in contrast to our study, which investigated lifetime sexual violence. Studies on the health effects of non-partner sexual violence are limited with less robust data than for intimate partner violence.[5] Our data from the MoBa does not differentiate between intimate partner violence and sexual abuse by non-partners, but it is not unlikely that the question about severe sexual violence (rape) primarily reflects non-partner sexual abuse. Some studies have shown significant associations for adverse neonatal outcomes in a crude analysis; these became non-significant when adjusting for socio-demographic and behavioural factors,[38, 39] as ours. The exposure in these studies involved intimate partner violence during pregnancy, and the study by Webster et al. [39] also included lifetime physical violence.

Several pathways between sexual violence and adverse neonatal outcomes are suggested, both direct and indirect.[5] The direct pathway of violence during pregnancy can lead to a preterm birth, and examples of indirect pathways include more health-risk behaviours, depression and stress/anxiety.[5, 40] Both experienced violence and living in an abusive environment can cause increased stress levels, which could be on the pathway between abuse and adverse neonatal outcome. Maternal exposure to stress can influence the hypothalamic pituitary axis (HPA) hormones, and it is suggested that changes in these hormones may cause negative outcomes, such as a reduction in gestational age and foetal growth restriction.[4, 41]
The prevalence of abuse during pregnancy is small in our study and may have decreased the power to detect an association between violence during pregnancy and adverse neonatal outcomes, an association that is supported by other studies.[10, 14, 42, 43] In our study,

sexual violence was assessed approximately in gestational week 17, and events of violence after that may have been missed. The studies that report the highest prevalence of violence have measured this several times during pregnancy. [6] Studies have reported a violence prevalence during pregnancy of between 3 to 19%.[6, 44] A direct comparison to our study is difficult because these numbers estimate both physical and sexual abuse during pregnancy; they may suggest that sexual violence during pregnancy is underreported in our study. Underreporting among the non-exposed may have caused a misclassification that has diminished the associations between sexual violence and neonatal outcomes in our study. Living in an abusive relationship may also stop women from disclosing the violence. However, our prevalence of recent sexual (0.9%) violence is similar to the prevalence of 1% reported in a national population based study on violence among Norwegian women.[45] This number reflects the prevalence of sexual violence reported during the last year, not especially among pregnant women.

Conclusion

Overall, our findings provide no evidence for an association between lifetime sexual violence and adverse neonatal outcomes. A small significant effect on the gestational age at birth was detected, but the clinical importance of this is most likely limited for the health of the newborn. PTB, LBW and SGA all have complex origins with multiple possible pathways.[1, 2] Although we did not find an association between sexual violence and PTB, LBW or SGA in adjusted analyses, crude analyses in our study suggested that sexual violence may be a risk factor for adverse neonatal outcomes for some women; however, for the majority of women, the relationship is confounded by other risk factors. Antenatal care is one of the most important entry points in which women seek health care without necessarily disclosing ongoing exposure to violence or a history of sexual violence. It is recommended that

caregivers and clinicians ask women about exposure to violence when assessing conditions that may be complicated by violence,[46] and more knowledge about this conditions is needed. Additionally, antenatal care may offer opportunities for women to receive help, both if they are exposed to violence and in providing assistance to change behavioural factors contributing to adverse outcomes.

Competing interests

None.

Contributions to authorship

LH participated in the conception and design of the study, performed the analysis and drafted the manuscript. BS participated in the conception of the study, advised on the statistical analyses and drafting of the manuscript. SV advised on the statistical analyses and the drafting of the manuscript. ML participated in the conception and design of the study, advised on the statistical analyses and participated in drafting the manuscript. All authors read and approved the final version.

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Data Sharing Statement

No additional data are available.

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Figure 1. Inclusion and exclusion process

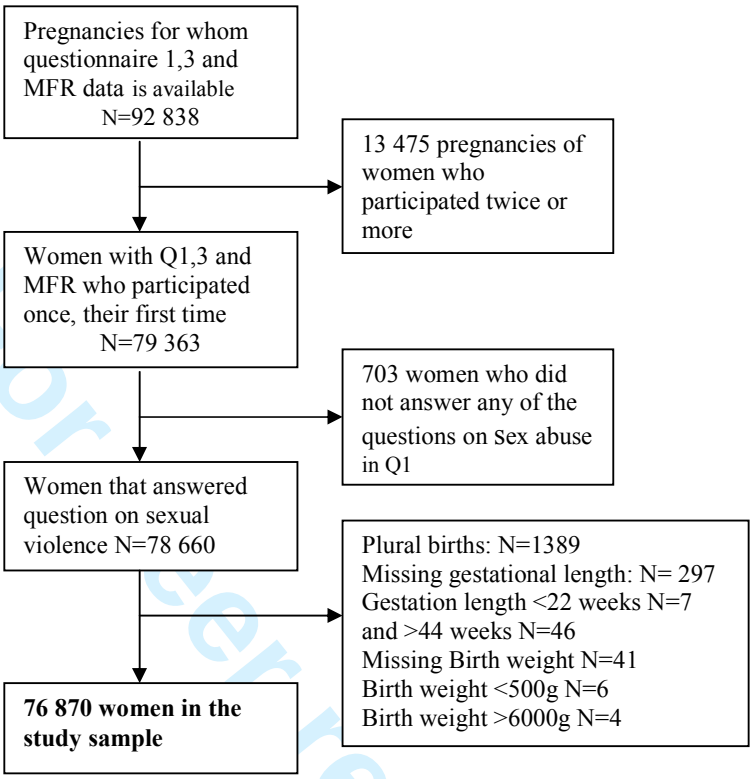

Table S1: Odds of preterm birth (PTB), low birth weight (LBW) and small for gestational age (SGA) with 95% confidence intervals (CI) according to previous and recent sexual violence

	N (%)	Prevalence (%)	Crude odds ratio (95% CI)	Adjusted odds ratio (95% CI)
PTB		**3620 (4.7)**		
No sexual violence	62 699 (81.6)	2931 (4.7)	1	1
Previous sexual violence	13487 (17.5)	650 (4.8)	1.03 (0.95-1.13)	0.99 (0.90-1.09)
Recent sexual violence	684 (0.9)	39 (5.7)	1.23 (0.89-1.71)	1.17 (0.83-1.65)
LBW		**2107 (2.7)**		
No sexual violence	62 699 (81.6)	1681 (2.7)	1	1
Previous sexual violence	13 487 (17.5)	397 (2.9)	1.10 (0.99-1.23)	1.0 (0.86-1.12)
Recent sexual violence	684 (0.9)	29 (4.2)	1.60 (1.04-2.33)	1.45 (0.97-2.17)
SGA		**6257 (8.1)**		
No sexual violence	62 699 (81.6)	5061 (8.1)	1	1
Previous sexual violence	13 487 (17.5)	1136 (8.4)	1.05 (0.98-1.12)	0.98 (0.92-1.06)
Recent sexual violence	684 (0.9)	60 (8.8)	1.10 (0.84-1.43)	1.18 (0.90-1.56)

*Adjusted for maternal age, parity, education, smoking, body mass index and mental distress

Table S2: Odds of preterm birth (PTB), low birth weight (LBW) and small for gestational age (SGA) with 95% confidence intervals (CI) according to previous and recent severe violence (rape)

	N (%)	Prevalence (%)	Crude odds ratio (95% CI)	Adjusted odds ratio (95% CI)*
PTB		**3620 (4.7)**		
No rape	74 124 (96.4)	3458 (4.7)	1	1
Previous rape	2680 (3.5)	157 (5.9)	1.27 (1.08-1.50)	1.14 (0.97-1.36)
Recent rape	66 (0.1)	5 (7.6)	1.68 (0.67-4.17)	1.72 (0.68-4.33)
LBW		**2107 (2.7)**		
No rape	74 124 (96.4)	2013(2.7)	1	1
Previous rape	2680 (3.5)	91 (3.4)	1.26 (1.02-1.56)	1.06 (0.84-1.33)
Recent rape	66 (0.1)	3 (4.5)	1.71 (0.54-5.44)	1.55 (0.48-5.02)
SGA		**6257 (8.1)**		
No rape	74 124 (96.4)	6007 (8.1)	1	1
Previous rape	2680 (3.5)	247 (9.2)	1.15 (1.01-1.32)	1.06 (0.92-1.23)
Recent rape	66 (0.1)	3 (4.5)	0.54 (0.17-1.72)	0.55 (0.17-1.79)

*Adjusted for maternal age, parity, education, smoking, body mass index and mental distress

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	page 1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	page 2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	page 3 and
Objectives	3	State specific objectives, including any prespecified hypotheses	page 4
Methods			
Study design	4	Present key elements of study design early in the paper	From page 4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection in addition reference is given for further reading of detailed information on MoBa study (referece 22)	Page 4
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	NA
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Presented on pages 5-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Page 5-7
Bias	9	Describe any efforts to address potential sources of bias controlling for confounding and covariates	pages 6 and 7.
Study size	10	Explain how the study size was arrived at	figure 1 and page5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Page 6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	page 7 and 8
		(*b*) Describe any methods used to examine subgroups and interactions	page 8
		(*c*) Explain how missing data were addressed	page 8
		(*d*) If applicable, explain how loss to follow-up was addressed	NA
		(*e*) Describe any sensitivity analyses	page 8
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed All listed in Figure 1	
		(b) Give reasons for non-participation at each stage	Page 5

		(c) Consider use of a flow diagram Figure 1	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Table 1: page 9 and 10
		(b) Indicate number of participants with missing data for each variable of interest	Table 1
		(c) Summarise follow-up time (eg, average and total amount)	NA
Outcome data	15*	Report numbers of outcome events or summary measures over time	Table 1
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Page 6-7, 11 - 12 and Table 2 and 3
		(*b*) Report category boundaries when continuous variables were categorized	Page 6 and Table 1
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	page 12-13Supplementary Tables 1 and 2
Discussion			
Key results	18	Summarise key results with reference to study objectives	page 13
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Page 13-16
Generalisability	21	Discuss the generalisability (external validity) of the study results	Page 14
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Page 17

