Is teenage pregnancy an obstetric risk in a welfare society? A population-based study in Finland, from 2006 to 2011.

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TITLE PAGE

Is teenage pregnancy an obstetric risk in a welfare society? A population-based study in Finland, from 2006 to 2011.

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ABSTRACT

Objective: To assess obstetric outcomes in teenage pregnancies in a country with a low teenage delivery rate and comprehensive high-quality prenatal care.

Design: Retrospective population-based register study.

Setting: Finland**.**

Participants: All nulliparous teenagers (13–15 years [n=84], 16–17 years [n=1234], 18–19 years [n=5987]) and controls (25–29-year-old women [n=51 142]) with singleton deliveries in 2006–2011.

Main outcome measures: Risk of adverse obstetric outcomes adjusted for demographic factors and clinically relevant pregnancy complications.

Results: Teenage mothers were more likely than controls to live in rural areas (16.0% [n=1168] *vs.* 11.8% [n=6035]), smoke (36.4% [n=2661] *vs.* 7.0% [n=3580]) and misuse alcohol or drugs (1.1% [n=82] *vs.* 0.2% [n=96]) (p<0.001 for all). Teenagers made a good mean number of antenatal clinic visits (16.4 *vs*. 16.5), but were more likely to have attended fewer than half of the recommended visits (2.9% [n=155] *vs.* 1.4% [=716]).

Teenagers faced increased risks of several obstetric complications, e.g. anaemia (adjusted odds ratio 1.8, 95% confidence interval 1.6 to 2.1), proteinuria (1.8, 1.2 to 2.6) urinary tract infection (UTI) (2.9, 1.8 to 4.8) pyelonephritis (6.3, 3.8 to 10.4) and eclampsia (3.2, 1.4 to 7.3), the risks increasing with descending age for most outcomes. Elevated risks of pre-eclampsia (3.7, 1.5 to 9.0) and preterm delivery (2.5, 1.2 to 5.3) were also found among 13—15-year-olds. However, teenage mothers were

more likely to have vaginal delivery (1.9, 1.7 to 2.0) without complications. Inadequate prenatal care among teenagers was a risk factor of eclampsia (12.6, 2.6 to 62.6), UTI (5.8, 1.7 to 19.7) and adverse neonatal outcomes.

Conclusions: Pregnant teenagers tended to be socioeconomically disadvantaged *vs.* controls and faced higher risks of various pregnancy complications. Special attention should be paid to enrolling teenagers into adequate prenatal care in early pregnancy.

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ARTICLE SUMMARY

Article focus

- Teenage pregnancy is associated with maternal anaemia and preterm birth. Association with other adverse obstetric outcomes, especially maternal complications, is less clear.
- Adequate antenatal care among teenagers has been shown to decrease adverse neonatal outcomes, but comprehensive care to all women was not offered in the previous study settings.
- We examined age-specific risks of adverse obstetric outcomes among teenagers, focusing on maternal pregnancy complications and the role of inadequate antenatal care.

Key messages

- In addition to a higher risk of anaemia, elevated risks of urinary tract infection, pyelonephritis, proteinuria and eclampsia were found among teenagers as well as pre-eclampsia and preterm delivery among the youngest girls.
- Inadequate antenatal care may place teenagers at markedly elevated risks of urinary tract infection, eclampsia and adverse neonatal outcomes even in a welfare society offering high-quality care to all pregnant women.

Strengths and limitations of this study

- The present study was nationwide, giving a realistic reflection of the situation regarding obstetric challenges among all teenage pregnancies during the study period.
- We were able to investigate a number of factors that have been sparsely reported in connection with teenage pregnancies, including proteinuria, cystitis and pyelonephritis during pregnancy, fear of childbirth and pain relief during delivery.
- Our study was retrospective and we could not look at the socioeconomic or educational status of women.

INTRODUCTION

Pregnancy during teenage years is associated with socioeconomic and health inequalities as regards both mother and child,[1-5] including higher risks of deprivation,[2] behavioural and emotional difficulties,[2] maltreatment,[1] morbidity[1] and premature mortality.[1 4] Therefore, it is a global concern. Although most pronounced in developing countries, teenage pregnancy also remains a significant problem in the developed world. The incidence of teenage pregnancy ending in delivery varies widely, with Nordic countries having comparatively low rates: 6/1000 in Sweden[6] and 9/1000 in Finland,[6] compared with 24/1000 in England and Wales[7] and 34/1000 in the USA in 2010.[8]

Obstetric risks are often divided into categories of maternal complications, mode of delivery and its complications, and neonatal outcome. Teenage pregnancies are associated with maternal anaemia,[9-12] hypertensive problems[13 14] and premature birth,[15-17] while low risks as regards delivery complications have been reported in studies carried out in industrialised countries.[9-12 17] However, results concerning several adverse outcomes vary largely, possibly as a result of the great number of confounding factors. Poor socioeconomic conditions,[1 9 10] risky health behaviour,[9 12] inadequate prenatal care[17-19] and biological immaturity[15-17] have been suggested as possible explanations for adverse obstetric outcomes.

Although the issue of teenage pregnancy has been widely studied, a consensus of opinion on obstetric risks is lacking. Comprehensive, age-specific studies concerning maternal complications remain sparse.[9 16] In addition, the role of prenatal care in regard to these problems is not well established. The objective of the present study was to investigate the risks of adverse obstetric outcomes in teenagers in a country with a low rate of adolescent births and comprehensive high-quality prenatal

care, with special focus on maternal complications during pregnancy. Secondly, we aimed to focus on the effect on these outcomes of a low number of visits to antenatal clinics.

MATERIAL AND METHODS

Study population

We identified all childbirths (n=354 833, of which 349 531 were singleton births) between 1 January 2006 and 31 December 2011 in Finland using the national Medical Birth Register (MBR). Only singleton pregnancies of nulliparous women (n=97 838) were included. Cases of major congenital anomaly were excluded (n=4149). After exclusion, there was a total of 7305 singleton childbirths among 13—19-year-old nulliparous girls and women, further divided into three groups: 13—15-year-olds (n=84), 16—17-year-olds (n=1234), and 18—19-year-olds (n=5987). Singleton deliveries (n=51 142) among women aged 25—29 years served as reference material. Women with histories of abortion and miscarriage (n=11 703, 20.1%) were included.

Data collection

The study data were obtained from the MBR and the Hospital Discharge Register (HDR), maintained by the National Institute for Health and Welfare. Reporting to these national registers is obligatory and the data has been shown to be valid and to reflect good coverage.[20]

Data for the MBR is collected at all maternity hospitals in Finland.[21] It covers all live births and stillbirths with a birth weight of 500 grams or more or with a gestational age of 22 weeks or more. The

register includes information on maternal demographic factors, prenatal care, interventions and common diagnoses during pregnancy and delivery and neonatal outcomes until the age of seven days.

The HDR contains information on all in-patient periods in public and private hospitals and out-patient visits in the public sector. The information includes diagnosis (ICD-10 codes), dates of admission and discharge and the code of the hospital or other institution. We collected the data separately for pregnancy and delivery (delivery complications include diagnoses reported from the start of delivery until 42 days postpartum). Each complication was noted once per woman.

Study variables

The choice of study variables was based on previous literature and clinical relevance. All study variables are listed with ICD-10 codes, unless derived from the MBR in a separate check-box**.**

Maternal outcomes of interest were anaemia (haemoglobin below 100 g/l), pregnancy-induced hypertension (PIH) (O13, O16), pre-eclampsia (O14), eclampsia, gestational diabetes, intrahepatic cholestasis of pregnancy (O26.6), *placenta praevia*, sexually transmitted infections (*Chlamydia trachomatis* [A56], *Neisseria gonorrhoeae* and syphilis [A51-A54]), urinary tract infection (UTI) (N30, N34, N39.0, O23.1–O23.4, O23.9), pyelonephritis (N10, N12, O23.0), chorioamnionitis (O41.1), proteinuria (O12 excluding O12.0), preterm contractions (before 37 weeks of gestation; O47.0), bleeding in early pregnancy (O20) and fear of childbirth (O99.80).

Delivery outcomes of interest were mode of delivery (vaginal delivery, vaginal breech delivery, assisted vaginal delivery [vacuum extraction or forceps] and Caesarean section [elective, urgent and emergency]), induction of labour, use of oxytocin, episiotomy, pain relief during delivery (regional anaesthesia, other medication and non-medical pain relief), anal sphincter rupture, shoulder dystocia,

placental abruption, uterine curettage, abnormal bleeding during (O67) and after delivery (O72), uterine rupture (O71.0–O71.1) and postpartum infection (O85, O86, N71, N72).

Neonatal outcomes selected for analysis were premature birth (extremely premature [<28 weeks] and premature [<37 weeks of gestation]), birth weight adjusted for gestational age[22] (divided into small-for-gestational-age [SGA], average-for-gestational-age [AGA] and large-for-gestational age [LGA]), 5-min Apgar score below 7, cord blood pH below 7.05 at birth, resuscitation of the newborn, use of a respirator, use of antibiotics, phototherapy, admission to a neonatal intensive care unit, intrauterine fetal death (delivery of a stillborn at 22 weeks of gestation or later) and neonatal death (death of a live-born at 0–6 days of age).

Demographic factors are presented in Table 1. Of these, alcohol or drug misuse during pregnancy (Z72.1–Z72.2), pre-existing diabetes (E10–E12, O24.0–O24.3) and pre-existing hypertension (I10, O10–O11) were derived from the HDR and other variables from the MBR.

Table 1. Demographic characteristics according to age group (years)

	13–15	16–17	18–19	All teenagers	25–29	P for difference
n	84	1234	5987	7305	51 142	
Cohabitation status						
Married/cohabiting	13 (15.5)	598 (48.5)	4248 (71.0)	4859 (66.5)	45 262 (88.5)	<0.001
Single	45 (53.6)	471 (38.2)	1132 (18.9)	1644 (22.5)	2608 (5.1)	
Missing data	26 (30.9)	165 (13.3)	607 (10.1)	802 (11.0)	3272 (6.4)	
Type of residence						
Urban	52 (61.9)	820 (66.5)	3980 (66.5)	4852 (66.4)	37589 (73.5)	<0.001
Densely populated	14 (16.7)	185 (15.0)	1050 (17.5)	1249 (17.1)	7313 (14.3)	
Rural	16 (19.0)	222(18.0)	930 (15.5)	1168 (16.0)	6035 (11.8)	
Missing data	2 (2.4)	7 (0.5)	27 (0.5)	36 (0.5)	205 (0.4)	
Smoking during pregnancy						
Yes	28 (33.3)	506 (41.3)	2127 (35.5)	2661 (36.4)	3580 (7.0)	<0.001
Quit during 1st trimester	11(13.1)	157 (12.7)	725 (12.1)	893 (12.2)	3324 (6.5)	
Missing data	6 (7.1)	37 (3.0)	171 (2.9)	214 (2.9)	921 (1.8)	
Alcohol or drug misuse during pregnancy	3 (3.6)	14 (1.1)	65 (1.1)	82 (1.1)	96 (0.2)	<0.001
BMI before pregnancy						
Underweight*	16 (19.0)	155 (12.6)	57 (9.6)	228 (10.3)	1841 (3.6)	<0.001
Obese**	109 (1.3)	63 (5.1)	395 (6.6)	567 (6.3)	4347 (8.5)	
Missing data	6 (7.1)	57 (4.6)	174 (2.9)	237 (3.2)	1074 (2.1)	
History of spontaneous abortion(s)	2 (2.4)	51 (4.1)	479 (8.0)	532 (7.3)	5984 (11.7)	<0.001
Pre-existing hypertension	0 (0)	1 (0.1)	6 (0.1)	7 (0.1)	102 (0.2)	0.026
Pre-existing diabetes	0 (0)	7 (0.6)	42 (0.7)	49 (0.7)	358 (0.7)	0.834

Data expressed as n (%).

*BMI <18.5 kg/m^2

**BMI ≥ 30.0 kg/m^2

The area of residence at the time of delivery was divided into urban, densely populated or rural according to national classification by Statistics Finland.[23] Pre-pregnancy BMI was calculated on the basis of height and weight measures reported by the pregnant women. As the "adult" BMI curve plateau is seen at 15—16 years of age, and the total number of teenagers below this age was small in our study, we used the same BMI for adolescents and adults instead of using the ISO-BMI for adolescents.

Adequacy of prenatal care was calculated on the basis of the expected number of antenatal clinic visits[24] adjusted for gestational age at birth. Inadequate prenatal care was defined as attendance at fewer than half of the recommended number of visits.

Statistical analysis

To assess differences between age groups, the χ^2 test and Fisher's exact test were used as appropriate. A P-value <0.05 was defined as statistically significant. To determine the estimated risks of adverse outcomes we calculated unadjusted and adjusted odds ratios (ORs) with their 95% confidence intervals (CIs), using binary logistic regression. To minimise confounding effects, we used several multivariate models depending on the outcome variable analysed. Our basic multivariate model included all demographic factors presented in Table 1 (except for history of spontaneous abortions, which was used for preterm birth only) and adequacy of prenatal care. Pregnancy complications were added to the model when found to be clinically relevant. Variables were removed from the model when necessary as a result of small numbers of cases regarding rare adverse outcomes.

A subgroup analysis was carried out including only teenagers, dividing the group into those with inadequate and adequate prenatal care. We analysed unadjusted and adjusted estimates of risk (ORs) with their 95% CIs using the group with adequate care as the control group. For the multivariate model, we used the basic multivariate model (see above), excluding pre-existing hypertension and diabetes as a result of small numbers of cases. We also used preterm birth as a confounding factor when analysing the estimated risks of a low Apgar score, need of intensive care, and death. We did not use other confounding factors in the subgroup analysis because teenagers with inadequate prenatal care might have been diagnosed with pregnancy complications less often as a result of a low number of visits, thus causing possible bias.

To further minimise bias, we used list-wise deletion in logistic regression analysis when data was missing. The percentages of missing cases as regards demographic factors are shown in Table 1.

IBM SPSS statistics 19.0 and 20.0 for Windows were used for the statistical analyses.

RESULTS

Demographics

All the demographic characteristics of the teen agers *vs.* the reference women differed significantly, except for pre-existing diabetes (Table 1). Pregnant teenagers were more likely to be single, live in a rural area, smoke and be diagnosed with misuse of alcohol or drugs during pregnancy. Pre-existing hypertension was more common in the reference group.

All groups showed a good mean number of visits to an antenatal clinic (Table 2). However, teenagers started their prenatal care significantly later in pregnancy. All teenage groups were also more likely to show a significantly lower attendance rate.

Table 2: Prenatal care according to age group (years)

	13–15	16–17	18–19	All teenagers	25–29	P for difference
n	84	1234	5987	7305	51 142	
All prenatal visits (Mean ± SD)	14.6 ± 6.0	16.1 ± 5.8	16.5 ± 5.3	16.4 ± 5.4	16.5 ± 4.7	<0.001
Hospital polyclinic visits (Mean ± SD)	4.3 ± 2.3	3.7 ± 2.9	3.1 ± 2.7	3.2 ± 2.8	2.7 ± 2.5	<0.001
First prenatal visit, gestational weeks	18.8 ± 9.0	12.6 ± 7.2	10.2 ± 5.0	10.7 ± 5.6	9.0 ± 3.1	<0.001
Low attendance (%)						
<50% of expected visits	4 (4.9)	7 (5.4)	144 (2.4)	155 (2.9)	716 (1.4)	<0.001

Pregnancy complications

Significantly increased risks of anaemia, eclampsia, proteinuria, UTIs and pyelonephritis were noted among the teenagers. The youngest group of teenagers (13—15-year-olds) had an elevated risk of pre-eclampsia and a small excess risk was also noted among 18—19-year-olds after controlling for confounding factors (Table 3). The frequency of gestational diabetes (5.3% [n=385] *vs.* 8.2% [n=4173], adjusted odds ratio [adj. OR] 0.7, 95% CI 0.6 to 0.7) and *placenta praevia* (0.04% [n=3] *vs.* 0.3% [n=161], adj. OR 0.1, 0.01 to 0.8) was lower among 13—19-year-olds, whereas teenagers were more often diagnosed with preterm contractions (4.0% [n=289] *vs.* 2.6% [n=1333], adj. OR 1.5, 1.3 to 1.7) compared with reference women. The differences between 13—15-year-olds and the reference group were non-significant as regards gestational diabetes, *placenta praevia* and preterm contractions, as was the case between 16—17-year-olds and the reference group as regards *placenta praevia*.

