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Impact of maternal age on obstetric and neonatal outcome with emphasis on adolescents and older women-a Swedish Medical Birth Register Study.

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Abstract

Objectives: To evaluate the associations between maternal age and obstetric and neonatal outcomes in primiparous women with emphasis on teenagers and older women.

Design: A population-based cohort study.

Setting: The Swedish Medical Birth Register.

Participants: Primiparous women with singleton births from 1992 through 2010 (N=798,674) were divided into seven age groups: <17 years, 17-19 years, and additional five five-year classes. The reference group consisted of the women age 25-29 years.

Primary outcome: Obstetric and neonatal outcome.

Results: The teenager groups had significantly more vaginal deliveries (OR 2.04 (1.79-2.32) and 1.95 (1.88-2.02) for age <17 years and 17–19 years, respectively); fewer caesarean sections (OR 0.57 (0.48-0.67) and 0.55 (0.53-0.58)), and instrumental deliveries (OR 0.43 (0.36-0.52) and 0.50 (0.48-0.53)) compared with women age 25-29. The opposite was found among older women reaching a 4-fold increased risk for caesarean section. The teenagers showed no increased risk of adverse neonatal outcome but presented an increased risk of prematurity <32 weeks (OR 1.66 (1.10-2.51) and 1.20 (1.04-1.38)). Women with advancing age (≥ 30 years) revealed significantly increased risks of prematurity, perineal lacerations, preeclampsia, abruption, placenta previa, postpartum haemorrhage and unfavourable neonatal outcomes compared with women age 25-29.

Conclusions: For clinicians counselling young mothers it is of importance to highlight the obstetrically positive consequences that fewer maternal complications and favourable neonatal outcomes are expected. The average age of primiparous women has increased and women over 30 years seem to be at a higher risk of severe adverse obstetric and neonatal outcome. There is a need to develop surveillance programs in obstetric care customized for older women.

Article summary

Impact of maternal age on obstetric and neonatal outcome with emphasis on adolescents and older women-a Swedish Medical Birth Register Study.

Strengths and limitations of this study:

- A strength of the present study is that it includes primiparous women of an entire country where the antenatal care program is equally available to all pregnant women and is comprehensive.
- Another advantage is the large number of individuals available for evaluation, which makes it possible to divide the study population into subgroups with sufficient numbers in each stratum to provide high statistical power.
- A limitation is that the external validity is reduced to facilities with similar socio-economic and demographic characteristics and health care systems with comparable standards.
- The Swedish medical birth register contain a large body of information concerning the mother and the child but only the available data in the register could be used for outcome evaluation and adjustments for putative confounders.

INTRODUCTION

There are a large number of studies evaluating obstetric and neonatal outcome over the full range of reproductive maternal ages, but especially with a focus on the youngest and the oldest mothers. Young mothers have been shown to be exposed to an increased risk of anaemia, low birth weight, foetal death, eclampsia and preterm birth although they at the same time were more likely to have a spontaneous normal vaginal delivery and the risk of preeclampsia and post-partum haemorrhage were significantly decreased.[1-6] These studies evaluated outcomes in developed countries. Many studies performed in developing countries presented in recent years on the topic of teenage pregnancies have found similar obstetric and neonatal outcomes.[7-11]

Complications during pregnancy and delivery at advanced maternal age (either defined as 35 years and older or 40 years or older) have also been evaluated in developed countries. Advanced maternal age has been found to be associated with gestational diabetes, preeclampsia, placenta previa, caesarean section (CS), placental abruption, preterm delivery, low birth weight, intrauterine foetal death and an increased perinatal mortality.[12-20] The difference in obstetric and neonatal outcomes between teenagers and women at advanced age seemed to be lower risks for several unwanted and threatening outcomes in the teenage group; thus there were no obvious benefits concerning obstetric and neonatal outcomes at advanced maternal ages. The earlier published studies concerning the impact of maternal age on perinatal outcome differ in many aspects methodologically as well as in socio-demographic characteristics of the populations and health care systems. All these factors make interpretation of comparisons between data sets difficult.