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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TITLE PAGE

Title: Sexual violence and neonatal outcomes: a Norwegian population-based cohort study

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ABSTRACT

Objective**:** The objective of this study was to explore the association between sexual violence and neonatal outcomes.
Design: National cohort study.
Setting: Women were recruited to the Norwegian Mother and Child Cohort Study (MoBa) when attending routine ultrasound examinations from 1999-2008.
Population: A total of 76 870 pregnant women.
Methods: Sexual violence and maternal characteristics were self-reported in postal questionnaires during pregnancy. Neonatal outcomes were retrieved from the Medical Birth Registry of Norway (MBRN). Risk estimations were performed with linear and logistic regression analysis.
Outcome measures: Gestational age at birth, birth weight, preterm birth (PTB), low birth weight (LBW) and small for gestational age (SGA).
Results**:** Of 76 870 women, 18.4% reported a history of sexual violence. A total of 4.7% had a premature birth, 2.7% had children with a birth weight <2500 g and 8.1% children were small for gestational age. Women reporting both moderate and severe sexual violence (rape) had a significantly reduced gestational length (2 days) when the birth was provider-initiated in an analysis adjusted for age, parity, education, smoking, BMI and mental distress. Those exposed to severe sexual violence had a significantly reduced gestational length of 0.51 days with a spontaneous start of birth. Crude estimates showed that severe sexual violence was associated with PTB, LBW and SGA. When controlling for the above-mentioned socio-demographic and behavioural factors, the association was no longer significant.
Conclusions: Sexual violence was not associated with adverse neonatal outcomes. Moderate and severe violence had a small but significant effect on gestational age; however, the clinical influence of this finding is most likely limited. Women exposed to sexual violence in this study reported more of the socio-demographic and behavioural factors associated with PTB, LBW and SGA compared with non-abused women.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- This study was based on information from a large population-based study described as sufficient for large-scale epidemiologic studies.
- All outcomes were collected prospectively from a quality-assessed birth register.
- The setting, with small social and health inequalities, was suitable to isolate the effect of sexual violence on adverse neonatal outcomes.
- A non-validated instrument for measuring of the exposure variable was a limitation to this study.

INTRODUCTION

Preterm birth is a common and costly health problem.[1, 2] Approximately one in ten babies are born preterm worldwide, and prematurity is considered to be the leading cause of death for newborns.[2] Low birth weight (LBW) can be a consequence of preterm birth (PTB) or intra uterine growth restriction, the latter leading to the birth of small for gestational age (SGA) infants.[3] Research has suggested some biological risk factors for PTB and LBW: multiple pregnancies, a previous preterm birth and uterine or placental abnormalities.[1, 3] Studies also emphasise other, less understood factors for both PTB and LBW.[1] These are maternal age, socio-economic status, ethnicity, maternal weight, substance abuse, stress, depression and violence.[1, 2, 4]

Violence against women is a significant public health problem, and a recent report from the World Health Organization (WHO) state that 35% of women worldwide have experienced either physical and/or sexual intimate partner violence or non-partner sexual violence.[5] A pregnancy does not protect women from violence, and the prevalence of physical or sexual violence during pregnancy ranges from 3.4-11% in high-income countries.[6] It is recognised that violence has an adverse impact on women's physical, sexual, reproductive, and mental health.[5, 7]

A connection between PTB or LBW and violence against women has been reported, but the association is both supported and contradicted.[5, 8-20] Several pathways between sexual violence and adverse pregnancy outcomes are suggested.[5] A direct pathway of sexual violence can result in immediate complications as bleeding and rupture of membranes that can lead to a preterm birth.[5, 16] Other, more indirect pathways are suggested mediated by stress

and stress responses [18] or by behavioural factors such as smoking or substance abuse, used to cope with the negative consequences of violence.[5]

Studies have primarily addressed physical abuse during pregnancy and PTB or LBW [8, 10, 11, 16-19, 21] or child sexual abuse and PTB/LBW.[9, 12] Results from a new meta-analysis published in the recent WHO report [5] have demonstrated an association between intimate partner violence, including both physical and sexual abuse, and PTB with an adjusted odds ratio (AOR) of 1.41 (95% CI 1.21-1.62) and AOR of 1.16 (95% CI: 1.02-1.29) with LBW.[5] However, studies that have investigated the impact of sexual violence on neonatal outcomes specifically, are limited and few population-based studies with large sample sizes that enable controlling for confounding variables have been conducted [5, 11] The Norwegian Mother and Child Cohort Study (MoBa) is a population-based prospective cohort study of pregnant women that includes measurements of lifetime sexual violence, sexual violence during pregnancy and other relevant covariates which makes it suitable to examine associations between sexual violence and neonatal outcome. In this study, we assessed the relationship between sexual violence and gestational age at birth and birth weight. Additionally, we explored the associations between sexual violence and PTB, LBW and SGA.

METHODS

This study was a sub-project in the MoBa study that was conducted by the Norwegian Institute of Public health from 1999-2008.[22] All pregnant women in Norway were eligible to participate in MoBa, and they were recruited during their routine fetal ultrasound examination. Of the invited women, 40.6% consented to participate. Data were obtained through extensive self-administered questionnaires that contained demographic factors, general health, reproductive history and questions about maternal health status during

pregnancy. Our analyses were based on questionnaire 1 (Q1), which was completed during (approximately) gestational week 17, and questionnaire 3 (Q3), which was completed during (approximately) gestational week 30. Data from MoBa were linked with data from the Medical Birth Registry of Norway (MBRN), which provided information on pregnancy and birth outcome. The current study is based on version VI of the quality-assured data files released for research in 2011. The MoBa study is described in detail elsewhere.[22] The questionnaires that were used in MoBa are available at the internet-site: http://www.fhi.no/studier/den-norske-mor-og-barn-undersokelsen/sporreskjemaer

Study population

This study included women who had a singleton birth between 22 and 44 weeks of gestation, who completed both Q1 and Q3, had MBRN data available and participated for the first time (79 363 women). While a pregnancy is the observation unit in the MoBa study, women are the observation unit in our study; hence, the exclusion of 13 475 pregnancies of women who participated more than once. We excluded 703 women who did not answer the questions on sexual violence. Further, we excluded records with missing data on gestational length (n= 297) and birth weight (n=41). We also excluded 6 children with birth weight <500 g and 4 children with birth weight >6000 g, leaving a study sample of 76 870 women (Figure 1).

Ethical statement

Informed consent was obtained from each women participating in the study. The Regional Committee for Medical Research Ethics (Ref.SAFH 95/313 RTL) and the Norwegian Data Inspectorate approved the study.

Variables

Exposure variable

The exposure variable was collected from Q1.Women were asked if they had been pressured or forced to sexual relations. There were four possible answer options: 1) No, never 2) Yes, pressured, 3) Yes, forced with violence or 4) Yes, raped. A positive answer was defined as having experienced sexual violence. Women with more than one positive answer were classified according to the most severe level reported. The answering options were coded into three levels of severity for the sexual violence: 1) mild (pressured), 2) moderate (forced with violence) and 3) severe (raped). Women could also indicate when the violence had taken place: 1) during this pregnancy, 2) during the last six month before pregnancy or 3) earlier. Approximately 1 700 women who filled out the first version of Q1 had the answering options earlier and during the last 12 month when assessing time. We therefore created the variables previous and recent sexual violence, recent containing sexual violence during last 12 month, including the current pregnancy. Among the women who participated several times we included the first pregnancy only to ensure that the exposure was included only once per woman. More details about the exposure variable can be found in our previous studies [23;24] and in supplementary table 1.

Outcome variables

All outcome variables were obtained from the MBRN. Gestational age at birth in days was based on ultrasound at (approximately) gestational week 18. For women with no ultrasound, the gestational age was based on the last menstrual period (1.7%). PTB was defined as a gestational age <37, LBW as a birth weight <2500 grams, and SGA was defined as birth weight below the 10th percentile for the gestational age at birth. SGA was calculated using Norwegian specific fetal growth tables by Skjerven et al.[25]

Adjusting variables

Maternal age, parity, socio-economical status, smoking and body mass index (BMI) were considered as possible confounding factors and were adjusted for. All adjusting variables were taken from the MoBa. In Q1, age was categorised into 5 groups: younger than 20 years, 20–24 years, 25–29 years, 30–34 years or 35 years and older. As a proxy for socio-economic status, we used the woman's education in years (categorised into 4 groups): primary (<12 years), secondary (12 years), higher ≤4 years (13–16 years and) and higher >4 years (≥17 years). Parity was dichotomised into nulli- and multiparous women. Smoking was categorised as no smoking or smoking, which included both daily and occasional smoking. BMI was grouped into 4 categories: <20, 20-24.9, 25.0-29.9 or ≥30.0 kg/m2. We also adjusted for mental distress because it is considered to be associated with both the exposure and the outcome.[4,5] Mental distress was measured using 5 items from The Hopkins symptoms checklist (SCL-5) with a cut-off at ≥2.0 points, as suggested by Strand [26] and obtained from Q3.

Because of the co-occurrence of different violence types,[7] we examined the effect of physical and emotional abuse as a child or as an adult in the multivariable statistical models. Information on adult physical violence was taken from Q1 and consisted of a positive answer to whether women as an adult had experienced being slapped, hit, kicked or otherwise bothered in a physical manner. Child physical violence was taken from Q3 and consisted of a positive answer to the question "Have you experienced physical violence before the age of 18?" Emotional abuse as a child (<18) or as an adult (≥18) consisted of a positive answer to either, "Someone has over a long period of time systematically tried to subdue, degrade or humiliate you" or "Someone has threatened to hurt you or someone close to you" or both.