Table 3: Maternal complications during pregnancy according to age group

		Maternal age in years				
		13–15	**16–17**	**18–19**	**All teenagers**	**25–29**
n		84	1234	5987	7305	51 142
Anaemia*[M1]	n (%)	6 (7.1)	64 (5.2)	245 (4.1)	315 (4.3)	1227 (2.4)
	OR (95% CI)	3.2 (1.4 to 7.3)	2.3 (1.7 to 2.9)	1.8 (1.5 to 2.0)	1.9 (1.7 to 2.1)	
	Adj. OR (95% CI)	3.1 (1.3 to 7.3)	2.2 (1.7 to 2.9)	1.8 (1.2 to 2.1)	1.8 (1.6 to 2.1)	1 (Ref.)
Pre-eclampsia[M2]	n (%)	6 (7.1)	26 (2.1)	182 (3.0)	214 (2.9)	1522 (3.0)
	OR (95% CI)	2.5 (1.1 to 5.8)	0.7 (0.5 to 1.0)	1.0 (0.9 to 1.2)	1.0 (0.9 to 1.1)	
	Adj. OR (95% CI)	3.7 (1.5 to 9.0)	0.9 (0.6 to 1.4)	1.2 (1.0 to 1.5)	1.2 (1.0 to 1.4)	1 (Ref.)
Eclampsia[M4]	n (%)	0 (0.0)	2 (0.2)	9 (0.2)	11 (0.2)	26 (0.1)
	OR (95% CI)	-	3.2 (0.8 to 13.5)	3.9 (1.4 to 6.3)	3.0 (1.4 to 6.0)	
	Adj. OR (95% CI)	-	2.3 (0.3 to 18.2)	3.3 (1.4 to 7.8)	3.2 (1.4 to 7.3)	1 (Ref.)
Proteinuria[M3]	n (%)	2 (2.4)	9 (0.7)	32 (0.5)	43 (0.6)	171 (0.3)
	OR (95% CI)	7.3 (1.8 to 29.8)	2.2 (1.1 to 4.3)	1.6 (1.1 to 2.3)	1.8 (1.3 to 2.5)	
	Adj. OR (95% CI)	12.3 (2.8 to 53.6)	2.4 (1.1 to 5.2)	1.6 (1.0 to 2.5)	1.8 (1.2 to 2.6)	1 (Ref.)
UTI[M5]	n (%)	0 (0.0)	6 (0.5)	21 (0.4)	27 (0.4)	75 (0.1)
	OR (95% CI)	-	3.3 (1.4 to 7.7)	2.4 (1.5 to 3.9)	2.5 (1.6 to 3.9)	
	Adj. OR (95% CI)	-	4.1 (1.7 to 10.2)	2.7 (1.6 to 4.6)	2.9 (1.8 to 4.8)	1 (Ref.)
Pyelonephritis[M6]	n (%)	0 (0.0)	8 (0.6)	27 (0.5)	35 (0.5)	45 (0.1)
	OR (95% CI)	-	7.4 (3.5 to 15.8)	5.1 (3.2 to 8.3)	5.5 (3.5 to 8.5)	
	Adj. OR (95% CI)	-	9.6 (4.2 to 21.9)	5.8 (3.4 to 10.0)	6.3 (3.8 to 10.4)	1 (Ref.)

* Haemoglobin < 100 g/l. All the variables are adjusted according to multivariate models:
M1: Demographic variables (Table 1 – history of spontaneous abortions) + adequacy of prenatal care
M2: M1 + (hypertension and proteinuria)
M3: M1 + hypertension
M4: M3 – misuse of alcohol or drugs and pre-existing hypertension
M5: M1 – misuse of alcohol or drugs
M6: M1 – pre-existing hypertension

There were no statistically significant differences between the groups as regards PIH (3.2% [n=233] *vs.* 4.2% [n=2158]), chorioamnionitis (0.6% [n=44] *vs.* 0.7% [n=377]), STIs (0.05% [n=10] *vs.* 0.02% [n=34]) bleeding in early pregnancy (0.4% for both [n=27 *vs*. 190]), intrahepatic cholestasis of pregnancy (1.1% [n=79] *vs.* 0.9% [n=460]) or fear of childbirth (1.3% for both [n=98 *vs*. 659]).

Regarding pregnancy complications among teenagers, we evaluated their effects on other adverse obstetric outcomes. Anaemia was a risk factor for very preterm birth (unadjusted odds ratio 2.5, 1.4 to 4.6), 5-min Apgar score of less than 7 (1.6, 1.2 to 2.1) and shoulder dystocia (2.8, 1.4 to 5.5). Proteinuria was found to be a risk factor for pre-eclampsia (7.7, 5.4 to 10.8), but not for eclampsia or adverse neonatal outcomes. UTI did not affect the risk of adverse obstetric outcomes, whereas pyelonephritis was a risk factor for IUGR (3.7, 1.1 to 12.0) among teenagers, but not adults.

Delivery outcomes

The estimated risks (adj. OR) among all teenagers (13—19 years of age) compared with the reference women were: Caesarean section 0.6 (0.6 to 0.7), operative vaginal delivery 0.6 (0.6 to 0.7), anal sphincter rupture 0.4 (0.3 to 0.5) and breech presentation 0.7 (0.6 to 0.8) (Figure 1). However, when analysed in subgroups according to age, the estimated risks among 13—15-year-olds did not differ significantly from those in the reference group, except for Caesarean section.

The percentages of planned Caesarean sections were similar among 13—15-year-olds and the reference women (4.8 % [n=4] *vs.* 4.5% [n=2301]), but significantly lower among 16—17- and 18—19-year-olds (2.4 % [n=30] and 3.2% [n=192], respectively). Regarding urgent Caesarean sections, the

frequencies were lower among all teenagers (7.2% [n=524] *vs.* 11.7% [n=5996]) and descended according to age. In the case of emergency Caesarean sections, however, there were no significant differences (1.1% [n=83] *vs.* 1.5% [n=766]).

The frequencies of induction of labour and use of oxytocin during labour were similar in the teenagers and reference women (16.8% 1226 *vs.* 17.2% 8788 and 49.7% [n=3630] *vs.* 50.3% [n=25744] respectively). Episiotomy was performed less often in all teenage groups (39.1% [n=2861] *vs.* 41.2% [n=21511]), although the difference was non-significant as regards 13—15-year-olds. Combined regional anaesthesia was used significantly more often in all teenage groups compared with the reference women (72.5% [n=5296] *vs.* 66.3% [n=33907]).

The incidence of uterine curettage after childbirth was lower among all 13—19-year-olds (0.5% [n=40] *vs.* 0.9% [n=446]), but the significance disappeared when the subgroups were analysed separately. Differences in the incidence of abnormal bleeding after childbirth were non-significant between 13—15-year-olds (4.8% [n=4]) and the reference group (3.5% [n=1772]), but significantly lower among 16—17- and 18—19-year-olds (1.8% [n=22] and 2.1% [n=125] respectively). No differences were seen as regards shoulder dystocia (0.2% for both [n=9 *vs.* 116), placental abruption (0.2% for both [n=19 *vs.* 13]), uterine rupture (none *vs.* 0.05% [n=24]), abnormal bleeding during delivery (0.2% for both [n=3 *vs*. 135]) and postpartum infection (0.5% [n=36] *vs.* 0.4% [n=229]).

Neonatal outcomes

Table 4 summarises the incidences of various neonatal outcomes. No significant differences emerged between the 13—19- and 25—29-year-olds as regards the proportions with a 5-min Apgar score of less than 7 (2.5% [n=161] *vs.* 2.8% [n=1213]), cord blood pH below 7.05 at birth (1.9% [n=139] *vs.* 1.5%

[n=767]), resuscitation of the newborn (1.0% for both [n= 70 vs. 522]), use of a respirator (1.0% [n=74] *vs.* 0.9% [n=456]) or use of antibiotics (6.6% [n=481] *vs.* 6.8% [n=3498]). Phototherapy was used similarly among all groups, although the frequency was significantly lower among 18—19-year-olds compared with the reference women (5.9% [n=443] *vs.* 6.8% [n=3457]).

Table 4: Neonatal outcomes according to age group

		Maternal age in years				
		13–15	**16–17**	**18–19**	**All teenagers**	**25–29**
n		84	1234	5987	7305	51 142
Extremely preterm <28 w[M3]	n (%)	2 (2.4)	3 (0.2)	23 (0.4)	28 (0.4)	149 (0.3)
	OR (95% CI)	8.5 (2.1 to 35.1)	0.8 (0.3 to 2.7)	1.3 (0.9 to 2.1)	1.3 (0.9 to 2.0)	
	Adj. OR (95% CI)	5.4 (0.7 to 41.5)	0.3 (0.0 to 2.4)	1.1 (0.6 to 1.9)	1.0 (0.6 to 1.7)	1 (Ref.)
Preterm <37 w[M2]	n (%)	11 (13.1)	68 (5.5)	296 (4.9)	375 (5.1)	2440 (4.8)
	OR (95% CI)	3.0 (1.6 to 5.7)	1.1 (0.9 to 1.5)	1.0 (0.9 to 1.2)	1.1 (1.0 to 1.2)	
	Adj. OR (95% CI)	2.5 (1.2 to 5.3)	1.0 (0.8 to 1.4)	0.9 (0.8 to 1.1)	1.0 (0.8 to 1.1)	1 (Ref.)
SGA[M1]	n (%)	2 (2.4)	52 (4.2)	199 (3.3)	253 (3.5)	1262 (2.5)
	OR (95% CI)	0.9 (0.2 to 3.5)	1.7 (1.3 to 2.3)	1.4 (1.2 to 1.6)	1.4 (1.2 to 1.6)	
	Adj. OR (95% CI)	0.5 (0.1 to 2.1)	1.2 (0.9 to 1.6)	1.0 (0.8 to 1.1)	1.0 (0.8 to 1.2)	1 (Ref.)
IUGR[M1]	n (%)	0 (0.0)	40 (3.2)	145 (2.4)	185 (2.5)	570 (1.1)
	OR (95% CI)	-	3.0 (2.1 to 4.1)	2.2 (1.8 to 2.6)	2.3 (1.9 to 2.7)	
	Adj. OR (95% CI)	-	2.3 (1.6 to 3.2)	1.7 (1.4 to 2.1)	1.8 (1.5 to 2.1)	1 (Ref.)
Intensive care[M4]	n (%)	19 (22.6)	138 (11.2)	654 (10.9)	811 (11.1)	5566 (10.9)
	OR (95% CI)	2.4 (1.4 to 4.0)	1.0 (0.9 to 1.2)	1.0 (0.9 to 1.1)	1.0 (0.9 to 1.1)	
	Adj. OR (95% CI)	1.9 (1.0 to 3.4)	0.9 (0.7 to 1.1)	0.9 (0.8 to 1.0)	0.9 (0.8 to 1.0)	1 (Ref.)
Stillbirth/neonatal death[M5]	n (%)	2 (2.4)	4 (0.3)	34 (0.6)	40 (0.5)	180 (0.4)
	OR (95% CI)	6.9 (1.7 to 28.3)	0.9 (0.3 to 2.5)	1.6 (1.1 to 2.3)	1.6 (1.1 to 2.2)	
	Adj. OR (95% CI)	0.4 (0.0 to 5.1)[M6]	0.6 (0.1 to 2.7)	1.4 (0.8 to 2.4)	1.2 (0.7 to 2.1)	1 (Ref.)

All the variables are adjusted according to multivariate models:

M1: Demographic variables (Table 1 – history of spontaneous abortions) + adequacy of prenatal care, gestational diabetes, PIH, placental abruption, chorioamnionitis, pre-eclampsia, eclampsia

M2: M1 + anaemia + history of spontaneous abortions

M3: M2 – misuse of alcohol or drugs

M4: M1 + preterm birth and IUGR

M5: M4 – (misuse of alcohol or drugs and pre-existing hypertension)

M6: M5 – (BMI and pre-existing diabetes)

Adequacy of prenatal care

To investigate the effect of low antenatal clinic attendance on obstetric outcomes, we performed a subgroup analysis of 210 teenagers with inadequate prenatal care compared with 6 905 teenagers with adequate care. Teenagers with inadequate prenatal care were significantly more likely to be single (33.3% [n=67] *vs.* 22.1% [n=1526], P<0.001) and to live in an urban area (73.9% [n=155] *vs.* 66.4% [n=485], P=0.03). Although the rate of smoking during pregnancy did not differ statistically significantly in the two groups (43.9% [n=92] *vs.* 37.3% [n=2576], P=0.07), teenagers with inadequate prenatal care were less likely to quit smoking during the 1st trimester (6.3% [n=13] *vs.* 12.8% [n=884], P=0.008). No differences between the groups emerged as regards being underweight (11.4% [n=138] *vs.* 10.4% [n=718], P=0.62) or obese (4.7% [n=10] *vs.* 6.3% [n=435], P=0.40), or as regards misuse of alcohol or drugs during pregnancy (0.5% [n=1] *vs.* 1.2% [n=81], P=0.73).

Teenagers with inadequate prenatal care were at significantly higher risks of eclampsia and UTI, even after adjustment for confounding factors (Table 5). No excess risks as regards delivery complications were seen. The increased risk of perinatal and neonatal mortality was almost entirely explained by premature births among teenagers with inadequate prenatal care.

Table 5: Maternal complications during pregnancy and neonatal outcomes according to adequacy of prenatal care

		Inadequate prenatal care	Adequate prenatal care
n		**210**	**6905**
PREGNANCY COMPLICATIONS			
Eclampsia[M4]	n (%)	2 (1.0)	7 (0.1)
	OR (95% CI)	9.5 (2.0 to 45.9)	
	Adj. OR (95% CI)	12.6 (2.6 to 62.6)	1 (Ref.)
UTI[M3]	n (%)	3 (1.4)	24 (0.3)
	OR (95% CI)	4.2 (1.2 to 13.9)	
	Adj. OR (95% CI)	5.8 (1.7 to 19.7)	1 (Ref.)
NEONATAL OUTCOMES			
Extremely preterm <28 w[M6]	n (%)	5 (2.4)	20 (0.3)
	OR (95% CI)	8.4 (3.1 to 22.6)	
	Adj. OR (95% CI)	0.7 (0.1 to 5.1)	1 (Ref.)
Preterm <37 w[M1]	n (%)	35 (16.7)	319 (4.6)
	OR (95% CI)	4.1 (2.8 to 6.0)	
	Adj. OR (95% CI)	1.1 (0.7 to 1.7)	1 (Ref.)
Apgar at 5 min <7[M2]	n (%)	10 (5.8)	140 (2.3)
	OR (95% CI)	2.7 (1.4 to 5.1)	
	Adj. OR (95% CI)	1.9 (0.8 to 4.3)	1 (Ref.)
Intensive care[M2]	n (%)	33 (15.7)	733 (10.6)
	OR (95% CI)	1.6 (1.1 to 2.3)	
	Adj. OR (95% CI)	1.0 (0.6 to 1.7)	1 (Ref.)
Pre/neonatal death[M5]	n (%)	5 (2.4)	28 (0.4)
	OR (95% CI)	6.0 (2.3 to 15.7)	
	Adj. OR (95% CI)	0.7 (0.1 to 7.1)	1 (Ref.)

All the variables are adjusted according to multivariate models:
M1: Demographic variables (Table 1 – pre-existing hypertension and diabetes)
M2: M1 + preterm birth – history of spontaneous abortions
M3: M1 – misuse of alcohol or drugs – history of spontaneous abortions
M4: M1 – misuse of alcohol or drugs, BMI and history of spontaneous abortions
M5: M2 – misuse of alcohol or drugs
Missing data as regards confounding variables in inadequate *vs.* adequate prenatal care group: cohabitation 17.1% *vs.* 9.7%, smoking 10.0% *vs.* 2.2%, BMI 19.5% *vs.* 2.1%.

DISCUSSION

Our comprehensive population-based study indicated that pregnant teenagers are at an increased risk of eclampsia, proteinuria, cystitis, pyelonephritis and anaemia. The youngest teenagers also had a higher risk of pre-eclampsia. However, teenagers were more likely to have a normal vaginal delivery without excessive risks of delivery complications when compared with women "at the best age for delivery" (25—29 years). Regarding neonatal outcomes, the risk of preterm birth was increased among the youngest teenagers, whereas older teenagers were at risk of having SGA infants and infants with IUGR. An increased risk of stillbirth/neonatal death was also found. Inadequate prenatal care among teenagers increased the risks of eclampsia, UTI and several adverse neonatal outcomes. Confounding factors affected the risks of most neonatal outcomes, but their roles as regards maternal complications were less significant.

The registers used for our study are of high quality and have been shown to be in accordance with delivery records.[20] We were able to investigate a number of factors that have been sparsely reported in connection with teenage pregnancies, such as proteinuria, cystitis and pyelonephritis during pregnancy, fear of childbirth and pain relief during delivery. Our study was nationwide, giving a complete and realistic reflection of the situation regarding obstetric challenges among all teenage pregnancies during the study period.

In Finland, prenatal care, including routine visits to general practitioners and nurses/midwives, is provided free of charge by municipalities and used by virtually all pregnant women.[25] Specialised

maternity units in public hospitals take care of practically all obstetric patients and births. In addition, fetal screening including early ultrasonography with a nuchal translucency scan, blood tests and structural ultrasonography is offered to all pregnant women.[26] Thus, the opportunity to receive comprehensive prenatal care is available to all regardless of socioeconomic status or residence. This minimises the confounding effects which often complicate studies of this kind. We also divided teenagers into categories by age. Although evidence suggests that the risks of neonatal problems are higher in younger, biologically immature adolescents,[15-17] the majority of studies, especially those on maternal outcomes, have involved the use of a dichotomised study setting, neglecting the different stages of biological and psychological maturation in adolescents.[10 12 27-32] The importance of choosing the right reference group cannot be underestimated. The age of 20—24 years has often been used for reference, but age groups of even 20—39 years are seen. Childbearing has commonly been postponed in recent decades. The mean age of primigravid women in Finland was approximately 28 years during the study period; thus we chose primigravid women of 25—29 years of age as a reference group.