Since the 1970 Sweden has actively developed strategies in social care, education and health care in order to counteract the negative consequences of adolescent parenthood and now has one of the lowest incidences of adolescent deliveries worldwide, 5.5/1000.[21] An analysis of perinatal outcomes in relation to maternal age in the Swedish population will provide important knowledge that may be used to further improve social, antenatal, obstetric and neonatal care for teenagers who become parents.

The objective of the present study was to assess the impact of maternal age on obstetric and neonatal outcomes among singleton primiparous women in Sweden, with special emphasis on the adolescents and older mothers.

MATERIALS AND METHODS

This study analyses the obstetric and neonatal outcomes of all singleton primiparous women prospectively registered in the Swedish Medical Birth Register (MBR) who gave births from January 1, 1992 through December 31, 2010. MBR has collected information about deliveries in Sweden since 1973. It is compulsory for every health care provider to report to the MBR. Medical and other data on almost all (99%) deliveries in Sweden are listed in the register, which also includes stillbirths. Starting with the first antenatal visit, usually in gestational week 10-12, the information is collected prospectively in standardized medical record forms completed at the maternity health care centers at antenatal care visits, in the delivery units, and at the paediatric examination of the new-born. The standardized medical records are identical throughout the country. A description and validation of the register content is available.[22-24]

The study population was grouped according to maternal age into seven subgroups: <17 years; 17-19 years; 20-24 years, 25-29 years, 30-34 years; 35-39 years and 40+ years. In the outcome analyses we selected the group of women age 25-29 years as reference group since "the average singleton primiparous woman" with respect to age in the time period of the study fell into this interval (Figure 1).

The list of available variables in MBR has been extended throughout the years that the register has been active. The obstetric and neonatal outcome data for the purpose of this study are those that have been available since 1992. From 1992 until June 2008 the MBR includes stillbirths after 28 weeks of gestation and from July 2008 until 2010 all stillbirths after 22 weeks of gestation are included. Each outcome studied was either marked in the MBR or registered according to the International Statistical Classification of Diseases and Related Health Problems (ICD). The obstetric outcome variables studied were gestational age, mode of delivery, mode of onset of labour, perineal laceration, preeclampsia, abruptio placentae, placenta previa, use of epidural analgesia and postpartum haemorrhage (PPH) exceeding 1000 ml. The foetal and neonatal outcomes evaluated were Apgar-score at 5 minutes, foetal distress (ICD code), aspiration of meconium (ICD code), shoulder dystocia (ICD code), and stillbirth.

Small-for-gestational age (SGA) infants were defined as those with birth weight more than 2 standard deviations (SD) below the mean birth weight for gestational age (sex and parity specific) according to a Swedish reference curve.[25] Large-for-gestational age (LGA) infants were those with a birth weight above 2 SD. All descriptive and background data were extracted from the MBR. The register information on these variables was obtained from the antenatal care center records.

The study was approved by the Regional Ethical Review Board in Linköping, Sweden (Dnr 2011/479-31. Approved January 25; 2012).

Statistical analysis

Data are presented as counts and per cent or mean and one SD. Logistic regression analyses were used for comparison of groups for categorical data. Data on a continuous scale were compared using analysis of covariance (ANCOVA). Multivariate logistic regression models were used in order to adjust comparisons for the confounding factors. Consequently adjusted odds ratios (OR) and 95% confidence intervals (CIs) are reported. Maternal weight and height (used for calculation of maternal Body Mass Index (BMI)) and smoking habits in early pregnancy (unknown, no smoking, smoking) and year of delivery were included as confounders in the adjusted analyses. Gestational age was added to the confounders in the analyses of CS, preeclampsia and birth weight.