Previous preterm birth and inadequate antenatal care are considered to be associated with the exposure and the outcomes.[2, 3, 5] Because a previous preterm birth may be a result of sexual violence prior to the related pregnancy, we did not control for a previous preterm birth. In Norway, the majority of women attend antenatal care, a free and a well-integrated part of the public health system; therefore, we did not control for antenatal care. Ethnicity was not considered a relevant covariate in our study because the majority of the MoBa participants are ethnic Norwegian.

Statistical Analysis

Characteristics were presented as percentages within the entire sample and the different outcomes. Linear regression was performed to assess differences in birth weight and gestational age for children born to women with and without a history of mild, moderate and severe sexual violence. The association between sexual violence and PTB, LBW and SGA was estimated with crude and adjusted odds ratios using logistic regression analysis. Sexual violence was analysed as a categorical variable: 1=mild sexual violence, 2= moderate sexual violence and 3=severe sexual violence with no sexual violence as the reference group. All analyses were adjusted for maternal age, parity, education, smoking, BMI and mental distress in the first step. Birth weight was additionally adjusted for gestational age. We further adjusted for other types of violence in the second step. We initially tested the correlation between other types of violence and sexual violence because of co-occurrence, and all Pearson's correlation coefficients were below the generally accepted cut-off of <0.4 for use as a covariate in the regression analyses.[27] Post protocol, we stratified the sample into spontaneous start of birth and provider-initiated start of birth (induced start of birth or elective caesarean section) for gestational age because a provider-initiated start could influence the time point of birth. Information on how the birth started was taken from MBRN. We

additionally performed a sensitivity analysis in which we examined the association between sexual violence and SGA and LBW among women who had a spontaneous birth at term (≥37 weeks) because we wanted to examine the effect of violence in a group of women who were considered to be low risk according to gestational age and start of birth. When we examined the timing of the sexual violence, we compared women who were exposed to recent sexual violence (within the last 12 months) and those exposed to previous sexual violence to non-abused women. We also examined the timing among women reporting recent and previous severe sexual violence (rape) for all outcomes. The prevalence of missing data was generally low with 2.5% for BMI, 3.7% for education, and 0.7% for smoking during pregnancy. Because of this, no imputing methods for missing data were used,[28] except for the missing data for the SCL-5 (3.2%), which were replaced by the series mean. The results of the logistic regression analyses remained approximately the same when performed with the complete exclusion of missing data compared with using the imputed missing data for SCL-5.

The comparison group for all analyses was women not reporting any sexual violence. All analyses were performed with the statistical package SPSS for WINDOWS (SPSS Inc., Chicago, IL, USA) version 18. P-values <0.05 were considered statistically significant.

RESULTS

The mean gestational age at birth in the total sample was 279.6 days (standard deviation 11.9 days), and the mean birth weight was 3592.7 grams (standard deviation 547.1 g). Table 1 displays the characteristics in the total sample and by the different outcomes.

Table 1. Background characteristics in the total sample and by preterm birth (PTB): gestational age <week 37, low birth weight (LBW): weight <2500 g and small for gestational age (SGA) weight below the 10th percentile by gestational age at birth in the Mother and Child Cohort

	Total	PTB	LBW	SGA
	N=76 870	N=3620	N=2107	N=6257
	%	%	%	%

Age				
<20	1.5	2.2	2.6	1.9
20–24	12.2	12.7	13.8	13.2
25–29	36.2	34.6	34.8	36.4
30–34	35.7	33.7	33.2	34.2
≥35	14.4	16.7	15.6	14.3
Education				
Primary	2.4	3.1	3.9	2.7
Secondary	34.8	38.5	38.8	35.0
Higher ≤4 years	37.8	35.6	37.3	36.1
Higher >4 years	21.3	19.2	20.5	22.2
Missing	3.7	3.6	3.7	3.9
Parity				
Nulliparous	54.9	61.7	68.2	70.7
Multiparous	45.1	38.3	31.8	29.3
Smoking				
No	90.9	89.3	85.8	85.6
Yes	8.5	10.1	13.6	13.6
Missing	0.7	0.6	0.6	0.7
Pre-pregnancy body mass index				
<20	12.4	12.8	15.6	19.1
20–24.9	54.9	49.9	50.8	55.6
25–29.9	21.0	22.0	19.0	15.2
≥30	9.2	12.6	11.8	7.6
Missing	2.5	2.7	2.9	2.4
Mental distress				
No	93.3	92.3	91.3	92.3
Yes	6.8	7.7	8.7	7.7
Adult physical violence				
No	85.5	83.9	83.6	84.7
Yes	14.5	16.1	16.4	15.3
Child physical violence				
No	94.5	94.4	94.1	94.3
Yes	5.5	5.6	5.9	5.5
Adult emotional abuse				
No	83.6	82.1	81.3	82.5
Yes	16.4	17.9	18.7	17. 5
Child emotional abuse				
No	86.2	85.1	84.7	85.5

Yes	13.8	14.9	15.3	14.5

The prevalence of adverse neonatal outcomes was generally highest in the youngest (<20 y) and the oldest age groups (≥35 y) among smokers and women with primary school education. A BMI ≥30 was associated with PTB and LBW and BMI <20 with SGA. Women who reported mental distress also reported more PTB, LBW and SGA.

Among the 76 870 women enrolled, 9263 (12.1%) reported a history of mild sexual violence, 2102 (2.8%) moderate and 2746 (3.5%) severe. Women with a history of sexual violence were significantly younger and they were more likely to have primary school education. Additionally, these women more frequently reported smoking, a BMI ≥30 and mental distress. These women more often experienced other types of violence both as children and adults (data not provided in tables).

A lower gestational age at birth was observed for newborns from women who reported moderate and severe sexual violence with approximately two days when birth was provider-initiated (Table 2).

Table 2. Differences in gestational age for spontaneous and provider-initiated start of birth and birth weight for non-exposed women and women exposed to mild, moderate and severe sexual violence

	N= 76 870 (%)	**Mean**	**Crude estimate β (95% CI)**	**Adjusted estimate β (95% CI)***
Gestational age				
No sexual violence	62 699 (81.6)	279.7 days	1	1
Mild sexual violence	9263 (12.1)			
Spontaneous start	7323 (11.5)	279.9 days	0.09 (-0.16; 0.33)	0.22 (-0.04; -0.48)
Provider-initiated start	1940 (12.5)	280.3 days	0.36 (-0.37; 1.08)	0.64 (-0.11; 1.39)
Moderate sexual violence	2162 (2.8)			
Spontaneous start	1670 (2.7)	279.3 days	-0.40 (-0.87; 0.06)	-0.28 (-0.78; 0.21)
Provider-initiated start	492 (3.2)	277.6 days	-2.13 (-3.41; -0.84)	-2.02 (-3.39; -0.67)
Severe sexual violence	2746 (3.6)			
Spontaneous start	2048 (3.3)	278.7 days	-0.91 (-1.37; -0.44)	-0.65 (-1.15; -0.16)

Provider-initiated start	698 (4.5)	277.5 days	-2.24 (-3.47; -1.01)	-1.92 (-3.22; -0.62)
Birth weight				
No sexual violence	62 699 (81.6)	3594 g	1	1
Mild sexual violence	9263 (12.1)	3597 g	2.03 (-9.26; 13.32)	0.04 (-9.16; 9.23)**
Moderate sexual violence	2162 (2.8)	3582 g	-13.61 (-34.74; 7.51)	6.11 (-11.30; 23.52)**
Severe sexual violence	2746 (3.6)	3556 g	-38.33 (-59.17; -17.49)	-0.76 (-18.05; 16.53)**

*Adjusted for maternal age, parity, education, smoking, body mass index and mental distress
**Additional adjustment for gestational age

Among women with a spontaneous start of birth, the gestational age was approximately one half of a day shorter when women reported severe sexual violence. These findings were significant in an adjusted analysis. A crude analysis showed that women who reported a history of severe violence delivered on average 38.3 g lighter children, a difference that disappeared when controlling for gestational age, mother's age, parity, education, smoking, BMI and mental distress. There were no differences regarding birth weight between women with a history of mild or moderate sexual violence compared with non-abused women.

Results from the logistic regression analysis are presented in Table 3.

Table 3. Odds of preterm birth (PTB), low birth weight (LBW) and small for gestational age (SGA) with 95% confidence intervals (CI) according to the different levels of sexual violence

	N (%)	Prevalence (%)	Crude odds ratio (95% CI)	Adjusted odds ratio (95% CI)*
PTB		**3620 (4.7)**		
No sexual violence	62 699 (81.6)	2931 (4.7)	1	1
Mild sexual violence	9263 (12.1)	412 (4.4)	0.95 (0.85-1.06)	0.93 (0.83-1.03)
Moderate sexual violence	2162 (2.8)	115 (5.3)	1.15 (0.95-1.39)	1.14 (0.93-1.39)
Severe sexual violence	2746 (3.6)	162 (5.9)	1.28 (1.08-1.51)	1.15 (0.97-1.37)
LBW		**2107 (2.7)**		
No sexual violence	62 699 (81.6)	1681 (2.7)	1	1
Mild sexual violence	9263 (12.1)	257 (2.8)	1.04 (0.91-1.18)	0.98 (0.85-1.12)
Moderate sexual violence	2162 (2.8)	75 (3.5)	1.30 (1.03-1.65)	1.19 (0.93-1.53)
Severe sexual violence	2746 (3.6)	94 (3.4)	1.29 (1.04-1.59)	1.07 (0.85-1.34)
SGA		**6257 (8.1)**		
No sexual violence	62 699 (81.6)	5061 (8.1)	1	1
Mild sexual violence	9263 (12.1)	768 (8.3)	1.03 (0.95-1.12)	1.00 (0.91-1.08)
Moderate sexual violence	2162 (2.8)	178 (8.3)	1.02 (0.87-1.19)	0.95 (0.80-1.12)

Severe sexual violence	2746 (3.6)	250 (9.1)	1.14 (1.00-1.30)	1.05 (0.91-1.21)

*Adjusted for maternal age, parity, education, smoking, body mass index and mental distress

Women who reported severe sexual violence had higher odds of PTB, LBW and SGA in a crude analysis, an association that was attenuated and no longer significant when adjusted for maternal age, parity, education, smoking, BMI and mental distress. Other types of violence, both as a child and adult, had small attenuating effects on the odds ratios and were not included in the final models.