Our study is retrospective, which remains a limitation. The reliability of the data depends on the accuracy of reporting. There was more missing data regarding confounding effects in the teenage group, as in the subgroup of teenagers with inadequate prenatal care. We could not look at the socioeconomic or educational status of adolescents in this study. The MBR includes information on maternal occupation, which is, however, less relevant as regards teenagers and young adults. Unfortunately, there is no information on fathers in the MBR as a result of confidentiality rules. If socioeconomic status had been used in logistic regression analysis as a confounding factor, the risks of some outcomes among teenagers might have been smaller. We were not able to obtain information

on weight gain during pregnancy. Poor weight gain is a known risk factor of adverse neonatal outcomes, such as low birth weight. Our study group of 13—15-year-olds was small in number, thus leading to lack of power in detecting risks of rare outcomes. However, we felt it important to analyse this group separately to discover the effect of very young age on the risk of adverse obstetric outcomes.

Relevant results in relation to those of other studies

Overall, there was a high rate of attendance at antenatal clinics, which was expected, as antenatal care is offered free of charge to all pregnant mothers. It can be speculated that women not reached by the antenatal care system may be socially disadvantaged in various areas of life. Poor socioeconomic status is often known to precede teenage pregnancy.[33 34] This view is supported by our finding that teenagers smoked and were diagnosed with misuse of alcohol or drugs significantly more often than reference women. Similar findings come from many parts of the developed world,[9 11 35 36] whereas early marriage and childbirth are more common in other, often developing parts of the world, thus leading to different social circumstances and possibly different pregnancy outcomes.

The increased risk of anaemia seen among teenagers is in accordance with findings from several earlier studies.[10-12 29] Physical growth and menstruation results in an increase in iron requirements that is often not met by nutrition. This leads to a negative iron balance and makes teenagers more susceptible to anaemia during pregnancy.[37] Poor fetal outcomes may occur, especially in cases of severe or first trimester anaemia.[37 38] In our study, anaemia was a risk factor of very preterm birth, a low 5-min Apgar score and shoulder dystocia.

Previous studies carried out in industrialised countries have revealed no excess risks of pre-eclampsia or PIH among adolescents,[9-12] whereas higher risks have been reported in developing countries.[14 31] Our results are partly contradictory, indicating a higher risk of pre-eclampsia among the youngest teenagers. The relatively small number of pregnant mothers aged 13—15 years in our study places some uncertainty on this finding. In two earlier studies, younger and older adolescents were distinguished. A large Latin-American cross-sectional study revealed an increasing rate of pre-eclampsia with descending age, but there was no significant difference in risk after adjustment for confounding factors.[16] A French study revealed a lower risk among teenagers, but the number of very young teenagers was even smaller than in the present study.[11]

Our results confirm findings in earlier studies, showing an elevated risk of eclampsia among pregnant teenagers.[39 40] A report by the National Center for Health Statistics in the US showed an increasing trend in frequency with descending age (0.6% in 10—14-year-olds and 0.3% among 25—29-year-olds).[41] Because of a smaller number of cases and rarity of the condition, we could not evaluate such a trend. The essential role of prenatal care in the prevention of eclampsia has been previously emphasised,[42] although not in studies confined to teenagers. We found a marked 12-fold risk of eclampsia among teenagers with inadequate versus adequate care, highlighting the importance of adequate prenatal care in teenage pregnancies.

We found an increasing risk of proteinuria in pregnancy with descending age. An earlier study on the risk factors of proteinuria during pregnancy revealed a 1.5-fold risk among women below the age of 20.[43] Although the outcome of isolated proteinuria is mostly favourable, it is sometimes known to precede pre-eclampsia and even eclampsia[44 45] and has been associated with preterm birth.[46] Whether or not isolated proteinuria is part of the same disease spectrum as pre-eclampsia is

controversial.[43 47] In our study, proteinuria was found to be a risk factor as regards pre-eclampsia, but not eclampsia or adverse neonatal outcome.

Earlier studies on UTI and pyelonephritis in pregnant teenagers are sparse. In two UK studies 1.5- to 1.6-fold risks of UTI[10] and pyelonephritis[9] were reported among all teenagers. In contrast, no excess risk was found in a Latin American study in which teenagers were analysed in subgroups by age.[16] Our findings suggest higher risks of both UTI and pyelonephritis, with a trend toward a higher incidence with descending age. However, no cases were found among teenagers of 13–15 years of age, possibly because of the relative rarity of these diagnoses. Only a hypothesis for the reason behind the increased risks has been presented – reduced resistance to infections in pregnant teenagers.[10] We speculate that teenagers might be sexually more active during pregnancy compared with older women, placing them at a higher risk of UTI. In addition, poorer recognition of symptoms of UTI could lead to delayed care and explain the increased risk of pyelonephritis. UTIs, and pyelonephritis in particular, have been associated with higher risks of adverse neonatal outcomes,[48 49] although they are preventable with early detection and antimicrobial care.[50] Pyelonephritis was a risk factor of IUGR among teenagers, but not adults in our study.

Regarding other infections, our results do not support earlier findings of a higher risk of chorioamnionitis among adolescents compared with adult women.[10 12]

Our findings of lower or similar risks of delivery complications and a higher incidence of vaginal deliveries among teenagers are in line with findings in most studies in the developed world.[9-12] Opposite findings come mainly from studies in developing countries.[16 32] The use of pain relief,

especially combined anaesthetic analgesia, was high in all groups and was used even more often in teenagers compared with older women. This is in contrast to the results of a UK study.[9]

Three large retrospective cohort studies carried out in the US and Latin America revealed 1.2- to 2.0-fold risks of preterm birth and 1.1- to 1.5-fold risks of SGA infants among teenagers, with an increasing trend with descending age.[15-17] Only one of these studies showed an increased risk (1.2-fold) of IUGR among adolescents aged 15 years or less compared with older mothers.[17] Elevated (1.5-fold) risks of stillbirth and/or neonatal death were found among the youngest teenagers. However, among older teenagers and after adjustment for gestational age, the risks were either lower or non-significant.[15-17] These findings were largely confirmed in our study, although some differences were seen, possibly as a result of a smaller study population and the lack of socioeconomic status as a confounding factor. In addition, we found an excess risk of preterm birth only among the youngest teenagers. The lack of risk among older teenagers might be explained by the overall high quality and quantity of prenatal care in Finland.

In accordance with the results of several recent studies,[18 19 51] we found higher risks of adverse neonatal outcomes, including an excess risk of neonatal/infant mortality among teenagers with inadequate prenatal care.

Unanswered questions and implications

Our results add to existing literature, showing higher risks of various maternal complications among teenagers, often displaying an increasing trend with descending age. An increased risk of proteinuria during pregnancy was found, an outcome not analysed in past studies dealing with teenage pregnancy. Confirmation of this finding and its possible influence on other, more serious obstetric

outcomes is required. The effect of prenatal care on maternal outcomes should also be further analysed in the future. Clinical studies on the mode of delivery and its complications would shed more light on whether or not adolescents have better myometrial function compared with older women or whether the higher incidence of uncomplicated vaginal births is a consequence of other factors, such as more attentive care of adolescents. In addition to immediate obstetric risks, studies on long-term consequences indicate a higher incidence of morbidity and preterm mortality among both teenage mothers and their children,[1 2 4] and these risks should be examined in greater detail in the future.

The present study has practical implications: in addition to prevention and treatment of anaemia and eclampsia, and screening and counselling in connection with proteinuria, cystitis and pyelonephritis are important among pregnant adolescents. The higher risk of pre-eclampsia among the youngest teenagers should also be kept in mind. Teenagers in a welfare society are not a risk group as regards delivery complications, and neonatal outcomes are mainly good. However, the younger the expectant mother, the greater are the risks of several maternal and neonatal complications. Adequacy of prenatal care is of great importance in preventing serious adverse obstetric outcomes. Thus, extra efforts should be made to reach all pregnant teenagers and enrol them in adequate maternity care in early pregnancy.

FOOTNOTES

Contributors: OH, MG and SL had the initial research idea and all authors contributed to the design, interpretation and critical revision of data. All authors had full access to the data and take responsibility of the integrity of the data and accuracy of the data analysis. SL carried out the analysis and wrote the drafts of the paper with important intellectual input from all coauthors. All authors have approved the final version of the manuscript submitted for publication. OH and SL act as guarantors.

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Competing interests: All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work.

Ethical approval: No ethical approval was required for the present study.

Data sharing: No additional data available. Researchers can apply for the authorisation for the use of same health register data for scientific research from the register keeping organization (THL National Institute for Health and Welfare).

FIGURE LEGENDS

Figure 1: Frequencies (%) of operative delivery and other delivery outcomes according to age group.

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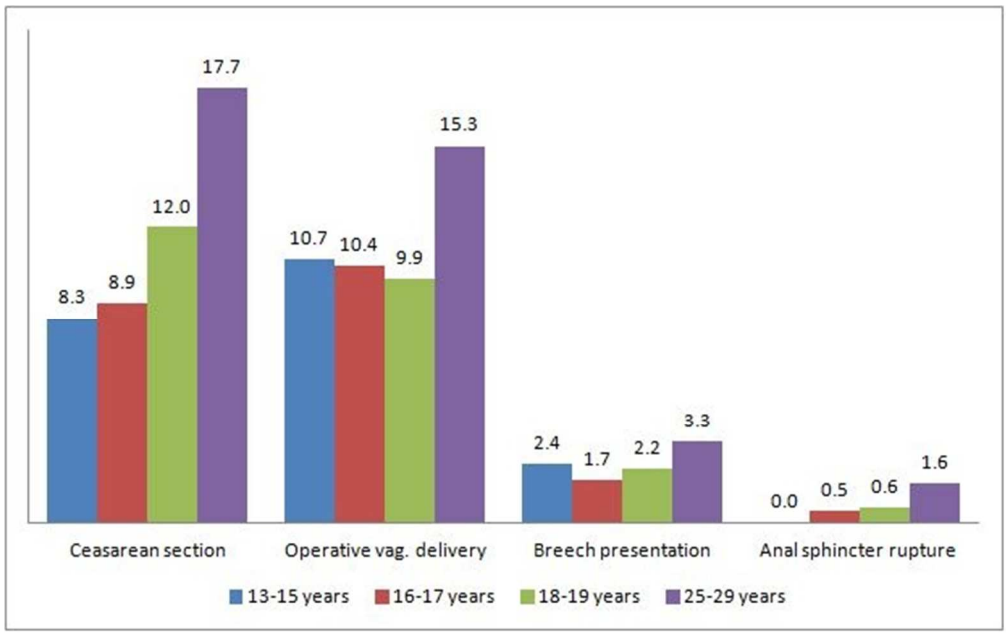

Fig. 1
52x32mm (300 x 300 DPI)

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	1 and 2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2 and 3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5
Objectives	3	State specific objectives, including any prespecified hypotheses	5 and 6
Methods			
Study design	4	Present key elements of study design early in the paper	2, 6 and 7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	6
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	-
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7 and 8
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	7 and 8
Bias	9	Describe any efforts to address potential sources of bias	6, 10 and 11
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7 and 8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	10 and 11
		(*b*) Describe any methods used to examine subgroups and interactions	10
		(*c*) Explain how missing data were addressed	11
		(*d*) If applicable, explain how loss to follow-up was addressed	-
		(*e*) Describe any sensitivity analyses	-
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	6
		(b) Give reasons for non-participation at each stage	6
		(c) Consider use of a flow diagram	-
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9, 11, 12
		(b) Indicate number of participants with missing data for each variable of interest	9 and 19
		(c) Summarise follow-up time (eg, average and total amount)	-
Outcome data	15*	Report numbers of outcome events or summary measures over time	12-17
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	12-17
		(*b*) Report category boundaries when continuous variables were categorized	12, 14, 15, 17, 19
		(*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	18, 19
Discussion			
Key results	18	Summarise key results with reference to study objectives	20
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	22-25
Generalisability	21	Discuss the generalisability (external validity) of the study results	25 and 26
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	27

*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

Is teenage pregnancy an obstetric risk in a welfare society? A population-based study in Finland, from 2006 to 2011.

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ABSTRACT

Objective: To assess obstetric outcomes in teenage pregnancies in a country with a low teenage delivery rate and comprehensive high-quality prenatal care.

Design: Retrospective population-based register study.

Setting: Finland.

Participants: All nulliparous teenagers (13–15 years [n=84], 16–17 years [n=1234], 18–19 years [n=5987]) and controls (25–29-year-old women [n=51 142]) with singleton deliveries in 2006–2011.

Main outcome measures: Risk of adverse obstetric outcomes adjusted for demographic factors and clinically relevant pregnancy complications, with a main focus on maternal pregnancy complications.

Results: Teenage mothers were more likely than controls to live in rural areas (16.0% [n=1168] *vs.* 11.8% [n=6035]), smoke (36.4% [n=2661] *vs.* 7.0% [n=3580]) and misuse alcohol or drugs (1.1% [n=82] *vs.* 0.2% [n=96]) (p<0.001 for all). Teenagers made a good mean number of antenatal clinic visits (16.4 *vs*. 16.5), but were more likely to have attended fewer than half of the recommended visits (3.0% [n=210] *vs.* 1.4% [n=716]).

Teenagers faced increased risks of several obstetric complications, e.g. anaemia (adjusted odds ratio 1.8, 95% confidence interval 1.6 to 2.1), proteinuria (1.8, 1.2 to 2.6) urinary tract infection (UTI) (2.9, 1.8 to 4.8) pyelonephritis (6.3, 3.8 to 10.4) and eclampsia (3.2, 1.4 to 7.3), the risks increasing with descending age for most outcomes. Elevated risks of pre-eclampsia (3.7, 1.5 to 9.0) and preterm delivery (2.5, 1.2 to 5.3) were also found among 13—15-year-olds. However, teenage mothers were

more likely to have vaginal delivery (1.9, 1.7 to 2.0) without complications. Inadequate prenatal care among teenagers was a risk factor of eclampsia (12.6, 2.6 to 62.6), UTI (5.8, 1.7 to 19.7) and adverse neonatal outcomes.

Conclusions: Pregnant teenagers tended to be socioeconomically disadvantaged *vs.* controls and faced higher risks of various pregnancy complications. Special attention should be paid to enrolling teenagers into adequate prenatal care in early pregnancy.

Word count: 299

ARTICLE SUMMARY

Article focus

- Teenage pregnancy is associated with maternal anaemia and preterm birth. Association with other adverse obstetric outcomes, especially maternal complications, is less clear.
- Adequate antenatal care among teenagers has been shown to decrease adverse neonatal outcomes, but comprehensive care to all women was not offered in the previous study settings.
- We examined age-specific risks of adverse obstetric outcomes among teenagers, focusing on maternal pregnancy complications and the role of inadequate antenatal care.

Key messages

- In addition to a higher risk of anaemia, elevated risks of urinary tract infection, pyelonephritis, proteinuria and eclampsia were found among teenagers as well as pre-eclampsia and preterm delivery among the youngest girls.
- Inadequate antenatal care may place teenagers at markedly elevated risks of urinary tract infection, eclampsia and adverse neonatal outcomes even in a welfare society offering high-quality care to all pregnant women.

Strengths and limitations of this study

- The present study was nationwide, giving a realistic reflection of the situation regarding obstetric challenges among all teenage pregnancies during the study period.
- We were able to investigate a number of factors that have been sparsely reported in connection with teenage pregnancies, including proteinuria, cystitis and pyelonephritis during pregnancy, fear of childbirth and pain relief during delivery.
- Our study was retrospective and we could not look at the socioeconomic or educational status of women.

INTRODUCTION

Pregnancy during teenage years is associated with socioeconomic and health inequalities as regards both mother and child,[1-5] including higher risks of deprivation,[2] behavioural and emotional difficulties,[2] maltreatment,[1] morbidity[1] and premature mortality.[1 4] Therefore, it is a global concern. Although most pronounced in developing countries, teenage pregnancy remains a significant problem also in the developed world. The incidence of teenage pregnancy ending in delivery varies widely, with Nordic countries having comparatively low rates: 6/1000 in Sweden[6] and 9/1000 in Finland,[6] compared with 24/1000 in England and Wales[7] and 34/1000 in the USA in 2010.[8]

Obstetric risks are often divided into categories of maternal complications, mode of delivery and its complications, and neonatal outcome. Teenage pregnancies are associated with maternal anaemia,[9-12] hypertensive problems[13-15] and preterm birth,[16-19] while low risks as regards delivery complications have been reported in studies carried out in industrialised countries.[9-12 19] However, results concerning several adverse outcomes vary largely, possibly as a result of the great number of confounding factors. Poor socioeconomic conditions,[1 9 10] risky health behaviour,[9 12] inadequate prenatal care[18 20-21] and biological immaturity[16-18] have been suggested as possible explanations for adverse obstetric outcomes.