The software STATISTICA 64 version 10 (StatSoft Inc. 2300 East 14th St. Tulsa, OK 74104 USA) was used to carry out the statistical analyses.

RESULTS

In the period 1992 – 2010, 798,732 women were registered in the MBR as giving birth to their first child. Information on maternal age was missing in 58 cases leaving 798,674 women for the analyses. The demographic, obstetric and neonatal data subdivided into maternal age groups are presented in Table 1 and 2.

Table 1. Demographic and descriptive obstetric characteristics of primiparous women with singleton births in the period 1992-2010.

	Age groups													
Characteristics	< 17 years (n=2392)		17-19 years (n=29816)		20-24 years (n=185942)		25-29 years (n=300822)		30-34 years (n=205905)		35-39 years (n=63163)		40+ years (n=10634)	
BMI (kg/m^2) †	22.8	3.7	23.2	4.1	23.8	4.3	23.7	4.0	23.8	4.0	24.4	4.1	24.7	4.3
Smoking†	666	27.8%	9012	30.2%	31675	17.0%	24676	8.2%	13971	6.8%	5287	8.4%	958	9.0%
Spontaneous onset labour	2055	85.9%	25853	86.7%	158879	85.4%	251340	83.6%	163876	79.6%	45330	71.2%	6261	58.9%
Induced labour	184	7.7%	2528	8.5%	17433	9.4%	30873	10.3%	25474	12.4%	10065	15.9%	2111	19.9%
Normal vaginal delivery	2030	84.9%	25096	84.2%	147082	79.1%	219993	73.1%	135099	65.6%	35112	55.6%	4724	44.4%
Forceps	7	0.3%	126	0.4%	1143	0.6%	2166	0.7%	1515	0.7%	575	0.9%	84	0.8%
Vacuum extraction	143	6.0%	2090	7.0%	18011	9.7%	36696	12.2%	29811	14.5%	10119	16.0%	1599	15.0%
CS¥	213	8.9%	2500	8.4%	19747	10.6%	42044	14.0%	39534	19.2%	17355	27.5%	4226	39.7%
CS elective 1999-2010 ‡	53	2.2%	373	1.3%	2828	1.5%	6973	2.3%	7656	3.7%	3853	6.1%	1132	10.6%
CS acute 1999-2010 ‡	73	3.1%	882	3.0%	7092	3.8%	16651	5.5%	17953	8.7%	7826	12.4%	1798	16.9%
GA < 28 weeks	20	0.8%	107	0.4%	464	0.2%	743	0.2%	640	0.3%	292	0.5%	73	0.7%
GA < 32 weeks	40	1.7%	308	1.0%	1436	0.8%	2415	0.8%	2048	1.0%	900	1.4%	206	1.9%
GA < 37 weeks	213	8.9%	1937	6.5%	11030	5.9%	18005	5.6%	12727	6.2%	4586	7.3%	877	8,2%
GA 37 – 41 weeks	1990	83.2%	25811	86.6%	161043	86.6%	257320	85.5%	172621	83.8%	51494	81.5%	8786	82.6%
GA ≥ 42 weeks	165	6.9%	1967	6.6%	13627	7.3%	25278	8.4%	20371	9.9%	7018	11.1%	957	9.0%
Epidural analgesia*	903	41.4%	11569	42.4%	68332	41.1%	105266	40.7%	70691	42.5%	20151	44.0%	2743	42.9%
Perineal laceration gr 1-2*	311	14.3%	3982	14.6%	32602	19.6%	70452	27.3%	55163	33.2%	15477	33.9%	2116	33.1%
Perineal laceration gr 3-4*	23	1.1%	272	1.0%	3030	1.8%	8202	3.2%	6846	4.1%	1856	4.1%	222	3.5%
Preeclampsia	43	1.8%	576	1.9%	4317	2.3%	6520	2.2%	4265	2.1%	1610	2.5%	365	3.4%
Abruptio placentae	16	0.7%	135	0.5%	643	0.3%	1171	0.4%	955	0.5%	390	0.6%	87	0.8%
Placenta previa	2	0.1%	16	0.1%	159	0.1%	505	0.2%	612	0.3%	375	0.6%	89	0.8%
Bleeding > 1000 ml (VD)	65	3.0%	667	2.4%	5078	3.1%	10931	4.2%	9720	5.9%	3173	6.9%	485	7.6%
Bleeding > 1000 ml (CS)	2	0.9%	28	1.1%	252	1.3%	541	1.3%	578	1.5%	237	1.4%	80	1.9%