The sensitivity analysis, in which we examined the association between a history of sexual violence and SGA and LBW in a sub-sample of women who had a spontaneous term birth, showed the same pattern as in the total sample reported in Table 3. Women who reported severe sexual violence had higher odds of LBW and SGA in a crude analysis but not in the adjusted analysis (Data not provided in tables).

A crude analysis was used to examine if the timing of the violence was associated with adverse outcome. Women who reported recent sexual violence had a higher risk for LBW (OR 1.60 95% CI 1.04-2.17) compared with non-abused women. The association was no longer significant in the adjusted analysis. In our study, 684 (0.9%) women reported recent sexual violence (mild, moderate and severe) and 13 487 (17.5%) previous sexual violence (Supplementary Table S2). There was no association between recent severe sexual violence (rape) and adverse neonatal outcome (Supplementary Table S3). There were 66 (0.1%) women who reported recent rape in this study.

DISCUSSION

Main outcome

We found that moderate and severe sexual violence were associated with a reduction in gestational age at birth. The largest effect was observed when birth was provider-initiated among women exposed to moderate or severe violence. These women had an approximately two-day reduction in gestational age. There was no significant association between sexual violence and PTB, LBW or SGA in the adjusted analysis.

Strength

This study, based on information from a large population-based study, the Norwegian Mother and Child Cohort study (MoBa), which is linked to the Medical Birth Registry (MBRN), gave a unique opportunity to assess the association between sexual violence and outcome for newborns. The validity of the data in MoBa has in earlier research been described as sufficient for large-scale epidemiologic studies.[29, 30] Our study was strengthened by the fact that the information on the different outcome variables was collected prospectively from the quality-assessed MBRN.[31] The outcomes in this study are part of a complex phenomenon that has several different risk factors.[2] The setting in this study, with small social and health inequalities, may therefore be suitable to isolate the effect of sexual violence on adverse neonatal outcomes.

Limitations

There are also limitations to our study. The participation rate of 40.6% in MoBa is low, and MoBa suffers to some extent from selection bias. The women included in the study are older, have more education, smoke less and are less likely to be of a non-Norwegian origin than the Norwegian population. Although it is likely that there is a socioeconomic gradient that

influence prevalence estimates, a recent study by Nilsen et al. found no evidence that the exposure-outcome associations in the MoBa study were affected by selection bias.[32] This socioeconomic gradient may also limit the generalisability of our findings. The lack of a validated instrument for measuring the exposure is a limitation to this study, and violence measured in modules as part of a larger questionnaire, as that in MoBa, may achieve a lower disclosure rate.[5] However, a similar prevalence to that found in our study was reported in a Nordic study examining sexual violence and health.[33] The exposure was measured in gestational week 17, and sexual violence during pregnancy after this is therefore not included. In addition, we have no information on the context and frequency of the violence or information regarding the perpetrator.

To our knowledge, no studies have examined the influence of lifetime sexual violence reported during pregnancy on the gestational age at birth for newborns. There were minor differences in the gestational age between abused and non-abused women in this study, and the clinical importance of our findings for the health of the newborn is most likely limited. However, the difference between the provider-initiated and spontaneous initiation of birth may be of interest. Shorter provider-initiated pregnancies may suggest an increase in elective inductions and elective caesarean sections for those exposed to violence. This is supported by others [34, 35] and in our previous study on sexual violence and maternal outcome.[36] Studies have emphasised the meaning of control for abused women when giving birth,[37] and choosing a planned start of birth may help the abused women remain in control.

Unlike the current meta-analysis (not yet published), mentioned in a WHO report [5] we did not find sexual violence to be associated with PTB and LBW in adjusted analysis. To our knowledge, no study has found an association between violence and SGA. The studies

included in the meta-analysis were limited to sexual and/or physical intimate partner violence. However, our findings are supported by a Canadian population based study with a sample of 6 421 pregnant women [17] and a prospective cohort study including 1 555 women from the US.[15] The exposure in these studies was physical and sexual violence prior to pregnancy and in pregnancy without being limited to an intimate partner.[15, 17] These studies showed no association between violence and PTB or LBW.

The nature of the exposure measured in the MoBa study makes it difficult to directly compare our findings to others, mainly because we examined lifetime sexual violence by any perpetrator, not limited to intimate partner. Sexual violence is considered to be traumatic for the victim regardless if the perpetrator is a partner or not.[38] When an intimate partner is the perpetrator, sexual violence may in addition be accompanied by controlling behaviour and include both physical and emotional abuse.[38] Rape by strangers is usually a single violent event with a higher risk of physical injury. Both forms of violence are associated with adverse health effects,[5, 38] but the effect may differ. Unfortunately, we were not able to examine the effect of the perpetrator in this study because the MoBa study does not provide this information. However, research suggests that a substantial proportion of sexual violence occurs within an intimate relationship.[38] It is not unlikely that the question about severe sexual violence (rape) primarily reflects non-partner sexual abuse and that mild sexual violence (pressured to sexual acts) may be a more psychological exposure. Our crude analyses showed different results, with a significantly higher OR for adverse neonatal outcome among women who reported severe sexual violence, thus supporting the idea that the different levels of violence are different exposures. The use of a more comprehensive instrument when measuring the exposure, with multiple response options regarding context, frequency and perpetrator would have clarified this further and provided more comprehensive knowledge

about the nature of the violence. Nevertheless, we had the opportunity to control for both emotional and physical abuse in preliminary analysis and this did not change the ORs.

The prevalence of abuse during pregnancy is small in our study and may have decreased the power to detect an association between violence during pregnancy and adverse neonatal outcomes, an association that is supported by other studies.[10, 14, 39, 40] Living in an abusive relationship may have stopped women from disclosing the violence. In our study, sexual violence was assessed approximately in gestational week 17, and events of violence after that have been missed. Some studies suggest that the risk of sexual violence may increase with the length of the pregnancy for women that are exposed.[41] The studies that report the highest prevalence of violence have measured this several times during pregnancy.[6] Studies have reported a violence prevalence during pregnancy of between 3 to 19%.[6, 42], including both physical and sexual violence. Underreporting among the non-exposed may have caused a misclassification that has diminished the associations between sexual violence and neonatal outcomes in our study. Since the exposure was collected before the outcome, it is unlikely that misclassification was related to the outcome, thus resulting in a nondifferential misclassification that has biased the result towards the null. However, our prevalence of recent sexual (0.9%) violence is similar to the prevalence of 1% reported in a survey that assessed intimate partner violence among a representative sample of Norwegian women.[43] This number reflects the prevalence of sexual violence reported during the last year.

Several pathways between sexual violence and adverse neonatal outcomes are suggested, both direct and indirect.[5] The direct pathway of violence during pregnancy can cause immediate complications as bleeding, rupture of membranes and PTB, and examples of indirect

pathways include more health-risk behaviours, depression and stress/anxiety.[5, 44] Both experienced violence and living in an abusive environment can cause increased stress levels, which could be on the pathway between abuse and adverse neonatal outcome. Maternal exposure to stress can influence the hypothalamic pituitary axis (HPA) hormones, and it is suggested that changes in these hormones may cause negative outcomes, such as a reduction in gestational age and fetal growth restriction.[4, 45] It has been proposed that mental distress and symptoms of depression are on the causal pathway between violence and adverse health outcome, yet it has also been suggested that women with mental health difficulties are more likely to be victims of violence.[46] Because the relationship may be bi-directional, we chose to control for mental distress in our study. Similarly, the health risk behaviours smoking and BMI may be on the pathway between sexual violence and neonatal outcome. Nevertheless, we kept these covariates in the regression analysis because they are especially related to birth weight and PTB.[3, 47]

Conclusion

Overall, our findings provide no evidence for an association between lifetime sexual violence and adverse neonatal outcomes. A small significant effect on the gestational age at birth was detected, but the clinical importance of this is most likely limited for the health of the newborn. PTB, LBW and SGA all have complex origins with multiple possible pathways.[1, 2] Although we did not find an association between sexual violence and PTB, LBW or SGA in adjusted analyses, crude analyses in our study suggested that sexual violence may be a risk factor for adverse neonatal outcomes for some women; however, for the majority of women, the relationship was confounded by other risk factors. It is possible that these factors were the result of prior exposure to violence, but this could not be assessed in this study. Antenatal care is one of the most important entry points in which women seek health care without necessarily

disclosing ongoing exposure to violence or a history of sexual violence. It is recommended that caregivers and clinicians ask women about exposure to violence when assessing conditions that may be complicated by violence,[48] and more knowledge about this conditions is needed. Additionally, antenatal care may offer opportunities for women to receive help, both if they are exposed to violence and in providing assistance to change behavioural factors contributing to adverse outcomes.

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Contributions to authorship

LH participated in the conception and design of the study, performed the analysis and drafted the manuscript. BS participated in the conception of the study, advised on the statistical analyses and drafting of the manuscript. SV advised on the statistical analyses and the drafting of the manuscript. ML participated in the conception and design of the study, advised on the statistical analyses and participated in drafting the manuscript. All authors read and approved the final version.

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Data Sharing Statement

No additional data are available.

Competing interests

None.