Although the issue of teenage pregnancy has been widely studied, a consensus of opinion on obstetric risks is lacking. Comprehensive, age-specific studies concerning maternal complications remain sparse.[9 17] In addition, the role of prenatal care in regard to these problems is not well established. The objective of the present study was to investigate the risks of adverse obstetric outcomes in teenagers in a country with a low rate of adolescent births and comprehensive high-quality prenatal

care, with special focus on maternal complications during pregnancy. Secondly, we aimed to focus on the effect on these outcomes of a low number of visits to antenatal clinics.

MATERIAL AND METHODS

Study population

We identified all childbirths (n=354 833, of which 349 531 were singleton births) between 2006 and 2011 in Finland using the national Medical Birth Register (MBR). Only singleton pregnancies of nulliparous women (n=97 838) were included. Cases of major congenital anomaly (defined as major anatomical anomaly, chromosomal anomaly or congenital hypothyroidism)[22] were excluded (n=4149). After exclusion, there was a total of 7305 singleton childbirths among 13—19-year-old nulliparous girls and women, further divided into three groups: 13—15-year-olds (n=84), 16—17-year-olds (n=1234), and 18—19-year-olds (n=5987). Singleton deliveries (n=51 142) among women aged 25—29 years served as reference material. Women with histories of abortion and miscarriage (n=11 703, 20.1%) were included.

Data collection

The study data were obtained from the MBR and the Hospital Discharge Register (HDR), maintained by the National Institute for Health and Welfare. Reporting to these national registers is obligatory and the data has been shown to be valid and to reflect good coverage.[23]

Data for the MBR is collected at all maternity hospitals in Finland.[24] It covers all live births and stillbirths with a birth weight of 500 grams or more or with a gestational age of 22 weeks or more. The HDR contains information on all in-patient periods in public and private hospitals and out-patient

visits in the public sector. We collected the data separately for pregnancy and delivery (delivery complications include diagnoses reported from the start of delivery until 42 days postpartum). Each complication was noted once per woman.

Study variables

The choice of study variables was based on previous literature and clinical relevance. All study variables are listed with ICD-10 codes, unless derived from the MBR in a separate check-box**.**

Maternal outcomes: anaemia (haemoglobin below 100 g/l), pregnancy-induced hypertension (PIH) (O13, O16), pre-eclampsia (O14), eclampsia, proteinuria (O12 excluding O12.0), gestational diabetes, intrahepatic cholestasis of pregnancy (O26.6), *placenta praevia*, sexually transmitted infections (*Chlamydia trachomatis* [A56], *Neisseria gonorrhoeae* and syphilis [A51-A54]), urinary tract infection (UTI) (N30, N34, N39.0, O23.1–O23.4, O23.9), pyelonephritis (N10, N12, O23.0), chorioamnionitis (O41.1), , bleeding in early pregnancy (O20) and fear of childbirth (O99.80).

Delivery outcomes: mode of delivery (vaginal delivery, vaginal breech delivery, assisted vaginal delivery [vacuum extraction or forceps] and Caesarean section [elective, urgent and emergency]), induction of labour, use of oxytocin, episiotomy, pain relief during delivery (regional anaesthesia, other medication and non-medical pain relief), anal sphincter rupture, shoulder dystocia, placental abruption, uterine curettage, abnormal bleeding during (O67) and after delivery (O72), uterine rupture (O71.0–O71.1) and postpartum infection (O85, O86, N71, N72).

Neonatal outcomes: preterm birth (extremely preterm [<28 weeks] and preterm [<37 weeks of gestation]), birth weight adjusted for gestational age according to the Finnish fetal growth curves[25]

(divided into small-for-gestational-age [SGA, defined as <-2 SD], average-for-gestational-age [AGA] and large-for-gestational age [LGA, defined as > +2 SD]), 5-min Apgar score below 7, cord blood pH below 7.05 at birth, resuscitation of the newborn, use of a respirator, use of antibiotics, , admission to a neonatal intensive care unit, stillbirth (delivery of a stillborn at 22 weeks of gestation or later) and neonatal death (death of a live-born at 0–6 days of age).

Demographic factors are presented in Table 1. Of these, alcohol or drug misuse during pregnancy (Z72.1–Z72.2), pre-existing diabetes (E10–E12, O24.0–O24.3) and pre-existing hypertension (I10, O10–O11) were derived from the HDR and other variables from the MBR.

Table 1. Demographic characteristics according to age group (years)

	13–15	16–17	18–19	All teenagers	25–29	P* for difference
n	84	1234	5987	7305	51 142	
Cohabitation status						
Married/cohabiting	13 (15.5)	598 (48.5)	4248 (71.0)	4859 (66.5)	45 262 (88.5)	<0.001
Single	45 (53.6)	471 (38.2)	1132 (18.9)	1644 (22.5)	2608 (5.1)	
Missing data	26 (30.9)	165 (13.3)	607 (10.1)	802 (11.0)	3272 (6.4)	
Type of residence						
Urban	52 (61.9)	820 (66.5)	3980 (66.5)	4852 (66.4)	37589 (73.5)	<0.001
Densely populated	14 (16.7)	185 (15.0)	1050 (17.5)	1249 (17.1)	7313 (14.3)	
Rural	16 (19.0)	222(18.0)	930 (15.5)	1168 (16.0)	6035 (11.8)	
Missing data	2 (2.4)	7 (0.5)	27 (0.5)	36 (0.5)	205 (0.4)	
Smoking during pregnancy						
Yes	28 (33.3)	506 (41.3)	2127 (35.5)	2661 (36.4)	3580 (7.0)	<0.001
Quit during 1st trimester	11(13.1)	157 (12.7)	725 (12.1)	893 (12.2)	3324 (6.5)	
Missing data	6 (7.1)	37 (3.0)	171 (2.9)	214 (2.9)	921 (1.8)	
Alcohol or drug misuse during pregnancy	3 (3.6)	14 (1.1)	65 (1.1)	82 (1.1)	96 (0.2)	<0.001
BMI before pregnancy						
Underweight**	16 (19.0)	155 (12.6)	57 (9.6)	228 (10.3)	1841 (3.6)	<0.001
Obese***	109 (1.3)	63 (5.1)	395 (6.6)	567 (6.3)	4347 (8.5)	
Missing data	6 (7.1)	57 (4.6)	174 (2.9)	237 (3.2)	1074 (2.1)	
History of spontaneous abortion(s)	2 (2.4)	51 (4.1)	479 (8.0)	532 (7.3)	5984 (11.7)	<0.001
Pre-existing hypertension	0 (0)	1 (0.1)	6 (0.1)	7 (0.1)	102 (0.2)	0.026
Pre-existing diabetes	0 (0)	7 (0.6)	42 (0.7)	49 (0.7)	358 (0.7)	0.834

Data expressed as n (%).

*P-values refer to differences between all the age groups.

**BMI <18.5 kg/m^2

***BMI ≥ 30.0 kg/m^2

The area of residence at the time of delivery was divided into urban, densely populated or rural according to national classification by Statistics Finland.[26] Pre-pregnancy BMI was calculated on the basis of height and weight measures reported by the pregnant women.

Adequacy of prenatal care was calculated on the basis of the recommended number of antenatal clinic visits in Finland (13-17 visits in full term pregnancies)[27] adjusted for gestational age at birth. Inadequate prenatal care was defined as attendance at fewer than half of the recommended number of visits.

Statistical analysis

To assess differences between age groups, the χ^2 test and Fisher's exact test were used as appropriate. A P-value <0.05 was defined as statistically significant. The estimated risks (unadjusted and adjusted odds ratios [ORs] with their 95% confidence intervals [CIs]) of adverse outcomes were calculated using binary logistic regression. Our basic multivariate model included all demographic factors presented in Table 1 (except for history of spontaneous abortions, which was used for preterm birth only) and adequacy of prenatal care. Pregnancy complications were added to the model when found to be clinically relevant. Variables were removed from the model when necessary as a result of small numbers of cases.

A subgroup analysis was carried out including only teenagers, dividing the group into those with inadequate and adequate prenatal care (reference group). The risks were analysed using binary logistic regression. We used the basic multivariate model (see above), excluding pre-existing hypertension and diabetes as a result of small numbers of cases.

To minimise bias, we used list-wise deletion in logistic regression analysis when data was missing. The percentages of missing cases as regards demographic factors are shown in Table 1.

IBM SPSS statistics 19.0 and 20.0 for Windows were used for the statistical analyses.

RESULTS

Demographics

All the demographic characteristics of the teenagers *vs.* the reference women differed significantly, except for pre-existing diabetes (Table 1). Pregnant teenagers were more likely to be single, live in a rural area, smoke and be diagnosed with misuse of alcohol or drugs during pregnancy. Pre-existing hypertension was more common in the reference group.

All groups showed a good mean number of visits to an antenatal clinic (Table 2). However, teenagers started their prenatal care significantly later in pregnancy. All teenage groups were also more likely to show a significantly lower attendance rate.

Table 2: Prenatal care according to age group (years)

	13–15	**16–17**	**18–19**	**All teenagers**	**25–29**	**P* for difference**
n	84	1234	5987	7305	51 142	
All antenatal visits (Mean ± SD)	14.6 ± 6.0	16.1 ± 5.8	16.5 ± 5.3	16.4 ± 5.4	16.5 ± 4.7	<0.001
Hospital polyclinic visits (Mean ± SD)	4.3 ± 2.3	3.7 ± 2.9	3.1 ± 2.7	3.2 ± 2.8	2.7 ± 2.5	<0.001
First antenatal visit, gestational weeks	18.8 ± 9.0	12.6 ± 7.2	10.2 ± 5.0	10.7 ± 5.6	9.0 ± 3.1	<0.001
First antenatal visit ≥ 20 gestational weeks	43 (51.2)	192 (15.6)	358 (6.0)	593 (8.1)	728 (1.4)	<0.001
Low attendance (%)						
<50% of expected visits	4 (4.9)	65 (5.4)	141 (2.4)	210 (3.0)	691 (1.4)	<0.001

1st trimester ultrasonographic screening	30 (35.7)	671 (54.4)	3733 (62.4)	4434 (60.7)	37429 (73.2)	<0.001
2nd trimester ultrasonographic screening	45 (53.6)	850 (68.9)	4299 (71.8)	5194 (71.1)	39620 (77.5)	<0.001

* P-values refer to differences between all the age groups.

Pregnancy complications

Significantly increased risks of anaemia, eclampsia, proteinuria, UTI and pyelonephritis were noted among the teenagers. The youngest group of teenagers (13—15-year-olds) had an elevated risk of pre-eclampsia and a small excess risk was also noted among 18—19-year-olds after controlling for confounding factors (Table 3). The frequency of gestational diabetes (5.3% [n=385] *vs.* 8.2% [n=4173], adjusted odds ratio [adj. OR] 0.7, 95% CI 0.6 to 0.7) and *placenta praevia* (0.04% [n=3] *vs.* 0.3% [n=161], adj. OR 0.1, 0.01 to 0.8) was lower among 13—19-year-olds although the differences between 13—15-year-olds and the reference group were non-significant, as was the case between 16—17-year-olds and the reference group as regards *placenta praevia.*

Table 3: Maternal complications during pregnancy according to age group

		Maternal age in years				
		13–15	**16–17**	**18–19**	**All teenagers**	**25–29**
n		84	1234	5987	7305	51 142
Anaemia*[M1]	n (%)	6 (7.1)	64 (5.2)	245 (4.1)	315 (4.3)	1227 (2.4)
	OR (95% CI)	3.2 (1.4 to 7.3)	2.3 (1.7 to 2.9)	1.8 (1.5 to 2.0)	1.9 (1.7 to 2.1)	
	Adj. OR (95% CI)	3.1 (1.3 to 7.3)	2.2 (1.7 to 2.9)	1.8 (1.2 to 2.1)	1.8 (1.6 to 2.1)	1 (Ref.)
Pre-eclampsia[M2]	n (%)	6 (7.1)	26 (2.1)	182 (3.0)	214 (2.9)	1522 (3.0)
	OR (95% CI)	2.5 (1.1 to 5.8)	0.7 (0.5 to 1.0)	1.0 (0.9 to 1.2)	1.0 (0.9 to 1.1)	
	Adj. OR (95% CI)	3.7 (1.5 to 9.0)	0.9 (0.6 to 1.4)	1.2 (1.0 to 1.5)	1.2 (1.0 to 1.4)	1 (Ref.)
Eclampsia[M4]	n (%)	0 (0.0)	2 (0.2)	9 (0.2)	11 (0.2)	26 (0.1)
	OR (95% CI)	-	3.2 (0.8 to 13.5)	3.9 (1.4 to 6.3)	3.0 (1.4 to 6.0)	
	Adj. OR (95% CI)	-	2.3 (0.3 to 18.2)	3.3 (1.4 to 7.8)	3.2 (1.4 to 7.3)	1 (Ref.)
Proteinuria[M3]	n (%)	2 (2.4)	9 (0.7)	32 (0.5)	43 (0.6)	171 (0.3)
	OR (95% CI)	7.3 (1.8 to 29.8)	2.2 (1.1 to 4.3)	1.6 (1.1 to 2.3)	1.8 (1.3 to 2.5)	
	Adj. OR (95% CI)	12.3 (2.8 to 53.6)	2.4 (1.1 to 5.2)	1.6 (1.0 to 2.5)	1.8 (1.2 to 2.6)	1 (Ref.)
UTI[M5]	n (%)	0 (0.0)	6 (0.5)	21 (0.4)	27 (0.4)	75 (0.1)
	OR (95% CI)	-	3.3 (1.4 to 7.7)	2.4 (1.5 to 3.9)	2.5 (1.6 to 3.9)	
	Adj. OR (95% CI)	-	4.1 (1.7 to 10.2)	2.7 (1.6 to 4.6)	2.9 (1.8 to 4.8)	1 (Ref.)
Pyelonephritis[M6]	n (%)	0 (0.0)	8 (0.6)	27 (0.5)	35 (0.5)	45 (0.1)
	OR (95% CI)	-	7.4 (3.5 to 15.8)	5.1 (3.2 to 8.3)	5.5 (3.5 to 8.5)	
	Adj. OR (95% CI)	-	9.6 (4.2 to 21.9)	5.8 (3.4 to 10.0)	6.3 (3.8 to 10.4)	1 (Ref.)

* Haemoglobin < 100 g/l.

All the variables are adjusted according to multivariate models:

M1: Demographic variables (Table 1 – history of spontaneous abortions) + adequacy of prenatal care

M2: M1 + (PIH and proteinuria)

M3: M1 + PIH

M4: M3 – misuse of alcohol or drugs and pre-existing hypertension

M5: M1 – misuse of alcohol or drugs

M6: M1 – pre-existing hypertension

There were no statistically significant differences between the groups as regards PIH (3.2% [n=233] *vs.* 4.2% [n=2158]), chorioamnionitis (0.6% [n=44] *vs.* 0.7% [n=377]), STIs (0.05% [n=10] *vs.* 0.02% [n=34]), bleeding in early pregnancy (0.4% for both [n=27 *vs*. 190]), intrahepatic cholestasis of pregnancy (1.1% [n=79] *vs.* 0.9% [n=460]) or fear of childbirth (1.3% for both [n=98 *vs*. 659]).

Regarding pregnancy complications among teenagers, we evaluated their effects on other adverse obstetric outcomes. Anaemia was a risk factor for very preterm birth (adjusted odds ratio 2.1, 1.1 to 4.2). Proteinuria was found to be a risk factor for pre-eclampsia (5.4, 3.6 to 8.0), but not for eclampsia or adverse neonatal outcomes. UTI and pyelonephritis did not affect the risks of adverse obstetric outcomes.

Delivery outcomes

The estimated risks (adj. OR) among all teenagers (13—19 years of age) compared with the reference women were: Caesarean section 0.6 (0.6 to 0.7), operative vaginal delivery 0.6 (0.6 to 0.7), anal sphincter rupture 0.4 (0.3 to 0.5) and breech presentation 0.7 (0.6 to 0.8) (Figure 1). However, when analysed in subgroups according to age, the estimated risks among 13—15-year-olds did not differ significantly from those in the reference group, except for Caesarean section.

The percentages of planned Caesarean sections were similar among 13—15-year-olds and the reference women (4.8 % [n=4] *vs.* 4.5% [n=2301]), but significantly lower among 16—17- and 18—19-year-olds (2.4 % [n=30] and 3.2% [n=192], respectively). Regarding urgent Caesarean sections, the frequencies were lower among all teenagers (7.2% [n=524] *vs.* 11.7% [n=5996]) and descended

according to age. In the case of emergency Caesarean sections, however, there were no significant differences (1.1% [n=83] *vs.* 1.5% [n=766]).

The frequencies of induction of labour and use of oxytocin during labour were similar in the teenagers and reference women (16.8% [n=1226] *vs.* 17.2% [n=8788] and 49.7% [n=3630] *vs.* 50.3% [n=25744] respectively). Episiotomy was performed less often in all teenage groups (39.1% [n=2861] *vs.* 41.2% [n=21511]), although the difference was non-significant as regards 13—15-year-olds. Combined regional anaesthesia was used significantly more often in all teenage groups compared with the reference women (72.5% [n=5296] *vs.* 66.3% [n=33907]).