Figures denote means and one standard deviation or counts and proportions.
BMI = body mass index; CS = caesarean section; GA = gestational age at delivery; VD = vaginal delivery
† Reported height, weight and smoking habits at first antenatal visit. ¥All CS independent of status of performance – acute or elective.

*Epidural analgesia and perineal lacerations in vaginal deliveries. †Caesarean section was subdivided into elective and acute CS from 1999.

Table 2: Descriptive neonatal outcome among primiparous women with singleton births in the period 1992-2010.

	Age groups													
Characteristics	< 17 years (n=2392)		17-19 years (n=29816)		20-24 years (n=185942)		25-29 years (n=300822)		30-34 years (n=205905)		35-39 years (n=63163)		40+ years (n=10634)	
Birth weight (gram)	3348	592	3403	565	3453	554	3470	555	3452	572	3415	612	3360	640
Foetal distress	8	0.3%	122	0.4%	932	0.5%	1621	0.5%	1070	0.5%	388	0.6%	56	0.5%
Aspiration of meconium	0	0%	30	0.1%	363	0.2%	649	0.2%	563	0.3%	193	0.3%	42	0.4%
Shoulder dystocia	6	0.3%	78	0.3%	793	0.4%	1580	0.5%	1382	0.7%	489	0.8%	79	0.7%
Stillbirth	7	0.3%	102	0.3%	571	0.3%	893	0.3%	768	0.4%	347	0.5%	87	0.8%
SGA	91	3.8%	1136	3.8%	6016	3.2%	8831	2.9%	7216	3.5%	2962	4.7%	617	5.8%
LGA	47	2.0%	539	1.8%	3838	2.1%	5943	2.0%	3846	1.9%	1279	2.0%	224	2.1%
Apgar score < 7 at 5 minutes	43	1.8%	381	1.3%	2409	1.3%	4158	1.4%	3354	1.6%	1274	2.0%	240	2.3%

Figures denote means and one standard deviation or counts and proportions.
LGA = Large for gestational age; SGA = Small for gestational age

The results of the multivariate analyses models of obstetric and neonatal outcomes are shown in Table 3 and 4, respectively.

Table 3. Mode of delivery and obstetric data among primiparous women with singleton births in the period 1992–2010 in relation to maternal age group. Maternal age 25-29 was set as reference.