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TITLE PAGE

Title: Sexual violence and neonatal outcomes: a Norwegian population-based cohort study

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ABSTRACT

Objective**:** The objective of this study was to explore the association between sexual violence and neonatal outcomes.
Design: National cohort study.
Setting: Women were recruited to the Norwegian Mother and Child Cohort Study (MoBa) when attending routine ultrasound examinations from 1999-2008.
Population: A total of 76 870 pregnant women.
Methods: Sexual violence and maternal characteristics were self-reported in postal questionnaires during pregnancy. Neonatal outcomes were retrieved from the Medical Birth Registry of Norway (MBRN). Risk estimations were performed with linear and logistic regression analysis.
Outcome m~~M~~easures: Gestational age at birth, birth weight, preterm birth (PTB), low birth weight (LBW) and small for gestational age (SGA).
Results**:** Of 76 870 women, 18.4% reported a history of sexual violence. A total of 4.7% had a premature birth, 2.7% had children with a birth weight <2500 g and 8.1% children were small for gestational age. Women reporting both moderate and severe sexual violence (rape) had a significantly reduced gestational length (2 days) when the birth was provider-initiated in an analysis adjusted for age, parity, education, smoking, BMI and mental distress. Those exposed to severe sexual violence had a significantly reduced gestational length of 0.51 days with a spontaneous start of birth. Crude estimates showed that severe sexual violence was associated with PTB, LBW and SGA. When controlling for the above-mentioned socio-demographic and behavioural factors, the association was no longer significant.
Conclusions: Sexual violence was not associated with adverse neonatal outcomes. Moderate and severe violence had a small but significant effect on gestational age; however, the clinical influence of this finding is most likely limited. Women exposed to sexual violence in this study reported more of the socio-demographic and behavioural factors associated with PTB, LBW and SGA compared with non-abused women.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- This study was based on information from a large population-based study described as sufficient for large-scale epidemiologic studies.
- All outcomes were collected prospectively from a quality-assessed birth register.
- The setting, with small social and health inequalities, was suitable to isolate the effect of sexual violence on adverse neonatal outcomes.
- A non-validated instrument for measuring of the exposure variable was a limitation to this study.

INTRODUCTION

Preterm birth is a common and costly health problem.[1, 2] Approximately one in ten babies are born preterm worldwide, and prematurity is considered to be the leading cause of death for newborns.[2] Low birth weight (LBW) can be a consequence of preterm birth (PTB) or intra uterine growth restriction, the latter leading to the birth of small for gestational age (SGA) infants.[3] Research has suggested ~~identified~~ some biological risk factors for PTB and LBW: ~~ethnicity,~~ multiple pregnancies, a previous preterm birth and uterine or placental abnormalities.[1, 3] Studies also emphasise other, less understood ~~behavioural and social factors as important but less understood~~ factors for both PTB and LBW.[1] These are ~~factors can be~~ maternal age, socio-economic status, ethnicity, maternal weight, substance abuse, stress, depression and violence.[1, 2, 4]

Violence against women is a significant public health problem, and a recent report from the World Health Organization (WHO) state that 35% of women worldwide have experienced either physical and/or sexual intimate partner violence or non-partner sexual violence.[5] A pregnancy does not protect women from violence, and the prevalence of physical or sexual violence during pregnancy ranges from 3.4-11% in high-income countries.[6] It is recognised that violence has an adverse impact on women's physical, sexual, reproductive, and mental health.[5, 7]

A connection between PTB or LBW and violence against women has been reported, but the association is both supported and contradicted.[5, 8-20] Several pathways between sexual violence and adverse pregnancy outcomes are suggested.[5] A direct pathway of sexual violence can result in immediate complications as bleeding and rupture of membranes that can

lead to a preterm birth.[5, 16] Other, more indirect pathways are suggested mediated by stress and stress responses [18] or by behavioural factors such as smoking or substance abuse, used to cope with the negative consequences of violence.[5]

Studies have primarily addressed physical abuse during pregnancy and PTB or LBW [8, 10, 11, 16-19, 21] or child sexual abuse and PTB/LBW.[9, 12] Results from a new meta-analysis published in the recent WHO report [5] have demonstrated an association between intimate partner violence, including both physical and sexual abuse, and PTB with an adjusted odds ratio (AOR) of 1.41 (95% CI 1.21-1.62) and AOR of 1.16 (95% CI: 1.02-1.29) with LBW.[5] However, ~~studies on sexual violence and neonatal outcomes~~ studies that have investigated the impact of sexual violence on neonatal outcomes specifically, are limited and few population-based studies with large sample sizes that enable controlling for confounding variables have been conducted [5, 11] ~~Thus, there is a need to study the potential effect of lifetime sexual violence on outcomes for newborns using a large cohort.~~ The Norwegian Mother and Child Cohort Study (MoBa) is a population-based prospective cohort study of pregnant women that includes measurements of lifetime sexual violence, sexual violence during pregnancy and other relevant covariates which makes it suitable to examine associations between sexual violence and neonatal outcome. In this study, we assessed the relationship between sexual violence and gestational age at birth and birth weight. Additionally, we explored the associations between sexual violence and PTB, LBW and SGA.

METHODS

This study was a sub-project in the MoBa -study that was conducted by the Norwegian Institute of Public health from 1999-2008.[22] All pregnant women in Norway were eligible to participate in MoBa, and they were recruited during their routine f~~o~~etal ultrasound

examination. Of the invited women, 40.6% consented to participate. Data were obtained through extensive self-administered questionnaires that contained demographic factors, general health, reproductive history and questions about maternal health status during pregnancy. Our analyses were based on questionnaire 1 (Q1), which was completed during (approximately) gestational week 17, and questionnaire 3 (Q3), which was completed during (approximately) gestational week 30. Data from MoBa were linked with data from the Medical Birth Registry of Norway (MBRN), which provided information on pregnancy and birth outcome. The current study is based on version VI of the quality-assured data files released for research in 2011. The MoBa study is described in detail elsewhere.[22] The questionnaires that were used in MoBa are available at the internet-site: http://www.fhi.no/studier/den-norske-mor-og-barn-undersokelsen/sporreskjemaer

Study population

This study included women who had a singleton birth between 22 and 44 weeks of gestation, who completed both Q1 and Q3, had MBRN data available and participated for the first time (79 363 women). While a pregnancy is the observation unit in the MoBa study, women are the observation unit in our study; hence, the exclusion of 13 475 pregnancies of women who participated more than once. We excluded 703 women who did not answer the questions on sexual violence. Further, we excluded records with missing data on gestational length (n= 297) and birth weight (n=41). We also excluded 6 children with birth weight <500 g and 4 children with birth weight >6000 g, leaving a study sample of 76 870 women (Figure 1).

Ethical statement

Informed consent was obtained from each women participating in the study. The Regional Committee for Medical Research Ethics (Ref.SAFH 95/313 RTL) and the Norwegian Data Inspectorate approved the study.

Variables

Exposure variable

The exposure variable was collected from Q1.~~; here, the w~~Women were asked if they had been ~~1)~~ pressured or forced to ~~perform~~ sexual relations. There were four possible answer options: 1) No, never~~acts,~~ ~~2)~~ Yes, pressured, ~~23~~) Yes, forced with violence or ~~43~~) Yes, raped. A positive answer was defined as having experienced sexual violence. Women with more than one positive answer were classified according to the most severe level reported. The answering options were coded into three levels of severity for the sexual violence: 1) mild (pressured), 2) moderate (forced with violence) and 3) severe (raped). ~~, and by the timing of the abuse (previously or recent). Recent meant exposed to sexual violence in the current pregnancy or the last 6 or 12 months before pregnancy.~~ Women could also indicate when the violence had taken place: 1) during this pregnancy, 2) during the last six month before pregnancy or 3) earlier. Approximately 1 700 women who filled out the first version of Q1 had the answering options earlier and during the last 12 month when assessing time. We therefore created the variables previous and recent sexual violence, recent containing sexual violence during last 12 month, including the current pregnancy. Among the women who participated several times we included the first pregnancy only to ensure that the exposure was included only once per woman. ~~-~~More details about the exposure variable can be found in our previous studies ~~-~~[23;24] and in supplementary table 1.

Outcome variables

All outcome variables were obtained from the MBRN. Gestational age at birth in days was based on ultrasound at (approximately) gestational week 18. For women with no ultrasound, the gestational age was based on the last menstrual period (1.7%). PTB was defined as a gestational age <37, LBW as a birth weight <2500 grams, and SGA was defined as birth weight below the 10th percentile for the gestational age at birth. SGA was calculated using Norwegian specific foetal growth tables by Skjerven et al.[25]

Adjusting variables

Maternal age, parity, socio-economical status, smoking and body mass index (BMI) were considered as possible confounding factors and were adjusted for. All adjusting variables were taken from the MoBa. In Q1, age was categorised into 5 groups: younger than 20 years, 20–24 years, 25–29 years, 30–34 years or 35 years and older. As a proxy for socio-economic status, we used the woman's education in years (categorised into 4 groups): primary (<12 years), secondary (12 years), higher ≤4 years (13–16 years and) and higher >4 years (≥17 years). Parity was dichotomised into nulli- and multiparous women. Smoking was categorised as no smoking or smoking, which included both daily and occasional smoking. BMI was grouped into 4 categories: <20, 20-24.9, 25.0-29.9 or ≥30.0 kg/m2. We also adjusted for mental distress because it is considered to be associated with both the exposure and the outcome.[4,5] Mental distress was measured using 5 items from The Hopkins symptoms checklist (SCL-5) with a cut-off at ≥2.0 points, as suggested by Strand [26] and obtained from Q3.

Because of the co-occurrence of different violence types,[7] we examined the effect of physical and emotional abuse as a child or as an adult in the multivariable statistical models. Information on adult physical violence was taken from Q1 and consisted of a positive answer to whether women as an adult had experienced being slapped, hit, kicked or otherwise bothered in a physical manner. Child physical violence was taken from Q3 and consisted of a positive answer to the question "Have you experienced physical violence before the age of 18?" Emotional abuse as a child (<18) or as an adult (≥18) consisted of a positive answer to either, "Someone has over a long period of time systematically tried to subdue, degrade or humiliate you" or "Someone has threatened to hurt you or someone close to you" or both.

Previous preterm birth and inadequate antenatal care are considered to be associated with the exposure and the outcomes.[2, 3, 5] Because a previous preterm birth may be a result of sexual violence prior to the related pregnancy, we did not control for a previous preterm birth. In Norway, the majority of women attend antenatal care, a free and a well-integrated part of the public health system; therefore, we did not control for antenatal care. Ethnicity was not considered a relevant covariate ~~confounding factor~~ in our study because the majority of the MoBa participants are ethnic Norwegian.