The incidence of uterine curettage after childbirth was lower among all 13—19-year-olds (0.5% [n=40] *vs.* 0.9% [n=446]), but the significance disappeared when the subgroups were analysed separately. Differences in the incidence of abnormal bleeding after childbirth were non-significant between 13—15-year-olds (4.8% [n=4]) and the reference group (3.5% [n=1772]), but significantly lower among 16—17- and 18—19-year-olds (1.8% [n=22] and 2.1% [n=125] respectively). No differences were seen as regards shoulder dystocia (0.2% for both [n=9 *vs.* 116), placental abruption (0.2% for both [n=19 *vs.* 13]), uterine rupture (none *vs.* 0.05% [n=24]), abnormal bleeding during delivery (0.2% for both [n=3 *vs.* 135]) and postpartum infection (0.5% [n=36] *vs.* 0.4% [n=229]).

Neonatal outcomes

Table 4 summarises the incidences of various neonatal outcomes. No significant differences emerged between the 13—19- and 25—29-year-olds as regards 5-min Apgar score of less than 7 (2.5% [n=161] *vs.* 2.8% [n=1213]), cord blood pH below 7.05 at birth (1.9% [n=139] *vs.* 1.5% [n=767]), resuscitation of

the newborn (1.0% for both [n= 70 vs. 522]), use of a respirator (1.0% [n=74] *vs.* 0.9% [n=456]) or use of antibiotics (6.6% [n=481] *vs.* 6.8% [n=3498]).

Table 4: Neonatal outcomes according to age group

		Maternal age in years				
		13–15	**16–17**	**18–19**	**All teenagers**	**25–29**
n		84	1234	5987	7305	51 142
Extremely preterm <28 w[M3]	n (%)	2 (2.4)	3 (0.2)	23 (0.4)	28 (0.4)	149 (0.3)
	OR (95% CI)	8.5 (2.1 to 35.1)	0.8 (0.3 to 2.7)	1.3 (0.9 to 2.1)	1.3 (0.9 to 2.0)	
	Adj. OR (95% CI)	5.4 (0.7 to 41.5)	0.3 (0.0 to 2.4)	1.1 (0.6 to 1.9)	1.0 (0.6 to 1.7)	1 (Ref.)
Preterm <37 w[M2]	n (%)	11 (13.1)	68 (5.5)	296 (4.9)	375 (5.1)	2440 (4.8)
	OR (95% CI)	3.0 (1.6 to 5.7)	1.1 (0.9 to 1.5)	1.0 (0.9 to 1.2)	1.1 (1.0 to 1.2)	
	Adj. OR (95% CI)	2.5 (1.2 to 5.3)	1.0 (0.8 to 1.4)	0.9 (0.8 to 1.1)	1.0 (0.8 to 1.1)	1 (Ref.)
SGA[M1]	n (%)	2 (2.4)	52 (4.2)	199 (3.3)	253 (3.5)	1262 (2.5)
	OR (95% CI)	0.9 (0.2 to 3.5)	1.7 (1.3 to 2.3)	1.4 (1.2 to 1.6)	1.4 (1.2 to 1.6)	
	Adj. OR (95% CI)	0.5 (0.1 to 2.1)	1.2 (0.9 to 1.6)	1.0 (0.8 to 1.1)	1.0 (0.8 to 1.2)	1 (Ref.)
Intensive care[M4]	n (%)	19 (22.6)	138 (11.2)	654 (10.9)	811 (11.1)	5566 (10.9)
	OR (95% CI)	2.4 (1.4 to 4.0)	1.0 (0.9 to 1.2)	1.0 (0.9 to 1.1)	1.0 (0.9 to 1.1)	
	Adj. OR (95% CI)	1.9 (1.0 to 3.4)	0.9 (0.7 to 1.1)	0.9 (0.8 to 1.0)	0.9 (0.8 to 1.0)	1 (Ref.)
Stillbirth/neonatal death[M5]	n (%)	2 (2.4)	4 (0.3)	34 (0.6)	40 (0.5)	180 (0.4)
	OR (95% CI)	6.9 (1.7 to 28.3)	0.9 (0.3 to 2.5)	1.6 (1.1 to 2.3)	1.6 (1.1 to 2.2)	
	Adj. OR (95% CI)	0.4 (0.0 to 5.1)[M6]	0.6 (0.1 to 2.7)	1.4 (0.8 to 2.4)	1.2 (0.7 to 2.1)	1 (Ref.)

All the variables are adjusted according to multivariate models:

M1: Demographic variables (Table 1 – history of spontaneous abortions) + adequacy of prenatal care, gestational diabetes, PIH, placental abruption, chorioamnionitis, pre-eclampsia, eclampsia

M2: M1 + anaemia + history of spontaneous abortions

M3: M2 – misuse of alcohol or drugs

M4: M1 + preterm birth and IUGR

M5: M4 – (misuse of alcohol or drugs and pre-existing hypertension)

M6: M5 – (BMI and pre-existing diabetes)

Adequacy of prenatal care

To investigate the effect of low antenatal clinic attendance on obstetric outcomes, we performed a subgroup analysis of 210 teenagers with inadequate prenatal care compared with 6 905 teenagers with adequate care. Teenagers with inadequate prenatal care were significantly more likely to be single (33.3% [n=67] *vs.* 22.1% [n=1526], P<0.001) and to live in an urban area (73.9% [n=155] *vs.* 66.4% [n=485], P=0.03). Although the rate of smoking during pregnancy did not differ statistically significantly in the two groups (43.9% [n=92] *vs.* 37.3% [n=2576], P=0.07), teenagers with inadequate prenatal care were less likely to quit smoking during the 1st trimester (6.3% [n=13] *vs.* 12.8% [n=884], P=0.008). No significant differences between the groups emerged as regards being underweight (11.4% [n=138] *vs.* 10.4% [n=718], P=0.62) or obese (4.7% [n=10] *vs.* 6.3% [n=435], P=0.40), or misuse of alcohol or drugs during pregnancy (0.5% [n=1] *vs.* 1.2% [n=81], P=0.73).

Teenagers with inadequate prenatal care were at significantly higher risks of eclampsia and UTI, even after adjustment for confounding factors (Table 5). No excess risks of delivery complications were seen. The increased risk of stillbirth and neonatal mortality was almost entirely explained by premature births among teenagers with inadequate prenatal care.

Table 5: Maternal complications during pregnancy and neonatal outcomes according to adequacy of prenatal care.

		Inadequate prenatal care	Adequate prenatal care
n		**210**	**6905**
PREGNANCY COMPLICATIONS			
Eclampsia[M4]	n (%)	2 (1.0)	7 (0.1)
	OR (95% CI)	9.5 (2.0 to 45.9)	
	Adj. OR (95% CI)	12.6 (2.6 to 62.6)	1 (Ref.)
UTI[M3]	n (%)	3 (1.4)	24 (0.3)
	OR (95% CI)	4.2 (1.2 to 13.9)	
	Adj. OR (95% CI)	5.8 (1.7 to 19.7)	1 (Ref.)
NEONATAL OUTCOMES			
Extremely preterm <28 w[M6]	n (%)	5 (2.4)	20 (0.3)
	OR (95% CI)	8.4 (3.1 to 22.6)	
	Adj. OR (95% CI)	0.7 (0.1 to 5.1)	1 (Ref.)
Preterm <37 w[M1]	n (%)	35 (16.7)	319 (4.6)
	OR (95% CI)	4.1 (2.8 to 6.0)	
	Adj. OR (95% CI)	1.1 (0.7 to 1.7)	1 (Ref.)
Apgar at 5 min <7[M2]	n (%)	10 (5.8)	140 (2.3)
	OR (95% CI)	2.7 (1.4 to 5.1)	
	Adj. OR (95% CI)	1.9 (0.8 to 4.3)	1 (Ref.)
Intensive care[M2]	n (%)	33 (15.7)	733 (10.6)
	OR (95% CI)	1.6 (1.1 to 2.3)	
	Adj. OR (95% CI)	1.0 (0.6 to 1.7)	1 (Ref.)
Stillbirth/neonatal death[M5]	n (%)	5 (2.4)	28 (0.4)
	OR (95% CI)	6.0 (2.3 to 15.7)	
	Adj. OR (95% CI)	0.7 (0.1 to 7.1)	1 (Ref.)

All the variables are adjusted according to multivariate models:
M1: Demographic variables (Table 1 – pre-existing hypertension and diabetes)
M2: M1 + preterm birth – history of spontaneous abortions
M3: M1 – misuse of alcohol or drugs – history of spontaneous abortions
M4: M1 – misuse of alcohol or drugs, BMI and history of spontaneous abortions
M5: M2 – misuse of alcohol or drugs
Missing data as regards confounding variables in inadequate *vs.* adequate prenatal care group: cohabitation 17.1% *vs.* 9.7%, smoking 10.0% *vs.* 2.2%, BMI 19.5% *vs.* 2.1%.

DISCUSSION

Our comprehensive population-based study indicated an increased risk of eclampsia, proteinuria, UTI, pyelonephritis and anaemia among pregnant teenagers. The youngest teenagers were also faced with a higher risk of pre-eclampsia. However, teenagers were more likely to deliver vaginally without delivery complications when compared with the reference women. Regarding neonatal outcomes, the risk of preterm birth was increased among the youngest teenagers, whereas older teenagers were at risk of having SGA infants. Inadequate prenatal care among teenagers increased the risks of eclampsia, UTI and several adverse neonatal outcomes. Confounding factors affected the risks of most neonatal outcomes, but their roles concerning maternal complications were less significant.

The registers used for our study are of high quality and have been shown to be in accordance with delivery records.[23] We were able to investigate a number of factors that have been sparsely reported in connection with teenage pregnancies, such as proteinuria, UTI and pyelonephritis during pregnancy, fear of childbirth and pain relief during delivery. Our study was nationwide, giving a complete and realistic reflection of the situation regarding obstetric challenges among all teenage pregnancies during the study period.

In Finland, antenatal care, including routine visits to general practitioners and nurses/midwives, is provided free of charge by municipalities and used by virtually all pregnant women.[28] Specialised maternity units in public hospitals take care of practically all obstetric patients and births. In addition, fetal screening including early ultrasonography with a nuchal translucency scan, blood tests and structural ultrasonography is offered to all pregnant women.[29] Thus, the opportunity to

receive comprehensive prenatal care is available to all regardless of socioeconomic status or residence. This minimises the confounding effects which often complicate studies of this kind. We also divided teenagers into categories by age. Although evidence suggests that the risks of neonatal problems are higher in younger, biologically immature adolescents,[16-18] the majority of studies, especially those on maternal outcomes, have involved the use of a dichotomised study setting, neglecting the different stages of biological and psychological maturation in adolescents.[10 12 19 30-35] The importance of choosing the right reference group cannot be underestimated. The age of 20—24 years has often been used for reference, but age groups of even 20—39 years are seen. Childbearing has commonly been postponed in recent decades, in parallel with women's increasing level of education. The mean age of primigravid women in Finland was approximately 28 years during the study period; thus we chose primigravid women of 25—29 years of age as a reference group.

Our study is retrospective, which remains a limitation. The reliability of the data depends on the accuracy of reporting. In addition, the database did not allow for identification of precise timing of the different events during pregnancy. There was more missing data regarding confounding effects in the teenage group, as in the subgroup of teenagers with inadequate prenatal care. We could not look at the socioeconomic or educational status of adolescents in this study. The MBR includes information on maternal occupation, which is, however, less relevant as regards teenagers and young adults. Unfortunately, there is no information on fathers in the MBR as a result of confidentiality rules. Had socioeconomic status been available for use in our multivariate models, this might have affected risks of adverse obstetric outcomes among teenagers. We were not able to obtain information on weight gain during pregnancy. Poor weight gain is a known risk factor of adverse neonatal outcomes, such as low birth weight. Our study group of 13—15-year-olds was small in number, thus leading to lack of power in detecting risks of rare outcomes.

However, in order to discover the effect of very young age on the risk of adverse obstetric outcomes, this age group was analysed separately.

Relevant results in relation to those of other studies

Overall, there was a high rate of attendance at antenatal clinics, which was expected, as antenatal care is offered free of charge to all pregnant mothers. It can be speculated that women not reached by the antenatal care system may be socially disadvantaged in various areas of life. Poor socioeconomic status is often known to precede teenage pregnancy.[36 37] This view is supported by our finding that teenagers smoked and were diagnosed with misuse of alcohol or drugs significantly more often than reference women. Similar findings come from many parts of the developed world,[9 11 19 38 39] whereas early marriage and childbirth are more common in other, often developing parts of the world, thus leading to different social circumstances and possibly different pregnancy outcomes.

The increased risk of anaemia seen among teenagers is in accordance with findings from several earlier studies.[10-12 32] Physical growth and menstruation results in an increase in iron requirements that is often not met by nutrition. This leads to a negative iron balance and makes teenagers more susceptible to anaemia during pregnancy.[40] Poor fetal outcomes may occur, especially in cases of severe or first trimester anaemia.[40 41] In our study, anaemia was a risk factor of very preterm birth.

Previous studies carried out in industrialised countries have revealed no excess risks of pre-eclampsia or PIH among adolescents,[9-12 19] whereas higher risks have been reported in developing countries.[14 15 34] Our results are partly contradictory, indicating an increased risk of pre-eclampsia among the youngest teenagers. The relatively small number of pregnant mothers aged 13—15

years in our study places some uncertainty on this finding. A large Latin-American cross-sectional study revealed an increasing rate of pre-eclampsia with descending age, but there was no significant difference in risk after adjustment for confounding factors.[17] A French study revealed a lower risk among teenagers, but the number of very young teenagers was even smaller than in the present study.[11]

Our results confirm findings in earlier studies, showing an elevated risk of eclampsia among pregnant teenagers.[42 43] A report by the National Center for Health Statistics in the US showed an increasing trend in frequency with descending age (0.6% in 10—14-year-olds and 0.3% among 25—29-year-olds).[44] Because of a smaller number of cases and rarity of the condition, we could not evaluate such a trend. The essential role of prenatal care in the prevention of eclampsia has been previously emphasised,[45] although not in studies confined to teenagers. We found a marked 12-fold risk of eclampsia among teenagers with inadequate versus adequate care, highlighting the importance of adequate prenatal care in teenage pregnancies.

We found an increasing risk of proteinuria in pregnancy with descending age. An earlier study on the risk factors of proteinuria during pregnancy revealed a 1.5-fold risk among women below the age of 20.[46] Although the outcome of isolated proteinuria is mostly favourable, it is sometimes known to precede pre-eclampsia and even eclampsia[47 48] and has been associated with preterm birth.[49] Whether or not isolated proteinuria is part of the same disease spectrum as pre-eclampsia is controversial.[46 50] In our study, proteinuria was found to be a risk factor for pre-eclampsia, but not eclampsia or adverse neonatal outcomes.

Earlier studies on UTI and pyelonephritis in pregnant teenagers are sparse. Two UK studies reported 1.5- to 1.6-fold risks of UTI[10] and pyelonephritis[9] among all teenagers. In contrast, no excess risk was found in a Latin American study in which teenagers were analysed in subgroups by

age.[17] Our findings suggest higher risks of both UTI and pyelonephritis, with a trend toward a higher incidence with descending age. However, no cases were found among teenagers of 13–15 years of age, possibly because of the relative rarity of these diagnoses. Only a hypothesis for the reason behind the increased risks has been presented – reduced resistance to infections in pregnant teenagers.[10] We speculate that teenagers might be sexually more active during pregnancy compared with older women, placing them at a higher risk of UTI. In addition, poorer recognition of symptoms of UTI could lead to delayed care and explain the increased risk of pyelonephritis.

UTIs, and pyelonephritis in particular, have been associated with higher risks of adverse neonatal outcomes,[51 52] although they are preventable with early detection and antimicrobial care.[53]

Regarding other infections, our results do not support earlier findings of a higher risk of chorioamnionitis among adolescents compared with adult women.[10 12]

We detected lower or similar risks of delivery complications and a higher incidence of vaginal deliveries among teenagers, which is in line with findings in most studies in the developed world.[9-12 19] Contradictory findings derive mainly from studies in developing countries.[17 35] The use of pain relief, especially combined anaesthetic analgesia, was high in all groups and was used even more often in teenagers compared with older women. This is in contrast to the results of a UK study.[9]

Three large retrospective cohort studies carried out in the US and Latin America revealed 1.2- to 2.0-fold risks of preterm birth and 1.1- to 1.5-fold risks of SGA infants among teenagers, with an increasing trend with descending age.[16-18] Elevated (1.5-fold) risks of stillbirth and/or neonatal death were found among the youngest teenagers. However, among older teenagers and after adjustment for gestational age, the risks were either lower or non-significant.[16-18] These findings were largely confirmed in our study, although some differences were seen, possibly as a result of a

smaller study population and the lack of socioeconomic status as a confounding factor. In addition, we found an excess risk of preterm birth only among the youngest teenagers. The lack of risk among older teenagers might be explained by the overall high quality and quantity of prenatal care in Finland.