Statistical Analysis

Characteristics were presented as percentages within the entire sample and the different outcomes. Linear regression was performed to assess differences in birth weight and gestational age for children born to women with and without a history of mild, moderate and severe sexual violence. The association between sexual violence and PTB, LBW and SGA was estimated with crude and adjusted odds ratios using logistic regression analysis. Sexual

violence was analysed as a categorical variable: 1=mild sexual violence, 2= moderate sexual violence and 3=severe sexual violence with no sexual violence as the reference group. All analyses were adjusted for maternal age, parity, education, smoking, BMI and mental distress in the first step. Birth weight was additionally adjusted for gestational age. We further adjusted for other types of violence in the second step. We initially tested the correlation between other types of violence and sexual violence because of co-occurrence, and all Pearson's correlation coefficients were below the generally accepted cut-off of <0.4 for use as a covariate in the regression analyses.[27] Post protocol, we stratified the sample into spontaneous start of birth and provider-initiated start of birth (induced start of birth or elective caesarean section) for gestational age because a provider-initiated start could influence the time point of birth. Information on how the birth started was taken from MBRN. We additionally performed a sensitivity analysis in which we examined the association between sexual violence and SGA and LBW among women who had a spontaneous birth at term (≥37 weeks) because we wanted to examine the effect of violence in a group of women who were considered to be low risk according to gestational age and start of birth. When we examined the timing of the sexual violence, we compared women who were exposed to recent ~~(~~sexual violence (within the last ~~violence during pregnancy or the last 6 or~~ 12 months) and those exposed to previous sexual violence to non-abused women. We also examined the timing among women reporting recent and previous severe sexual violence (rape) for all outcomes. The prevalence of missing data was generally low with 2.5% for BMI, 3.7% for education, and 0.7% for smoking during pregnancy. Because of this, no imputing methods for missing data were used,[28] except for the missing data for the SCL-5 (3.2%), which were replaced by the series mean. The results of the logistic regression analyses remained approximately the same when performed with the complete exclusion of missing data compared with using the imputed missing data for SCL-5.

The comparison group for all analyses was women not reporting any sexual violence. All analyses were performed with the statistical package SPSS for WINDOWS (SPSS Inc., Chicago, IL, USA) version 18. P-values <0.05 were considered statistically significant.

RESULTS

The mean gestational age at birth in the total sample was 279.6 days (standard deviation 11.9 days), and the mean birth weight was 3592.7 grams (standard deviation 547.1 g). Table 1 displays the characteristics in the total sample and by the different outcomes.

Table 1. Background characteristics in the total sample and by preterm birth (PTB): gestational age <week 37, low birth weight (LBW): weight <2500 g and small for gestational age (SGA) weight below the 10th percentile by gestational age at birth in the Mother and Child Cohort

	Total	**PTB**	**LBW**	**SGA**
	N=76 870	N=3620	N=2107	N=6257
	%	%	%	%
Age				
<20	1.5	2.2	2.6	1.9
20–24	12.2	12.7	13.8	13.2
25–29	36.2	34.6	34.8	36.4
30–34	35.7	33.7	33.2	34.2
≥35	14.4	16.7	15.6	14.3
Education				
Primary	2.4	3.1	3.9	2.7
Secondary	34.8	38.5	38.8	35.0
Higher ≤4 years	37.8	35.6	37.3	36.1
Higher >4 years	21.3	19.2	20.5	22.2
Missing	3.7	3.6	3.7	3.9
Parity				
Nulliparous	54.9	61.7	68.2	70.7
Multiparous	45.1	38.3	31.8	29.3
Smoking				
No	90.9	89.3	85.8	85.6
Yes	8.5	10.1	13.6	13.6
Missing	0.7	0.6	0.6	0.7

Pre-pregnancy body mass index				
<20	12.4	12.8	15.6	19.1
20–24.9	54.9	49.9	50.8	55.6
25–29.9	21.0	22.0	19.0	15.2
≥30	9.2	12.6	11.8	7.6
Missing	2.5	2.7	2.9	2.4
Mental distress				
No	93.3	92.3	91.3	92.3
Yes	6.8	7.7	8.7	7.7
Adult physical violence				
No	85.5	83.9	83.6	84.7
Yes	14.5	16.1	16.4	15.3
Child physical violence				
No	94.5	94.4	94.1	94.3
Yes	5.5	5.6	5.9	5.5
Adult emotional abuse				
No	83.6	82.1	81.3	82.5
Yes	16.4	17.9	18.7	17. 5
Child emotional abuse				
No	86.2	85.1	84.7	85.5
Yes	13.8	14.9	15.3	14.5

The prevalence of adverse neonatal outcomes was generally highest in the youngest (<20 y) and the oldest age groups (≥35 y) among smokers and women with primary school education. A BMI ≥30 was associated with PTB and LBW and BMI <20 with SGA. Women who reported mental distress also reported more PTB, LBW and SGA.

Among the 76 870 women enrolled, 9263 (12.1%) reported a history of mild sexual violence, 2102 (2.8%) moderate and 2746 (3.5%) severe. Women with a history of sexual violence were significantly younger and they were more likely to have primary school education. Additionally, these women more frequently reported smoking, a BMI ≥30 and mental distress. These women more often experienced other types of violence both as children and adults (data not provided in tables).

A lower gestational age at birth was observed for newborns from women who reported moderate and severe sexual violence with approximately two days when birth was provider-initiated (Table 2).

Table 2. Differences in gestational age for spontaneous and provider-initiated start of birth and birth weight for non-exposed women and women exposed to mild, moderate and severe sexual violence

	N= 76 870 (%)	Mean	Crude estimate β (95% CI)	Adjusted estimate β (95% CI)*
Gestational age				
No sexual violence	62 699 (81.6)	279.7 days	1	1
Mild sexual violence	9263 (12.1)			
Spontaneous start	7323 (11.5)	279.9 days	0.09 (-0.16; 0.33)	0.22 (-0.04; -0.48)
Provider-initiated start	1940 (12.5)	280.3 days	0.36 (-0.37; 1.08)	0.64 (-0.11; 1.39)
Moderate sexual violence	2162 (2.8)			
Spontaneous start	1670 (2.7)	279.3 days	-0.40 (-0.87; 0.06)	-0.28 (-0.78; 0.21)
Provider-initiated start	492 (3.2)	277.6 days	-2.13 (-3.41; -0.84)	-2.02 (-3.39; -0.67)
Severe sexual violence	2746 (3.6)			
Spontaneous start	2048 (3.3)	278.7 days	-0.91 (-1.37; -0.44)	-0.65 (-1.15; -0.16)
Provider-initiated start	698 (4.5)	277.5 days	-2.24 (-3.47; -1.01)	-1.92 (-3.22; -0.62)
Birth weight				
No sexual violence	62 699 (81.6)	3594 g	1	1
Mild sexual violence	9263 (12.1)	3597 g	2.03 (-9.26; 13.32)	0.04 (-9.16; 9.23)**
Moderate sexual violence	2162 (2.8)	3582 g	-13.61 (-34.74; 7.51)	6.11 (-11.30; 23.52)**
Severe sexual violence	2746 (3.6)	3556 g	-38.33 (-59.17; -17.49)	-0.76 (-18.05; 16.53)**

*Adjusted for maternal age, parity, education, smoking, body mass index and mental distress
**Additional adjustment for gestational age

Among women with a spontaneous start of birth, the gestational age was approximately one half of a day shorter when women reported severe sexual violence. These findings were significant in an adjusted analysis. A crude analysis showed that women who reported a history of severe violence delivered on average 38.3 g lighter children, a difference that disappeared when controlling for gestational age, mother's age, parity, education, smoking, BMI and mental distress. There were no differences regarding birth weight between women with a history of mild or moderate sexual violence compared with non-abused women.

Results from the logistic regression analysis are presented in Table 3.

Table 3. Odds of preterm birth (PTB), low birth weight (LBW) and small for gestational age (SGA) with 95% confidence intervals (CI) according to the different levels of sexual violence

	N (%)	Prevalence (%)	Crude odds ratio (95% CI)	Adjusted odds ratio (95% CI)*
PTB		**3620 (4.7)**		
No sexual violence	62 699 (81.6)	2931 (4.7)	1	1
Mild sexual violence	9263 (12.1)	412 (4.4)	0.95 (0.85-1.06)	0.93 (0.83-1.03)
Moderate sexual violence	2162 (2.8)	115 (5.3)	1.15 (0.95-1.39)	1.14 (0.93-1.39)
Severe sexual violence	2746 (3.6)	162 (5.9)	1.28 (1.08-1.51)	1.15 (0.97-1.37)
LBW		**2107 (2.7)**		
No sexual violence	62 699 (81.6)	1681 (2.7)	1	1
Mild sexual violence	9263 (12.1)	257 (2.8)	1.04 (0.91-1.18)	0.98 (0.85-1.12)
Moderate sexual violence	2162 (2.8)	75 (3.5)	1.30 (1.03-1.65)	1.19 (0.93-1.53)
Severe sexual violence	2746 (3.6)	94 (3.4)	1.29 (1.04-1.59)	1.07 (0.85-1.34)
SGA		**6257 (8.1)**		
No sexual violence	62 699 (81.6)	5061 (8.1)	1	1
Mild sexual violence	9263 (12.1)	768 (8.3)	1.03 (0.95-1.12)	1.00 (0.91-1.08)
Moderate sexual violence	2162 (2.8)	178 (8.3)	1.02 (0.87-1.19)	0.95 (0.80-1.12)
Severe sexual violence	2746 (3.6)	250 (9.1)	1.14 (1.00-1.30)	1.05 (0.91-1.21)

*Adjusted for maternal age, parity, education, smoking, body mass index and mental distress

Women who reported severe sexual violence had higher odds of PTB, LBW and SGA in a crude analysis, an association that was attenuated and no longer significant when adjusted for maternal age, parity, education, smoking, BMI and mental distress. Other types of violence, both as a child and adult, had small attenuating effects on the odds ratios and were not included in the final models.