In accordance with the results of several recent studies,[20 21 54] we found higher risks of adverse neonatal outcomes, including an excess risk of neonatal/infant mortality among teenagers with inadequate prenatal care.

Unanswered questions and implications

Our results add to existing literature, showing higher risks of various maternal complications among teenagers, often displaying an increasing trend with descending age. An increased risk of proteinuria during pregnancy was found, an outcome not analysed in past studies dealing with teenage pregnancy. Confirmation of this finding and its possible influence on other, more serious obstetric outcomes is required. The effect of prenatal care on maternal outcomes should also be further analysed in the future. Clinical studies on the mode of delivery and its complications would shed more light on whether or not adolescents have better myometrial function compared with older women or whether the higher incidence of uncomplicated vaginal births is a consequence of other factors, such as more attentive care of adolescents. In addition to immediate obstetric risks, studies on long-term consequences indicate a higher incidence of morbidity and preterm mortality among both teenage mothers and their children,[1 2 4] and these risks should be examined in greater detail in the future.

The present study has practical implications: in addition to prevention and treatment of anaemia and eclampsia, screening and counselling in connection with proteinuria, cystitis and pyelonephritis are important among pregnant adolescents. The higher risk of pre-eclampsia among the youngest teenagers should also be kept in mind. Teenagers in a welfare society are not a risk group as regards delivery complications, and neonatal outcomes are mainly good. However, the younger the expectant mother, the greater are the risks of several maternal and neonatal complications. Adequacy of prenatal care is of great importance in preventing serious adverse obstetric outcomes. Thus, extra efforts should be made to reach all pregnant teenagers and enrol them in adequate maternity care in early pregnancy.

FOOTNOTES

Contributors: OH, MG and SL had the initial research idea and all authors contributed to the design, interpretation and critical revision of data. All authors had full access to the data and take responsibility of the integrity of the data and accuracy of the data analysis. SL carried out the analysis and wrote the drafts of the paper with important intellectual input from all coauthors. All authors have approved the final version of the manuscript submitted for publication. OH and SL act as guarantors.

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Ethical approval: No ethical approval was required for the present study. The organization responsible for the registers (THL National Institute for Health and Welfare) has given approval for the study (Dnro THL/1008/5.05.00/2012).

Data sharing: No additional data available. Researchers can apply for the authorisation for the use of same health register data for scientific research from the register keeping organization (THL National Institute for Health and Welfare).

FIGURE LEGENDS

Figure 1: Frequencies (%) of operative delivery and other delivery outcomes according to age group.

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TITLE PAGE

Is teenage pregnancy an obstetric risk in a welfare society? A population-based study in Finland, from 2006 to 2011.

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ABSTRACT

Objective: To assess obstetric outcomes in teenage pregnancies in a country with a low teenage delivery rate and comprehensive high-quality prenatal care.

Design: Retrospective population-based register study.

Setting: Finland.

Participants: All nulliparous teenagers (13–15 years [n=84], 16–17 years [n=1234], 18–19 years [n=5987]) and controls (25–29-year-old women [n=51 142]) with singleton deliveries in 2006–2011.

Main outcome measures: Risk of adverse obstetric outcomes adjusted for demographic factors and clinically relevant pregnancy complications, with a main focus on maternal pregnancy complications.

Results: Teenage mothers were more likely than controls to live in rural areas (16.0% [n=1168] *vs.* 11.8% [n=6035]), smoke (36.4% [n=2661] *vs.* 7.0% [n=3580]) and misuse alcohol or drugs (1.1% [n=82] *vs.* 0.2% [n=96]) (p<0.001 for all). Teenagers made a good mean number of antenatal clinic visits (16.4 *vs.* 16.5), but were more likely to have attended fewer than half of the recommended visits (3.0% [n=210] ~~2.9% [n=155]~~ *vs.* 1.4% [n=716]).

Teenagers faced increased risks of several obstetric complications, e.g. anaemia (adjusted odds ratio 1.8, 95% confidence interval 1.6 to 2.1), proteinuria (1.8, 1.2 to 2.6) urinary tract infection (UTI) (2.9, 1.8 to 4.8) pyelonephritis (6.3, 3.8 to 10.4) and eclampsia (3.2, 1.4 to 7.3), the risks increasing with descending age for most outcomes. Elevated risks of pre-eclampsia (3.7, 1.5 to 9.0) and preterm delivery (2.5, 1.2 to 5.3) were also found among 13—15-year-olds. However, teenage mothers were

more likely to have vaginal delivery (1.9, 1.7 to 2.0) without complications. Inadequate prenatal care among teenagers was a risk factor of eclampsia (12.6, 2.6 to 62.6), UTI (5.8, 1.7 to 19.7) and adverse neonatal outcomes.

Conclusions: Pregnant teenagers tended to be socioeconomically disadvantaged *vs.* controls and faced higher risks of various pregnancy complications. Special attention should be paid to enrolling teenagers into adequate prenatal care in early pregnancy.

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ARTICLE SUMMARY

Article focus

- Teenage pregnancy is associated with maternal anaemia and preterm birth. Association with other adverse obstetric outcomes, especially maternal complications, is less clear.
- Adequate antenatal care among teenagers has been shown to decrease adverse neonatal outcomes, but comprehensive care to all women was not offered in the previous study settings.
- We examined age-specific risks of adverse obstetric outcomes among teenagers, focusing on maternal pregnancy complications and the role of inadequate antenatal care.

Key messages

- In addition to a higher risk of anaemia, elevated risks of urinary tract infection, pyelonephritis, proteinuria and eclampsia were found among teenagers as well as pre-eclampsia and preterm delivery among the youngest girls.
- Inadequate antenatal care may place teenagers at markedly elevated risks of urinary tract infection, eclampsia and adverse neonatal outcomes even in a welfare society offering high-quality care to all pregnant women.

Strengths and limitations of this study

- The present study was nationwide, giving a realistic reflection of the situation regarding obstetric challenges among all teenage pregnancies during the study period.
- We were able to investigate a number of factors that have been sparsely reported in connection with teenage pregnancies, including proteinuria, cystitis and pyelonephritis during pregnancy, fear of childbirth and pain relief during delivery.
- Our study was retrospective and we could not look at the socioeconomic or educational status of women.

INTRODUCTION

Pregnancy during teenage years is associated with socioeconomic and health inequalities as regards both mother and child,[1-5] including higher risks of deprivation,[2] behavioural and emotional difficulties,[2] maltreatment,[1] morbidity[1] and premature mortality.[1 4] Therefore, it is a global concern. Although most pronounced in developing countries, teenage pregnancy ~~also~~ remains a significant problem also in the developed world. The incidence of teenage pregnancy ending in delivery varies widely, with Nordic countries having comparatively low rates: 6/1000 in Sweden[6] and 9/1000 in Finland,[6] compared with 24/1000 in England and Wales[7] and 34/1000 in the USA in 2010.[8]

Obstetric risks are often divided into categories of maternal complications, mode of delivery and its complications, and neonatal outcome. Teenage pregnancies are associated with maternal anaemia,[9-12] hypertensive problems[13-14 15] and preterm~~mature~~ birth,[16-19 5-17] while low risks as regards delivery complications have been reported in studies carried out in industrialised countries.[9-12 2 19 7] However, results concerning several adverse outcomes vary largely, possibly as a result of the great number of confounding factors. Poor socioeconomic conditions,[1 9 10] risky health behaviour,[9 12] inadequate prenatal care[18 7 20-21-19] and biological immaturity[16-18 5-17] have been suggested as possible explanations for adverse obstetric outcomes.

Although the issue of teenage pregnancy has been widely studied, a consensus of opinion on obstetric risks is lacking. Comprehensive, age-specific studies concerning maternal complications remain sparse.[9 17 6] In addition, the role of prenatal care in regard to these problems is not well established. The objective of the present study was to investigate the risks of adverse obstetric outcomes in teenagers in a country with a low rate of adolescent births and comprehensive high-quality prenatal

care, with special focus on maternal complications during pregnancy. Secondly, we aimed to focus on the effect on these outcomes of a low number of visits to antenatal clinics.

MATERIAL AND METHODS

Study population

We identified all childbirths (n=354 833, of which 349 531 were singleton births) between ~~1 January 2006 and 31 December 2011~~ 2006 and 2011 in Finland using the national Medical Birth Register (MBR). Only singleton pregnancies of nulliparous women (n=97 838) were included. Cases of major congenital anomaly (defined as major anatomical anomaly, chromosomal anomaly or congenital hypothyroidism)[22] were excluded (n=4149). After exclusion, there was a total of 7305 singleton childbirths among 13—19-year-old nulliparous girls and women, further divided into three groups: 13—15-year-olds (n=84), 16—17-year-olds (n=1234), and 18—19-year-olds (n=5987). Singleton deliveries (n=51 142) among women aged 25—29 years served as reference material. Women with histories of abortion and miscarriage (n=11 703, 20.1%) were included.

Data collection

The study data were obtained from the MBR and the Hospital Discharge Register (HDR), maintained by the National Institute for Health and Welfare. Reporting to these national registers is obligatory and the data has been shown to be valid and to reflect good coverage.[23~~0~~]

Data for the MBR is collected at all maternity hospitals in Finland.[24~~1~~] It covers all live births and stillbirths with a birth weight of 500 grams or more or with a gestational age of 22 weeks or more. ~~The~~

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~~register includes information on maternal demographic factors, prenatal care, interventions and common diagnoses during pregnancy and delivery and neonatal outcomes until the age of seven days.~~

The HDR contains information on all in-patient periods in public and private hospitals and out-patient visits in the public sector. ~~The information includes diagnosis (ICD-10 codes), dates of admission and discharge and the code of the hospital or other institution.~~ We collected the data separately for pregnancy and delivery (delivery complications include diagnoses reported from the start of delivery until 42 days postpartum). Each complication was noted once per woman.

Study variables

The choice of study variables was based on previous literature and clinical relevance. All study variables are listed with ICD-10 codes, unless derived from the MBR in a separate check-box.

Maternal outcomes: ~~of interest were~~ anaemia (haemoglobin below 100 g/l), pregnancy-induced hypertension (PIH) (O13, O16), pre-eclampsia (O14), eclampsia, proteinuria (O12 excluding O12.0), gestational diabetes, intrahepatic cholestasis of pregnancy (O26.6), *placenta praevia*, sexually transmitted infections (*Chlamydia trachomatis* [A56], *Neisseria gonorrhoeae* and syphilis [A51-A54]), urinary tract infection (UTI) (N30, N34, N39.0, O23.1–O23.4, O23.9), pyelonephritis (N10, N12, O23.0), chorioamnionitis (O41.1), ~~proteinuria (O12 excluding O12.0), preterm contractions (before 37 weeks of gestation; O47.0)~~, bleeding in early pregnancy (O20) and fear of childbirth (O99.80).

Delivery outcomes: ~~of interest were~~ mode of delivery (vaginal delivery, vaginal breech delivery, assisted vaginal delivery [vacuum extraction or forceps] and Caesarean section [elective, urgent and emergency]), induction of labour, use of oxytocin, episiotomy, pain relief during delivery (regional

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anaesthesia, other medication and non-medical pain relief), anal sphincter rupture, shoulder dystocia, placental abruption, uterine curettage, abnormal bleeding during (O67) and after delivery (O72), uterine rupture (O71.0–O71.1) and postpartum infection (O85, O86, N71, N72).

Neonatal outcomes: ~~selected for analysis were~~ preterm birth (extremely preterm [<28 weeks] and preterm [<37 weeks of gestation]), birth weight adjusted for gestational age according to the Finnish fetal growth curves[25~~2~~] (divided into small-for-gestational-age [SGA, defined as <-2 SD], average-for-gestational-age [AGA] and large-for-gestational age [LGA, defined as > +2 SD]), 5-min Apgar score below 7, cord blood pH below 7.05 at birth, resuscitation of the newborn, use of a respirator, use of antibiotics, ~~phototherapy~~, admission to a neonatal intensive care unit, stillbirth~~intrauterine fetal death~~ (delivery of a stillborn at 22 weeks of gestation or later) and neonatal death (death of a live-born at 0–6 days of age).

Demographic factors are presented in Table 1. Of these, alcohol or drug misuse during pregnancy (Z72.1–Z72.2), pre-existing diabetes (E10–E12, O24.0–O24.3) and pre-existing hypertension (I10, O10–O11) were derived from the HDR and other variables from the MBR.

Table 1. Demographic characteristics according to age group (years)

	13–15	16–17	18–19	All teenagers	25–29	P* for difference
n	84	1234	5987	7305	51 142	
Cohabitation status						
Married/cohabiting	13 (15.5)	598 (48.5)	4248 (71.0)	4859 (66.5)	45 262 (88.5)	<0.001
Single	45 (53.6)	471 (38.2)	1132 (18.9)	1644 (22.5)	2608 (5.1)	
Missing data	26 (30.9)	165 (13.3)	607 (10.1)	802 (11.0)	3272 (6.4)	
Type of residence						
Urban	52 (61.9)	820 (66.5)	3980 (66.5)	4852 (66.4)	37589 (73.5)	<0.001
Densely populated	14 (16.7)	185 (15.0)	1050 (17.5)	1249 (17.1)	7313 (14.3)	
Rural	16 (19.0)	222(18.0)	930 (15.5)	1168 (16.0)	6035 (11.8)	
Missing data	2 (2.4)	7 (0.5)	27 (0.5)	36 (0.5)	205 (0.4)	
Smoking during pregnancy						
Yes	28 (33.3)	506 (41.3)	2127 (35.5)	2661 (36.4)	3580 (7.0)	<0.001
Quit during 1st trimester	11(13.1)	157 (12.7)	725 (12.1)	893 (12.2)	3324 (6.5)	
Missing data	6 (7.1)	37 (3.0)	171 (2.9)	214 (2.9)	921 (1.8)	
Alcohol or drug misuse during pregnancy	3 (3.6)	14 (1.1)	65 (1.1)	82 (1.1)	96 (0.2)	<0.001
BMI before pregnancy						
Underweight**	16 (19.0)	155 (12.6)	57 (9.6)	228 (10.3)	1841 (3.6)	<0.001
Obese***	109 (1.3)	63 (5.1)	395 (6.6)	567 (6.3)	4347 (8.5)	
Missing data	6 (7.1)	57 (4.6)	174 (2.9)	237 (3.2)	1074 (2.1)	
History of spontaneous abortion(s)	2 (2.4)	51 (4.1)	479 (8.0)	532 (7.3)	5984 (11.7)	<0.001
Pre-existing hypertension	0 (0)	1 (0.1)	6 (0.1)	7 (0.1)	102 (0.2)	0.026
Pre-existing diabetes	0 (0)	7 (0.6)	42 (0.7)	49 (0.7)	358 (0.7)	0.834

Data expressed as n (%).

*P-values refer to differences between all the age groups.

**BMI <18.5 kg/m^2

***BMI ≥ 30.0 kg/m^2

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The area of residence at the time of delivery was divided into urban, densely populated or rural according to national classification by Statistics Finland.[2~~63~~] Pre-pregnancy BMI was calculated on the basis of height and weight measures reported by the pregnant women. ~~As the "adult" BMI curve plateau is seen at 15—16 years of age, and the total number of teenagers below this age was small in our study, we used the same BMI for adolescents and adults instead of using the ISO-BMI for adolescents.~~

Adequacy of prenatal care was calculated on the basis of the recommended~~expected~~ number of antenatal clinic visits in Finland (13-17 visits in full term pregnancies)[2~~74~~] adjusted for gestational age at birth. Inadequate prenatal care was defined as attendance at fewer than half of the recommended number of visits.

Statistical analysis

To assess differences between age groups, the χ^2 test and Fisher's exact test were used as appropriate. A P-value <0.05 was defined as statistically significant. T~~o determine t~~he estimated risks (unadjusted and adjusted odds ratios [ORs] with their 95% confidence intervals [CIs]) of adverse outcomes were calculated ~~unadjusted and adjusted odds ratios (ORs) with their 95% confidence intervals (CIs),~~ using binary logistic regression. ~~To minimise confounding effects, we used several multivariate models depending on the outcome variable analysed.~~ Our basic multivariate model included all demographic factors presented in Table 1 (except for history of spontaneous abortions, which was used for preterm birth only) and adequacy of prenatal care. Pregnancy complications were added to the model when found to be clinically relevant. Variables were removed from the model when necessary as a result of small numbers of cases ~~regarding rare adverse outcomes~~.

A subgroup analysis was carried out including only teenagers, dividing the group into those with inadequate and adequate prenatal care (reference group). The risks were~~We~~ analysed using binary logistic regression. ~~unadjusted and adjusted estimates of risk (ORs) with their 95% CIs using the group with adequate care as the control group. For the multivariate model, w~~We used the basic multivariate model (see above), excluding pre-existing hypertension and diabetes as a result of small numbers of cases. ~~We also used preterm birth as a confounding factor when analysing the estimated risks of a low Apgar score, need of intensive care, and death. We did not use other confounding factors in the subgroup analysis because teenagers with inadequate prenatal care might have been diagnosed with pregnancy complications less often as a result of a low number of visits, thus causing possible bias.~~

To ~~further~~ minimise bias, we used list-wise deletion in logistic regression analysis when data was missing. The percentages of missing cases as regards demographic factors are shown in Table 1.

IBM SPSS statistics 19.0 and 20.0 for Windows were used for the statistical analyses.

RESULTS

Demographics

All the demographic characteristics of the teen-agers *vs.* the reference women differed significantly, except for pre-existing diabetes (Table 1). Pregnant teenagers were more likely to be single, live in a rural area, smoke and be diagnosed with misuse of alcohol or drugs during pregnancy. Pre-existing hypertension was more common in the reference group.

All groups showed a good mean number of visits to an antenatal clinic (Table 2). However, teenagers started their prenatal care significantly later in pregnancy. All teenage groups were also more likely to show a significantly lower attendance rate.

Table 2: Prenatal care according to age group (years)

	13–15	16–17	18–19	All teenagers	25–29	P* for difference
n	84	1234	5987	7305	51 142	
All antepnatal visits (Mean ± SD)	14.6 ± 6.0	16.1 ± 5.8	16.5 ± 5.3	16.4 ± 5.4	16.5 ± 4.7	<0.001
Hospital polyclinic visits (Mean ± SD)	4.3 ± 2.3	3.7 ± 2.9	3.1 ± 2.7	3.2 ± 2.8	2.7 ± 2.5	<0.001
First antepnatal visit, gestational weeks	18.8 ± 9.0	12.6 ± 7.2	10.2 ± 5.0	10.7 ± 5.6	9.0 ± 3.1	<0.001
First antenatal visit ≥ 20 gestational weeks	43 (51.2)	192 (15.6)	358 (6.0)	593 (8.1)	728 (1.4)	<0.001
Low attendance (%)						
<50% of expected visits	4 (4.9)	65 (5.4)	141 (2.4)	210 (3.0)	691 (1.4)	<0.001
1st trimester ultrasonographic screening	30 (35.7)	671 (54.4)	3733 (62.4)	4434 (60.7)	37429 (73.2)	<0.001
2nd trimester ultrasonographic screening	45 (53.6)	850 (68.9)	4299 (71.8)	5194 (71.1)	39620 (77.5)	<0.001

*P-values refer to differences between all the age groups.

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Pregnancy complications

Significantly increased risks of anaemia, eclampsia, proteinuria, UTIs and pyelonephritis were noted among the teenagers. The youngest group of teenagers (13—15-year-olds) had an elevated risk of pre-eclampsia and a small excess risk was also noted among 18—19-year-olds after controlling for confounding factors (Table 3). The frequency of gestational diabetes (5.3% [n=385] *vs.* 8.2% [n=4173], adjusted odds ratio [adj. OR] 0.7, 95% CI 0.6 to 0.7) and *placenta praevia* (0.04% [n=3] *vs.* 0.3%

[n=161], adj. OR 0.1, 0.01 to 0.8) was lower among 13—19-year-olds ~~, whereas teenagers were more often diagnosed with preterm contractions (4.0% [n=289] *vs.* 2.6% [n=1333], adj. OR 1.5, 1.3 to 1.7) compared with reference women. T~~although the differences between 13—15-year-olds and the reference group were non-significant, ~~. as regards gestational diabetes, *placenta praevia* and preterm contractions,~~ as was the case between 16—17-year-olds and the reference group as regards *placenta praevia*.

Table 3: Maternal complications during pregnancy according to age group

		Maternal age in years				
		13–15	**16–17**	**18–19**	**All teenagers**	**25–29**
n		84	1234	5987	7305	51 142
Anaemia*[M1]	n (%)	6 (7.1)	64 (5.2)	245 (4.1)	315 (4.3)	1227 (2.4)
	OR (95% CI)	3.2 (1.4 to 7.3)	2.3 (1.7 to 2.9)	1.8 (1.5 to 2.0)	1.9 (1.7 to 2.1)	
	Adj. OR (95% CI)	3.1 (1.3 to 7.3)	2.2 (1.7 to 2.9)	1.8 (1.2 to 2.1)	1.8 (1.6 to 2.1)	1 (Ref.)
Pre-eclampsia[M2]	n (%)	6 (7.1)	26 (2.1)	182 (3.0)	214 (2.9)	1522 (3.0)
	OR (95% CI)	2.5 (1.1 to 5.8)	0.7 (0.5 to 1.0)	1.0 (0.9 to 1.2)	1.0 (0.9 to 1.1)	
	Adj. OR (95% CI)	3.7 (1.5 to 9.0)	0.9 (0.6 to 1.4)	1.2 (1.0 to 1.5)	1.2 (1.0 to 1.4)	1 (Ref.)
Eclampsia[M4]	n (%)	0 (0.0)	2 (0.2)	9 (0.2)	11 (0.2)	26 (0.1)
	OR (95% CI)	-	3.2 (0.8 to 13.5)	3.9 (1.4 to 6.3)	3.0 (1.4 to 6.0)	
	Adj. OR (95% CI)	-	2.3 (0.3 to 18.2)	3.3 (1.4 to 7.8)	3.2 (1.4 to 7.3)	1 (Ref.)
Proteinuria[M3]	n (%)	2 (2.4)	9 (0.7)	32 (0.5)	43 (0.6)	171 (0.3)
	OR (95% CI)	7.3 (1.8 to 29.8)	2.2 (1.1 to 4.3)	1.6 (1.1 to 2.3)	1.8 (1.3 to 2.5)	
	Adj. OR (95% CI)	12.3 (2.8 to 53.6)	2.4 (1.1 to 5.2)	1.6 (1.0 to 2.5)	1.8 (1.2 to 2.6)	1 (Ref.)
UTI[M5]	n (%)	0 (0.0)	6 (0.5)	21 (0.4)	27 (0.4)	75 (0.1)
	OR (95% CI)	-	3.3 (1.4 to 7.7)	2.4 (1.5 to 3.9)	2.5 (1.6 to 3.9)	
	Adj. OR (95% CI)	-	4.1 (1.7 to 10.2)	2.7 (1.6 to 4.6)	2.9 (1.8 to 4.8)	1 (Ref.)
Pyelonephritis[M6]	n (%)	0 (0.0)	8 (0.6)	27 (0.5)	35 (0.5)	45 (0.1)
	OR (95% CI)	-	7.4 (3.5 to 15.8)	5.1 (3.2 to 8.3)	5.5 (3.5 to 8.5)	
	Adj. OR (95% CI)	-	9.6 (4.2 to 21.9)	5.8 (3.4 to 10.0)	6.3 (3.8 to 10.4)	1 (Ref.)

* Haemoglobin < 100 g/l.

All the variables are adjusted according to multivariate models:

M1: Demographic variables (Table 1 – history of spontaneous abortions) + adequacy of prenatal care

M2: M1 + (PIH and proteinuria)

M3: M1 + PIH

M4: M3 – misuse of alcohol or drugs and pre-existing hypertension

M5: M1 – misuse of alcohol or drugs

M6: M1 – pre-existing hypertension

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There were no statistically significant differences between the groups as regards PIH (3.2% [n=233] *vs.* 4.2% [n=2158]), chorioamnionitis (0.6% [n=44] *vs.* 0.7% [n=377]), STIs (0.05% [n=10] *vs.* 0.02% [n=34]), bleeding in early pregnancy (0.4% for both [n=27 *vs*. 190]), intrahepatic cholestasis of pregnancy (1.1% [n=79] *vs.* 0.9% [n=460]) or fear of childbirth (1.3% for both [n=98 *vs*. 659]).

Regarding pregnancy complications among teenagers, we evaluated their effects on other adverse obstetric outcomes. Anaemia was a risk factor for very preterm birth (~~un~~adjusted odds ratio 2.1, 1.1 to 4.2)~~2.5, 1.4 to 4.6), 5-min Apgar score of less than 7 (1.6, 1.2 to 2.1) and shoulder dystocia (2.8, 1.4 to 5.5)~~. Proteinuria was found to be a risk factor for pre-eclampsia (5.4~~7.7~~, 3.6~~5.4~~ to 8.0~~10.8~~), but not for eclampsia or adverse neonatal outcomes. UTI and pyelonephritis did not affect the risks of adverse obstetric outcomes~~, whereas pyelonephritis was a risk factor for IUGR (3.67, 1.1 to 12.20~~

Delivery outcomes

The estimated risks (adj. OR) among all teenagers (13—19 years of age) compared with the reference women were: Caesarean section 0.6 (0.6 to 0.7), operative vaginal delivery 0.6 (0.6 to 0.7), anal sphincter rupture 0.4 (0.3 to 0.5) and breech presentation 0.7 (0.6 to 0.8) (Figure 1). However, when analysed in subgroups according to age, the estimated risks among 13—15-year-olds did not differ significantly from those in the reference group, except for Caesarean section.

The percentages of planned Caesarean sections were similar among 13—15-year-olds and the reference women (4.8 % [n=4] *vs.* 4.5% [n=2301]), but significantly lower among 16—17- and 18—19-year-olds (2.4 % [n=30] and 3.2% [n=192], respectively). Regarding urgent Caesarean sections, the

frequencies were lower among all teenagers (7.2% [n=524] *vs.* 11.7% [n=5996]) and descended according to age. In the case of emergency Caesarean sections, however, there were no significant differences (1.1% [n=83] *vs.* 1.5% [n=766]).

The frequencies of induction of labour and use of oxytocin during labour were similar in the teenagers and reference women (16.8% [n=1226] *vs.* 17.2% [n=8788] and 49.7% [n=3630] *vs.* 50.3% [n=25744] respectively). Episiotomy was performed less often in all teenage groups (39.1% [n=2861] *vs.* 41.2% [n=21511]), although the difference was non-significant as regards 13—15-year-olds. Combined regional anaesthesia was used significantly more often in all teenage groups compared with the reference women (72.5% [n=5296] *vs.* 66.3% [n=33907]).

The incidence of uterine curettage after childbirth was lower among all 13—19-year-olds (0.5% [n=40] *vs.* 0.9% [n=446]), but the significance disappeared when the subgroups were analysed separately. Differences in the incidence of abnormal bleeding after childbirth were non-significant between 13—15-year-olds (4.8% [n=4]) and the reference group (3.5% [n=1772]), but significantly lower among 16—17- and 18—19-year-olds (1.8% [n=22] and 2.1% [n=125] respectively). No differences were seen as regards shoulder dystocia (0.2% for both [n=9 *vs.* 116), placental abruption (0.2% for both [n=19 *vs.* 13]), uterine rupture (none *vs.* 0.05% [n=24]), abnormal bleeding during delivery (0.2% for both [n=3 *vs*. 135]) and postpartum infection (0.5% [n=36] *vs.* 0.4% [n=229]).

Neonatal outcomes

Table 4 summarises the incidences of various neonatal outcomes. No significant differences emerged between the 13—19- and 25—29-year-olds as regards ~~the proportions with a~~ 5-min Apgar score of less than 7 (2.5% [n=161] *vs.* 2.8% [n=1213]), cord blood pH below 7.05 at birth (1.9% [n=139] *vs.* 1.5%

[n=767]), resuscitation of the newborn (1.0% for both [n= 70 vs. 522]), use of a respirator (1.0% [n=74] *vs.* 0.9% [n=456]) or use of antibiotics (6.6% [n=481] *vs.* 6.8% [n=3498]). ~~Phototherapy was used similarly among all groups, although the frequency was significantly lower among 18—19-year-olds compared with the reference women (5.9% [n=443] *vs.* 6.8% [n=3457]).~~

Table 4: Neonatal outcomes according to age group

		Maternal age in years				
		13–15	**16–17**	**18–19**	**All teenagers**	**25–29**
n		84	1234	5987	7305	51 142
Extremely preterm <28 w[M3]	n (%)	2 (2.4)	3 (0.2)	23 (0.4)	28 (0.4)	149 (0.3)
	OR (95% CI)	8.5 (2.1 to 35.1)	0.8 (0.3 to 2.7)	1.3 (0.9 to 2.1)	1.3 (0.9 to 2.0)	
	Adj. OR (95% CI)	5.4 (0.7 to 41.5)	0.3 (0.0 to 2.4)	1.1 (0.6 to 1.9)	1.0 (0.6 to 1.7)	1 (Ref.)
Preterm <37 w[M2]	n (%)	11 (13.1)	68 (5.5)	296 (4.9)	375 (5.1)	2440 (4.8)
	OR (95% CI)	3.0 (1.6 to 5.7)	1.1 (0.9 to 1.5)	1.0 (0.9 to 1.2)	1.1 (1.0 to 1.2)	
	Adj. OR (95% CI)	2.5 (1.2 to 5.3)	1.0 (0.8 to 1.4)	0.9 (0.8 to 1.1)	1.0 (0.8 to 1.1)	1 (Ref.)
SGA[M1]	n (%)	2 (2.4)	52 (4.2)	199 (3.3)	253 (3.5)	1262 (2.5)
	OR (95% CI)	0.9 (0.2 to 3.5)	1.7 (1.3 to 2.3)	1.4 (1.2 to 1.6)	1.4 (1.2 to 1.6)	
	Adj. OR (95% CI)	0.5 (0.1 to 2.1)	1.2 (0.9 to 1.6)	1.0 (0.8 to 1.1)	1.0 (0.8 to 1.2)	1 (Ref.)
Intensive care[M4]	n (%)	19 (22.6)	138 (11.2)	654 (10.9)	811 (11.1)	5566 (10.9)
	OR (95% CI)	2.4 (1.4 to 4.0)	1.0 (0.9 to 1.2)	1.0 (0.9 to 1.1)	1.0 (0.9 to 1.1)	
	Adj. OR (95% CI)	1.9 (1.0 to 3.4)	0.9 (0.7 to 1.1)	0.9 (0.8 to 1.0)	0.9 (0.8 to 1.0)	1 (Ref.)
Stillbirth/neonatal death[M5]	n (%)	2 (2.4)	4 (0.3)	34 (0.6)	40 (0.5)	180 (0.4)
	OR (95% CI)	6.9 (1.7 to 28.3)	0.9 (0.3 to 2.5)	1.6 (1.1 to 2.3)	1.6 (1.1 to 2.2)	
	Adj. OR (95% CI)	0.4 (0.0 to 5.1)[M6]	0.6 (0.1 to 2.7)	1.4 (0.8 to 2.4)	1.2 (0.7 to 2.1)	1 (Ref.)

All the variables are adjusted according to multivariate models:

M1: Demographic variables (Table 1 – history of spontaneous abortions) + adequacy of prenatal care, gestational diabetes, PIH, placental abruption, chorioamnionitis, pre-eclampsia, eclampsia

M2: M1 + anaemia + history of spontaneous abortions

M3: M2 – misuse of alcohol or drugs

M4: M1 + preterm birth and IUGR

M5: M4 – (misuse of alcohol or drugs and pre-existing hypertension)

M6: M5 – (BMI and pre-existing diabetes)

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Adequacy of prenatal care

To investigate the effect of low antenatal clinic attendance on obstetric outcomes, we performed a subgroup analysis of 210 teenagers with inadequate prenatal care compared with 6 905 teenagers with adequate care. Teenagers with inadequate prenatal care were significantly more likely to be single (33.3% [n=67] *vs.* 22.1% [n=1526], P<0.001) and to live in an urban area (73.9% [n=155] *vs.* 66.4% [n=485], P=0.03). Although the rate of smoking during pregnancy did not differ statistically significantly in the two groups (43.9% [n=92] *vs.* 37.3% [n=2576], P=0.07), teenagers with inadequate prenatal care were less likely to quit smoking during the 1st trimester (6.3% [n=13] *vs.* 12.8% [n=884], P=0.008). No significant differences between the groups emerged as regards being underweight (11.4% [n=138] *vs.* 10.4% [n=718], P=0.62) or obese (4.7% [n=10] *vs.* 6.3% [n=435], P=0.40), or ~~as regards~~ misuse of alcohol or drugs during pregnancy (0.5% [n=1] *vs.* 1.2% [n=81], P=0.73).

Teenagers with inadequate prenatal care were at significantly higher risks of eclampsia and UTI, even after adjustment for confounding factors (Table 5). No excess risks of ~~as regards~~ delivery complications were seen. The increased risk of stillbirth~~perinatal~~ and neonatal mortality was almost entirely explained by premature births among teenagers with inadequate prenatal care.

Table 5: Maternal complications during pregnancy and neonatal outcomes according to adequacy of prenatal care.