The sensitivity analysis, in which we examined the association between a history of sexual violence and SGA and LBW in a sub-sample of women who had a spontaneous term birth, showed the same pattern as in the total sample reported in Table 3. Women who reported severe sexual violence had higher odds of LBW and SGA in a crude analysis but not in the adjusted analysis (Data not provided in tables).

A crude analysis was used to examine if the timing of the violence was associated with adverse outcome. Women who reported recent sexual violence had a higher risk for LBW (OR 1.60 95% CI 1.04-2.17) compared with non-abused women. The association was no longer significant in the adjusted analysis. In our study, 684 (0.9%) women reported recent sexual violence (mild, moderate and severe) and 13 487 (17.5%) previous sexual violence (Supplementary Table S2~~1~~). There was no association between recent severe sexual violence (rape) and adverse neonatal outcome (Supplementary Table S3~~2~~). There were 66 (0.1%) women who reported recent rape ~~during pregnancy or the last 6 or~~ in ~~12 months in~~ this study.

DISCUSSION

Main outcome

We found that moderate and severe sexual violence were associated with a reduction in gestational age at birth. The largest effect was observed when birth was provider-initiated among women exposed to moderate or severe violence. These women had an approximately two-day reduction in gestational age. There was no significant association between sexual violence and PTB, LBW or SGA in the adjusted analysis.

Strength

This study, based on information from a large population-based study, the Norwegian Mother and Child Cohort study (MoBa), which is linked to the Medical Birth Registry (MBRN), gave a unique opportunity to assess the association between sexual violence and outcome for newborns. The validity of the data in ~~the~~ MoBa has in earlier research been described as sufficient for large-scale epidemiologic studies.[29, 30] Our study was strengthened by the fact that the information on the different outcome variables was collected prospectively from the quality-assessed MBRN.[31] The outcomes in this study are part of a complex

phenomenon that has several different risk factors.[2] The setting in this study, with small social and health inequalities, may therefore be suitable to isolate the effect of sexual violence on adverse neonatal outcomes.

Limitations

There are also limitations to our study. The participation rate of 40.6% in MoBa is low, and MoBa suffers to some extent from selection bias. The women included in the study are older, have more education, smoke less and are less likely to be of a non-Norwegian origin than the Norwegian population. Although it is likely that there is a socioeconomic gradient that influence prevalence estimates, ~~A~~a recent study by Nilsen et al. ~~has~~ found ~~that this may affect the prevalence estimates, but there was~~ no evidence that the exposure-outcome associations in the MoBa study were affected by selection bias.[32] This socioeconomic gradient may also ~~Furthermore, as preterm birth is associated with ethnicity, the ethnic homogeneous sample in MoBa may~~ limit the generalisability of our findings. The lack of a validated instrument for measuring the exposure is a limitation to this study, and violence measured in modules as part of a larger questionnaire, as that in MoBa, may achieve a lower disclosure rate.[5] However, a similar prevalence to that found in our study was reported in a Nordic study examining sexual violence and health.[33] The exposure was measured in gestational week 17, and sexual violence during pregnancy after this is therefore not included. In addition, we have no information on the context and frequency of the violence or information regarding the perpetrator.

To our knowledge, no studies have examined the influence of lifetime sexual violence reported during pregnancy on the gestational age at birth for newborns. There were minor differences in the gestational age between abused and non-abused women in this study, and

the clinical importance of our findings for the health of the newborn is most likely limited. However, the difference between the provider-initiated and spontaneous initiation of birth may be of interest. Shorter provider-initiated pregnancies may suggest an increase in elective inductions and elective caesarean sections for those exposed to violence. This is supported by others [34, 35] and in our previous study on sexual violence and maternal outcome.[36] Studies have emphasised the meaning of control for abused women when giving birth,[37] and choosing a planned start of birth may help the abused women remain in control.

Unlike the current meta-analysis (not yet published), mentioned in a WHO report ~~(not yet published),~~[5] we did not find sexual violence to be associated with PTB and LBW in adjusted analysis. To our knowledge, no study has found an association between violence and SGA. The studies included in the meta-analysis were limited to ~~investigated both~~ sexual and/or physical intimate partner violence., ~~in contrast to our study, which investigated lifetime sexual violence.~~ However, our findings are supported by a Canadian population based study with a sample of 6 421 pregnant women [17] and a prospective cohort study including 1 555 women from the US [15]. The exposure in these studies was physical and sexual violence prior to pregnancy and in pregnancy without being limited to an intimate partner. [15, 17] These studies showed no association between violence and PTB or LBW.

The nature of the exposure measured in the MoBa study makes it difficult to directly compare our findings to others, mainly because we examined lifetime sexual violence by any perpetrator, not limited to intimate partner. Sexual violence is considered to be traumatic for the victim regardless if the perpetrator is a partner or not.[38] When an intimate partner is the perpetrator, sexual violence may in addition be accompanied by controlling behaviour and include both physical and emotional abuse.[38] Rape by strangers is usually a single violent

event with a higher risk of physical injury. Both forms of violence are associated with adverse health effects, [5, 38] but the effect may differ. ~~Studies on the health effects of non-partner sexual violence are limited with less robust data than for intimate partner violence.[5]~~ Unfortunately, we were not able to examine the effect of the perpetrator in this study because the MoBa study does not provide this information. However, research suggests that a substantial proportion of sexual violence occurs within an intimate relationship.[38] ~~Our data from the MoBa does not differentiate between intimate partner violence and sexual abuse by non-partners~~It ~~, but it~~ is not unlikely that the question about severe sexual violence (rape) primarily reflects non-partner sexual abuse . ~~,~~ and that mild sexual violence (pressured to sexual acts) may be a more psychological exposure. Our crude analyses showed different results, with a significantly higher OR for adverse neonatal outcome among women who reported severe sexual violence, thus supporting the idea that the different levels of violence are different exposures. The use of a more comprehensive instrument when measuring the exposure, with multiple response options regarding context, frequency and perpetrator would have clarified this further and provided more comprehensive knowledge about the nature of the violence. Nevertheless, we had the opportunity to control for both emotional and physical abuse in preliminary analysis and this did not change the ORs.

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~~Several pathways between sexual violence and adverse neonatal outcomes are suggested, both direct and indirect.[5] The direct pathway of violence during pregnancy can lead to a preterm birth, and examples of indirect pathways include more health-risk behaviours, depression and stress/anxiety.[5, 40] Both experienced violence and living in an abusive environment can cause increased stress levels, which could be on the pathway between abuse and adverse~~

~~neonatal outcome. Maternal exposure to stress can influence the hypothalamic pituitary axis (HPA) hormones, and it is suggested that changes in these hormones may cause negative outcomes, such as a reduction in gestational age and foetal growth restriction.[4, 41]~~

The prevalence of abuse during pregnancy is small in our study and may have decreased the power to detect an association between violence during pregnancy and adverse neonatal outcomes, an association that is supported by other studies.[10, 14, ~~42~~39, ~~43~~40] Living in an abusive relationship may have stopped women from disclosing the violence. In our study, sexual violence was assessed approximately in gestational week 17, and events of violence after that ~~may~~ have been missed. Some studies suggest that the risk of sexual violence may increase with the length of the pregnancy for women that are exposed.[41]~~.~~ The studies that report the highest prevalence of violence have measured this several times during pregnancy. [6] Studies have reported a violence prevalence during pregnancy of between 3 to 19%.[6, 4~~4~~2], including both ~~A direct comparison to our study is difficult because these numbers estimate both~~ physical and sexual violence. ~~abuse during pregnancy; they may suggest that sexual violence during pregnancy is underreported in our study.~~ Underreporting among the non-exposed may have caused a misclassification that has diminished the associations between sexual violence and neonatal outcomes in our study. Since the exposure was collected before the outcome, it is unlikely that misclassification was related to the outcome, thus resulting in a nondifferential misclassification that has biased the result towards the null. ~~Living in an abusive relationship may also stop women from disclosing the violence.~~

However, our prevalence of recent sexual (0.9%) violence is similar to the prevalence of 1% reported in a survey that assessed intimate partner violence ~~in a national population based study on violence~~ among a representative sample of Norwegian women.[4~~5~~3] This number reflects the prevalence of sexual violence reported during the last year. ~~r, not especially among pregnant women.~~

Several pathways between sexual violence and adverse neonatal outcomes are suggested, both direct and indirect.[5] The direct pathway of violence during pregnancy can cause immediate complications as bleeding, rupture of membranes and PTB, and examples of indirect pathways include more health-risk behaviours, depression and stress/anxiety.[5, 44] Both experienced violence and living in an abusive environment can cause increased stress levels, which could be on the pathway between abuse and adverse neonatal outcome. Maternal exposure to stress can influence the hypothalamic pituitary axis (HPA) hormones, and it is suggested that changes in these hormones may cause negative outcomes, such as a reduction in gestational age and fetal growth restriction.[4, 45] It has been proposed that mental distress and symptoms of depression are on the causal pathway between violence and adverse health outcome, yet it has also been suggested that women with mental health difficulties are more likely to be victims of violence.[46] Because the relationship may be bi-directional, we chose to control for mental distress in our study. Similarly, the health risk behaviours smoking and BMI may be on the pathway between sexual violence and neonatal outcome. Nevertheless, we kept these covariates in the regression analysis because they are especially related to birth weight and PTB.[3, 47]

Conclusion

Overall, our findings provide no evidence for an association between lifetime sexual violence and adverse neonatal outcomes. A small significant effect on the gestational age at birth was detected, but the clinical importance of this is most likely limited for the health of the newborn. PTB, LBW and SGA all have complex origins with multiple possible pathways.[1, 2] Although we did not find an association between sexual violence and PTB, LBW or SGA

in adjusted analyses, crude analyses in our study suggested that sexual violence may be a risk factor for adverse neonatal outcomes for some women; however, for the majority of women, the relationship was~~is~~ confounded by other risk factors. It is possible that these factors were the result of prior exposure to violence, but this could not be assessed in this study. Antenatal care is one of the most important entry points in which women seek health care without necessarily disclosing ongoing exposure to violence or a history of sexual violence. It is recommended that caregivers and clinicians ask women about exposure to violence when assessing conditions that may be complicated by violence,[4~~8~~6] and more knowledge about this conditions is needed. Additionally, antenatal care may offer opportunities for women to receive help, both if they are exposed to violence and in providing assistance to change behavioural factors contributing to adverse outcomes.