		Inadequate prenatal care	Adequate prenatal care
n		**210**	**6905**
PREGNANCY COMPLICATIONS			
Eclampsia[M4]	n (%)	2 (1.0)	7 (0.1)
	OR (95% CI)	9.5 (2.0 to 45.9)	
	Adj. OR (95% CI)	12.6 (2.6 to 62.6)	1 (Ref.)
UTI[M3]	n (%)	3 (1.4)	24 (0.3)
	OR (95% CI)	4.2 (1.2 to 13.9)	
	Adj. OR (95% CI)	5.8 (1.7 to 19.7)	1 (Ref.)
NEONATAL OUTCOMES			
Extremely preterm <28 w[M6]	n (%)	5 (2.4)	20 (0.3)
	OR (95% CI)	8.4 (3.1 to 22.6)	
	Adj. OR (95% CI)	0.7 (0.1 to 5.1)	1 (Ref.)
Preterm <37 w[M1]	n (%)	35 (16.7)	319 (4.6)
	OR (95% CI)	4.1 (2.8 to 6.0)	
	Adj. OR (95% CI)	1.1 (0.7 to 1.7)	1 (Ref.)
Apgar at 5 min <7[M2]	n (%)	10 (5.8)	140 (2.3)
	OR (95% CI)	2.7 (1.4 to 5.1)	
	Adj. OR (95% CI)	1.9 (0.8 to 4.3)	1 (Ref.)
Intensive care[M2]	n (%)	33 (15.7)	733 (10.6)
	OR (95% CI)	1.6 (1.1 to 2.3)	
	Adj. OR (95% CI)	1.0 (0.6 to 1.7)	1 (Ref.)
Stillbirth~~Pre~~/neonatal death[M5]	n (%)	5 (2.4)	28 (0.4)
	OR (95% CI)	6.0 (2.3 to 15.7)	
	Adj. OR (95% CI)	0.7 (0.1 to 7.1)	1 (Ref.)

All the variables are adjusted according to multivariate models:

M1: Demographic variables (Table 1 – pre-existing hypertension and diabetes)
M2: M1 + preterm birth – history of spontaneous abortions
M3: M1 – misuse of alcohol or drugs – history of spontaneous abortions
M4: M1 – misuse of alcohol or drugs, BMI and history of spontaneous abortions
M5: M2 – misuse of alcohol or drugs
Missing data as regards confounding variables in inadequate *vs.* adequate prenatal care group: cohabitation 17.1% *vs.* 9.7%, smoking 10.0% *vs.* 2.2%, BMI 19.5% *vs.* 2.1%.

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DISCUSSION

Our comprehensive population-based study indicated ~~that pregnant teenagers are at~~ an increased risk of eclampsia, proteinuria, UTI~~cystitis~~, pyelonephritis and anaemia among pregnant teenagers. The youngest teenagers were also faced with~~also had~~ a higher risk of pre-eclampsia. However, teenagers were more likely to ~~have a normal vaginal~~ deliver~~y~~ vaginally without delivery complications ~~without excessive risks of delivery complications~~ when compared with the reference women. ~~"at the best age for delivery" (25—29 years).~~ Regarding neonatal outcomes, the risk of preterm birth was increased among the youngest teenagers, whereas older teenagers were at risk of having SGA infants. ~~and infants with IUGR. An increased risk of stillbirth/neonatal death was also found.~~ Inadequate prenatal care among teenagers increased the risks of eclampsia, UTI and several adverse neonatal outcomes. Confounding factors affected the risks of most neonatal outcomes, but their roles concerning~~as regards~~ maternal complications were less significant.

The registers used for our study are of high quality and have been shown to be in accordance with delivery records.[2~~30~~] We were able to investigate a number of factors that have been sparsely reported in connection with teenage pregnancies, such as proteinuria, UTI~~cystitis~~ and pyelonephritis during pregnancy, fear of childbirth and pain relief during delivery. Our study was nationwide, giving a complete and realistic reflection of the situation regarding obstetric challenges among all teenage pregnancies during the study period.

In Finland, ante~~pre~~natal care, including routine visits to general practitioners and nurses/midwives, is provided free of charge by municipalities and used by virtually all pregnant women.[2~~85~~] Specialised maternity units in public hospitals take care of practically all obstetric

patients and births. In addition, fetal screening including early ultrasonography with a nuchal translucency scan, blood tests and structural ultrasonography is offered to all pregnant women.[2 9 6] Thus, the opportunity to receive comprehensive prenatal care is available to all regardless of socioeconomic status or residence. This minimises the confounding effects which often complicate studies of this kind. We also divided teenagers into categories by age. Although evidence suggests that the risks of neonatal problems are higher in younger, biologically immature adolescents,[1 6 5 7 1 8 7] the majority of studies, especially those on maternal outcomes, have involved the use of a dichotomised study setting, neglecting the different stages of biological and psychological maturation in adolescents.[10 12 19 30 27 35 2] The importance of choosing the right reference group cannot be underestimated. The age of 20—24 years has often been used for reference, but age groups of even 20—39 years are seen. Childbearing has commonly been postponed in recent decades, in parallel with women's increasing level of education. The mean age of primigravid women in Finland was approximately 28 years during the study period; thus we chose primigravid women of 25—29 years of age as a reference group.

Our study is retrospective, which remains a limitation. The reliability of the data depends on the accuracy of reporting. In addition, the database did not allow for identification of precise timing of the different events during pregnancy. There was more missing data regarding confounding effects in the teenage group, as in the subgroup of teenagers with inadequate prenatal care. We could not look at the socioeconomic or educational status of adolescents in this study. The MBR includes information on maternal occupation, which is, however, less relevant as regards teenagers and young adults. Unfortunately, there is no information on fathers in the MBR as a result of confidentiality rules. Had socioeconomic status been available for use in our multivariate models, this might have affected risks of adverse obstetric outcomes among teenagers. ~~If socioeconomic status had been used in logistic regression analysis as a confounding factor, the~~

~~risks of some outcomes among teenagers might have been smaller.~~ We were not able to obtain information on weight gain during pregnancy. Poor weight gain is a known risk factor of adverse neonatal outcomes, such as low birth weight. Our study group of 13—15-year-olds was small in number, thus leading to lack of power in detecting risks of rare outcomes. However, in order ~~we felt it important to analyse this group separately~~ to discover the effect of very young age on the risk of adverse obstetric outcomes, this age group was analysed separately.

Relevant results in relation to those of other studies

Overall, there was a high rate of attendance at antenatal clinics, which was expected, as antenatal care is offered free of charge to all pregnant mothers. It can be speculated that women not reached by the antenatal care system may be socially disadvantaged in various areas of life. Poor socioeconomic status is often known to precede teenage pregnancy.[3~~6~~ 3~~7~~] This view is supported by our finding that teenagers smoked and were diagnosed with misuse of alcohol or drugs significantly more often than reference women. Similar findings come from many parts of the developed world,[9 11 19 3~~8~~ 3~~9~~] whereas early marriage and childbirth are more common in other, often developing parts of the world, thus leading to different social circumstances and possibly different pregnancy outcomes.

The increased risk of anaemia seen among teenagers is in accordance with findings from several earlier studies.[10-12 3~~2~~ 3~~9~~] Physical growth and menstruation results in an increase in iron requirements that is often not met by nutrition. This leads to a negative iron balance and makes teenagers more susceptible to anaemia during pregnancy.[40 3~~7~~] Poor fetal outcomes may occur, especially in cases of severe or first trimester anaemia.[40 3~~7~~ 41 3~~8~~] In our study, anaemia was a risk factor of very preterm birth. ~~, a low 5-min Apgar score and shoulder dystocia.~~

Previous studies carried out in industrialised countries have revealed no excess risks of pre-eclampsia or PIH among adolescents,[9-12 19] whereas higher risks have been reported in developing countries.[14 15 34] Our results are partly contradictory, indicating an increased higher risk of pre-eclampsia among the youngest teenagers. The relatively small number of pregnant mothers aged 13—15 years in our study places some uncertainty on this finding. In two earlier studies, younger and older adolescents were distinguished. A large Latin-American cross-sectional study revealed an increasing rate of pre-eclampsia with descending age, but there was no significant difference in risk after adjustment for confounding factors.[16] A French study revealed a lower risk among teenagers, but the number of very young teenagers was even smaller than in the present study.[11]

Our results confirm findings in earlier studies, showing an elevated risk of eclampsia among pregnant teenagers.[42 39] [43 30] A report by the National Center for Health Statistics in the US showed an increasing trend in frequency with descending age (0.6% in 10—14-year-olds and 0.3% among 25—29-year-olds).[44 41] Because of a smaller number of cases and rarity of the condition, we could not evaluate such a trend. The essential role of prenatal care in the prevention of eclampsia has been previously emphasised,[45 2] although not in studies confined to teenagers. We found a marked 12-fold risk of eclampsia among teenagers with inadequate versus adequate care, highlighting the importance of adequate prenatal care in teenage pregnancies.

We found an increasing risk of proteinuria in pregnancy with descending age. An earlier study on the risk factors of proteinuria during pregnancy revealed a 1.5-fold risk among women below the age of 20.[46 3] Although the outcome of isolated proteinuria is mostly favourable, it is sometimes known to precede pre-eclampsia and even eclampsia[47 4] [48 5] and has been associated with preterm birth.[49 6] Whether or not isolated proteinuria is part of the same disease spectrum as pre-

eclampsia is controversial.[46 50] In our study, proteinuria was found to be a risk factor for as regards pre-eclampsia, but not eclampsia or adverse neonatal outcomes.

Earlier studies on UTI and pyelonephritis in pregnant teenagers are sparse. In two UK studies reported 1.5- to 1.6-fold risks of UTI[10] and pyelonephritis[9] were reported among all teenagers. In contrast, no excess risk was found in a Latin American study in which teenagers were analysed in subgroups by age.[17] Our findings suggest higher risks of both UTI and pyelonephritis, with a trend toward a higher incidence with descending age. However, no cases were found among teenagers of 13–15 years of age, possibly because of the relative rarity of these diagnoses. Only a hypothesis for the reason behind the increased risks has been presented – reduced resistance to infections in pregnant teenagers.[10] We speculate that teenagers might be sexually more active during pregnancy compared with older women, placing them at a higher risk of UTI. In addition, poorer recognition of symptoms of UTI could lead to delayed care and explain the increased risk of pyelonephritis.

UTIs, and pyelonephritis in particular, have been associated with higher risks of adverse neonatal outcomes,[51 52] although they are preventable with early detection and antimicrobial care.[53]

~~Pyelonephritis was a risk factor of IUGR among teenagers, but not adults in our study.~~

Regarding other infections, our results do not support earlier findings of a higher risk of chorioamnionitis among adolescents compared with adult women.[10 12]

We detected ~~Our findings of~~ lower or similar risks of delivery complications and a higher incidence of vaginal deliveries among teenagers, which is ~~are~~ in line with findings in most studies in the developed world.[9-12 19] Contradictory ~~Opposite~~ findings derive ~~come~~ mainly from studies in developing countries.[17 35] The use of pain relief, especially combined anaesthetic analgesia, was

high in all groups and was used even more often in teenagers compared with older women. This is in contrast to the results of a UK study.[9]

Three large retrospective cohort studies carried out in the US and Latin America revealed 1.2- to 2.0-fold risks of preterm birth and 1.1- to 1.5-fold risks of SGA infants among teenagers, with an increasing trend with descending age.[16,17] ~~Only one of these studies showed an increased risk (1.2-fold) of IUGR among adolescents aged 15 years or less compared with older mothers.[17]~~ Elevated (1.5-fold) risks of stillbirth and/or neonatal death were found among the youngest teenagers. However, among older teenagers and after adjustment for gestational age, the risks were either lower or non-significant.[16,17] These findings were largely confirmed in our study, although some differences were seen, possibly as a result of a smaller study population and the lack of socioeconomic status as a confounding factor. In addition, we found an excess risk of preterm birth only among the youngest teenagers. The lack of risk among older teenagers might be explained by the overall high quality and quantity of prenatal care in Finland.

In accordance with the results of several recent studies,[20,18,21,19,5,41] we found higher risks of adverse neonatal outcomes, including an excess risk of neonatal/infant mortality among teenagers with inadequate prenatal care.~~.~~

Unanswered questions and implications

Our results add to existing literature, showing higher risks of various maternal complications among teenagers, often displaying an increasing trend with descending age. An increased risk of proteinuria during pregnancy was found, an outcome not analysed in past studies dealing with teenage pregnancy. Confirmation of this finding and its possible influence on other, more serious obstetric outcomes is required. The effect of prenatal care on maternal outcomes should also be

further analysed in the future. Clinical studies on the mode of delivery and its complications would shed more light on whether or not adolescents have better myometrial function compared with older women or whether the higher incidence of uncomplicated vaginal births is a consequence of other factors, such as more attentive care of adolescents. In addition to immediate obstetric risks, studies on long-term consequences indicate a higher incidence of morbidity and preterm mortality among both teenage mothers and their children,[1 2 4] and these risks should be examined in greater detail in the future.

The present study has practical implications: in addition to prevention and treatment of anaemia and eclampsia, screening and counselling in connection with proteinuria, cystitis and pyelonephritis are important among pregnant adolescents. The higher risk of pre-eclampsia among the youngest teenagers should also be kept in mind. Teenagers in a welfare society are not a risk group as regards delivery complications, and neonatal outcomes are mainly good. However, the younger the expectant mother, the greater are the risks of several maternal and neonatal complications. Adequacy of prenatal care is of great importance in preventing serious adverse obstetric outcomes. Thus, extra efforts should be made to reach all pregnant teenagers and enrol them in adequate maternity care in early pregnancy.

FOOTNOTES

Contributors: OH, MG and SL had the initial research idea and all authors contributed to the design, interpretation and critical revision of data. All authors had full access to the data and take responsibility of the integrity of the data and accuracy of the data analysis. SL carried out the analysis and wrote the drafts of the paper with important intellectual input from all coauthors. All authors have approved the final version of the manuscript submitted for publication. OH and SL act as guarantors.

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Ethical approval: No ethical approval was required for the present study. The organization responsible for the registers (THL National Institute for Health and Welfare) has given approval for the study (Dnro THL/1008/5.05.00/2012).

Data sharing: No additional data available. Researchers can apply for the authorisation for the use of same health register data for scientific research from the register keeping organization (THL National Institute for Health and Welfare).

FIGURE LEGENDS

Figure 1: Frequencies (%) of operative delivery and other delivery outcomes according to age group.

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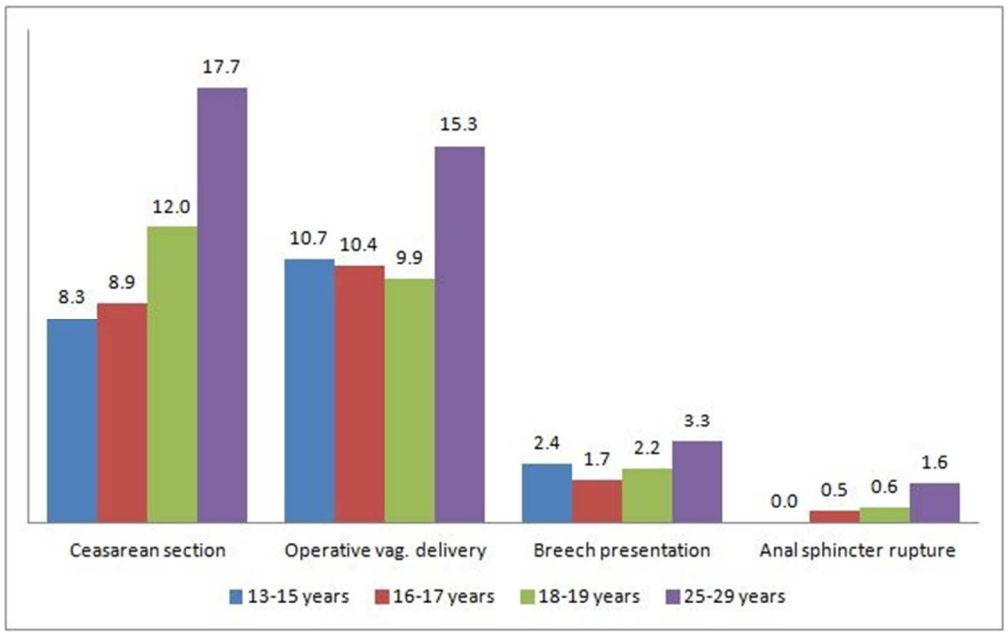

Fig. 1
52x32mm (300 x 300 DPI)

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	1 and 2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2 and 3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5
Objectives	3	State specific objectives, including any prespecified hypotheses	5 and 6
Methods			
Study design	4	Present key elements of study design early in the paper	2, 6 and 7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	6
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	-
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7 and 8
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	7 and 8
Bias	9	Describe any efforts to address potential sources of bias	6, 10 and 11
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7 and 8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	10 and 11
		(*b*) Describe any methods used to examine subgroups and interactions	10
		(*c*) Explain how missing data were addressed	11
		(*d*) If applicable, explain how loss to follow-up was addressed	-
		(*e*) Describe any sensitivity analyses	-
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	6
		(b) Give reasons for non-participation at each stage	6
		(c) Consider use of a flow diagram	-
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9, 11, 12
		(b) Indicate number of participants with missing data for each variable of interest	9 and 19
		(c) Summarise follow-up time (eg, average and total amount)	-
Outcome data	15*	Report numbers of outcome events or summary measures over time	12-17
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	12-17
		(*b*) Report category boundaries when continuous variables were categorized	12, 14, 15, 17, 19
		(*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	18, 19
Discussion			
Key results	18	Summarise key results with reference to study objectives	20
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	22-25
Generalisability	21	Discuss the generalisability (external validity) of the study results	25 and 26
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	27

*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.