Competing interests

None.

Contributions to authorship

LH participated in the conception and design of the study, performed the analysis and drafted the manuscript. BS participated in the conception of the study, advised on the statistical analyses and drafting of the manuscript. SV advised on the statistical analyses and the drafting of the manuscript. ML participated in the conception and design of the study, advised on the statistical analyses and participated in drafting the manuscript. All authors read and approved the final version.

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Figure 1. Inclusion and exclusion process

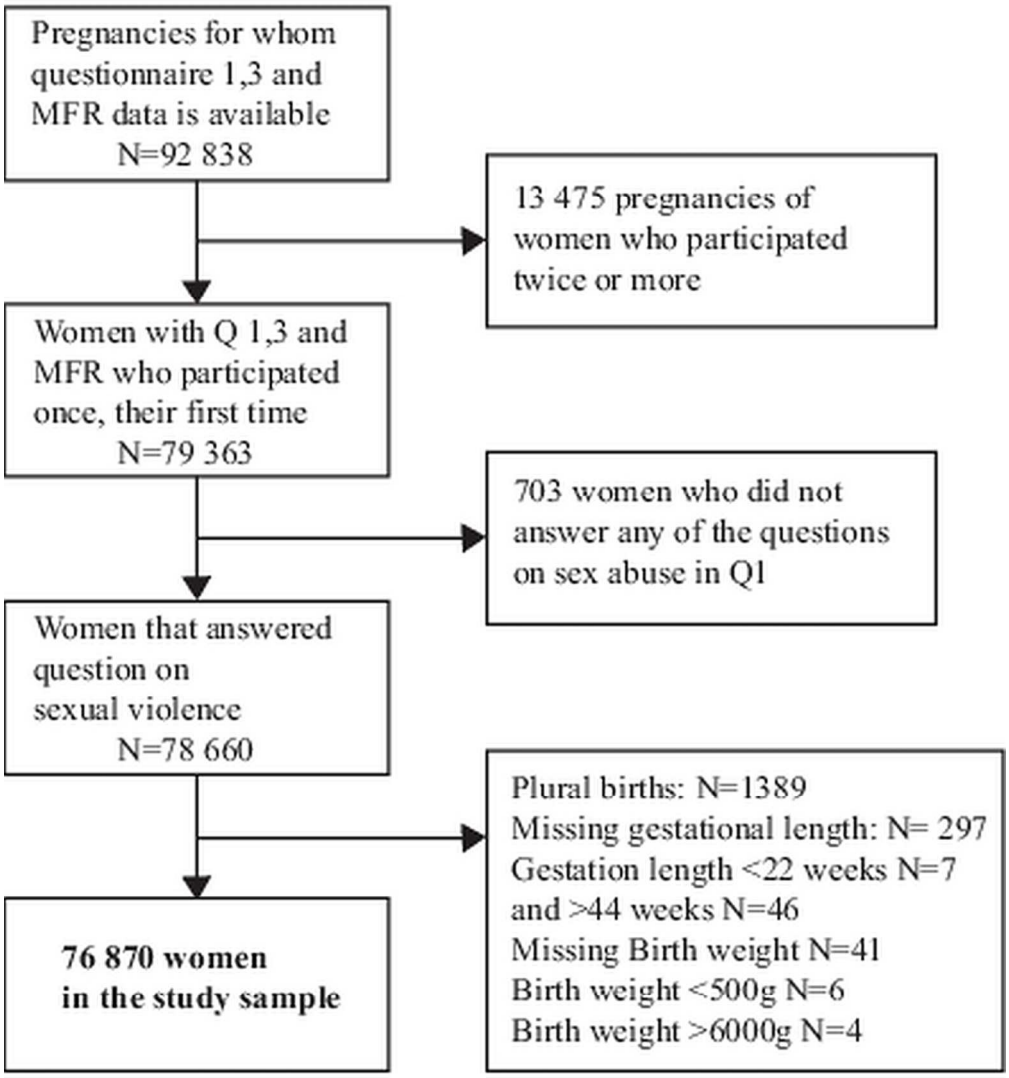

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Table S1. Questions on sexual violence in The Norwegian Mother and Child Cohort Study (MoBa)

The first version, answered by 1712 women (version A):

Have you ever in been pressured or forced to sexual relations?
(Fill in one or several boxes.)

	Last 12 months	Earlier
No, never...……..	☐	☐
Yes, pressured……..	☐	☐
Yes, forced with violence…….	☐	☐
Yes, raped…….….	☐	☐

The questions used in the other versions:

Have you ever in been pressured or forced to sexual relations?
(Fill in one or several boxes.)

	During this pregnancy	Last 6 months before pregnancy	Earlier
No, never...……..	☐	☐	☐
Yes, pressured……..	☐	☐	☐
Yes, forced with violence…….	☐	☐	☐
Yes, raped…….….	☐	☐	☐

Table S2: Odds of preterm birth (PTB), low birth weight (LBW) and small for gestational age (SGA) with 95% confidence intervals (CI) according to previous and recent sexual violence

	N (%)	Prevalence (%)	Crude odds ratio (95% CI)	Adjusted odds ratio (95% CI)
PTB		**3620 (4.7)**		
No sexual violence	62 699 (81.6)	2931 (4.7)	1	1
Previous sexual violence	13487 (17.5)	650 (4.8)	1.03 (0.95-1.13)	0.99 (0.90-1.09)
Recent sexual violence	684 (0.9)	39 (5.7)	1.23 (0.89-1.71)	1.17 (0.83-1.65)
LBW		**2107 (2.7)**		
No sexual violence	62 699 (81.6)	1681 (2.7)	1	1
Previous sexual violence	13 487 (17.5)	397 (2.9)	1.10 (0.99-1.23)	1.0 (0.86-1.12)
Recent sexual violence	684 (0.9)	29 (4.2)	1.60 (1.04-2.33)	1.45 (0.97-2.17)
SGA		**6257 (8.1)**		
No sexual violence	62 699 (81.6)	5061 (8.1)	1	1
Previous sexual violence	13 487 (17.5)	1136 (8.4)	1.05 (0.98-1.12)	0.98 (0.92-1.06)
Recent sexual violence	684 (0.9)	60 (8.8)	1.10 (0.84-1.43)	1.18 (0.90-1.56)

*Adjusted for maternal age, parity, education, smoking, body mass index and mental distress

Table S3: Odds of preterm birth (PTB), low birth weight (LBW) and small for gestational age (SGA) with 95% confidence intervals (CI) according to previous and recent severe violence (rape)

	N (%)	Prevalence (%)	Crude odds ratio (95% CI)	Adjusted odds ratio (95% CI)*
PTB		**3620 (4.7)**		
No rape	74 124 (96.4)	3458 (4.7)	1	1
Previous rape	2680 (3.5)	157 (5.9)	1.27 (1.08-1.50)	1.14 (0.97-1.36)
Recent rape	66 (0.1)	5 (7.6)	1.68 (0.67-4.17)	1.72 (0.68-4.33)
LBW		**2107 (2.7)**		
No rape	74 124 (96.4)	2013(2.7)	1	1
Previous rape	2680 (3.5)	91 (3.4)	1.26 (1.02-1.56)	1.06 (0.84-1.33)
Recent rape	66 (0.1)	3 (4.5)	1.71 (0.54-5.44)	1.55 (0.48-5.02)
SGA		**6257 (8.1)**		
No rape	74 124 (96.4)	6007 (8.1)	1	1
Previous rape	2680 (3.5)	247 (9.2)	1.15 (1.01-1.32)	1.06 (0.92-1.23)
Recent rape	66 (0.1)	3 (4.5)	0.54 (0.17-1.72)	0.55 (0.17-1.79)

*Adjusted for maternal age, parity, education, smoking, body mass index and mental distress

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	page 1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	page 2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	page 3 and
Objectives	3	State specific objectives, including any prespecified hypotheses	page 4
Methods			
Study design	4	Present key elements of study design early in the paper	From page 4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection in addition reference is given for further reading of detailed information on MoBa study (referece 22)	Page 4
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	NA
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Presented on pages 5-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Page 5-7
Bias	9	Describe any efforts to address potential sources of bias controlling for confounding and covariates	pages 6 and 7.
Study size	10	Explain how the study size was arrived at	figure 1 and page5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Page 6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	page 7 and 8
		(*b*) Describe any methods used to examine subgroups and interactions	page 8
		(*c*) Explain how missing data were addressed	page 8
		(*d*) If applicable, explain how loss to follow-up was addressed	NA
		(*e*) Describe any sensitivity analyses	page 8
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed All listed in Figure 1	
		(b) Give reasons for non-participation at each stage	Page 5

		(c) Consider use of a flow diagram Figure 1	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Table 1: page 9 and 10
		(b) Indicate number of participants with missing data for each variable of interest	Table 1
		(c) Summarise follow-up time (eg, average and total amount)	NA
Outcome data	15*	Report numbers of outcome events or summary measures over time	Table 1
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Page 6-7, 11 - 12 and Table 2 and 3
		(*b*) Report category boundaries when continuous variables were categorized	Page 6 and Table 1
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	page 12-13Supplementary Tables 1 and 2
Discussion			
Key results	18	Summarise key results with reference to study objectives	page 13
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Page 13-16
Generalisability	21	Discuss the generalisability (external validity) of the study results	Page 14
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Page 17

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.