	Age groups					
	< 17 years	17-19 years	20-24 years	30 - 34 years	35 - 39 years	40+ years
Characteristics	aOR (95%CI)†	aOR (95%CI)†	aOR (95%CI)†	aOR (95%CI)†	aOR (95%CI)†	aOR (95%CI)†
Spontaneous onset labour	1.20 (1.05-1.37)	1.26 (1.21-1.31)	1.16 (1.14-1.18)	0.78 (0.77-0.79)	0.52 (0.51-0.54)	0.30 (0.28-0.31)
Induced labour	0.78 (0.66-0.93)	0.86 (0.82-0.90)	0.91 (0.90-0.93)	1.19 (1.17-1.21)	1.54 (1.50-1.58)	1.97 (1.87-2.08)
Normal vaginal delivery	2.04 (1.79-2.32)	1.95 (1.88-2.02)	1.39 (1.37-1.41)	0.72 (0.71-0.73)	0.48 (0.47-0.49)	0.31 (0.30-0.32)
Forceps¥	0.41 (0.18-0.92)	0.48 (0.39-0.59)	0.77 (0.71-0.84)	1.20 (1.12-1.29)	1.66 (1.49-1.84)	1.75 (1.37-2.24)
Vacuum extraction¥	0.43 (0.36-0.52)	0.50 (0.48-0.53)	0.74 (0.72-0.75)	1.29 (1.27-1.32)	1.67 (1.63-1.72)	1.92 (1.80-2.04)
CS, all	0.57 (0.48-0.67)	0.55 (0.53-0.58)	0.72 (0.71-0.74)	1.44 (1.42-1.47)	2.21 (2.16-2.26)	3.78 (3.61-3.96)
CS elective 1999-2010 ‡	0.83 (0.60-1.14)	0.53 (0.47-0.60)	0.68 (0.65-0.71)	1.44 (1.39-1.49)	2.25 (2.15-2.35)	3.89 (3.61-4.20)
CS acute 1999-2010 ‡	0.53 (0.40-0.69)	0.56 (0.52-0.61)	0.71 (0.69-0.73)	1.44 (1.40-1.47)	1.94 (1.88-2.00)	2.68 (2.52-2.85)
GA < 28 weeks	2.84 (1.59-5.06)	1.25 (0.97-1.62)	0.89 (0.77-1.02)	1.17 (1.04-1.33)	1.61 (1.40-1.90)	2.48 (1.86-3.29)
GA < 32 weeks	1.66 (1.10-2.51)	1.20 (1.04-1.38)	0.92 (0.85-0.99)	1.24 (1.16-1.33)	1.68 (1.53-1.84)	2.25 (1.90-2.66)
GA < 37 weeks	1.46 (1.24-1.72)	1.03 (0.98-1.09)	0.97 (0.95-1.00)	1.02 (0.99-1.05)	1.19 (1.15-1.24)	1.37 (1.26-1.48)
GA 37 – 41 weeks	0.88 (0.77-0.99)	1.14 (1.09-1.18)	1.12 (1.10-1.14)	0.89 (0.86-0.89)	0.76 (0.74-0.78)	0.83 (0.79-0.88)
GA ≥42 weeks	0.89 (0.75-1.06)	0.79 (0.74-0.83)	0.85 (0.83-0.87)	1.20 (1.18-1.23)	1.35 (1.31-1.39)	1.06 (0.98-1.14)
Epidural analgesia¥	1.03 (0.93-1.13)	1.07 (1.04-1.10)	1.03 (1.01-1.04)	1.03 (1.02-1.05)	1.06 (1.04-1.09)	0.98 (0.93-1.03)
Perineal laceration grade 1-2¥	0.44 (0.38-0.50)	0.47 (0.45-0.49)	0.68 (0.67-0.69)	1.11 (1.10-1.13)	1.08 (1.05-1.10)	1.00 (0.94-1.07)
Perineal laceration grade 3-4¥	0.39 (0.25-0.60)	0.37 (0.32-0.42)	0.61 (0.58-0.64)	1.16 (1.12-1.20)	1.12 (1.05-1.18)	0.88 (0.75-1.02)
Preeclampsia	0.89 (0.62-1.27)	0.93 (0.84-1.02)	1.01 (0.96-1.05)	1.07 (1.03-1.12)	1.30 (1.22-1.39)	1.83 (1.62-2.06)
Abruptio placentae	1.76 (1.03-3.00)	1.02 (0.83-1.26)	0.83 (0.74-0.92)	1.27 (1.16-1.40)	1.71 (1.50-1.94)	2.09 (1.62-2.71)
Placenta praevia	0.57 (0.14-2.30)	0.28 (0.16-0.50)	0.52 (0.43-0.63)	1.74 (1.53-2.00)	3.47 (2.99-4.03)	5.23 (4.08-6.70)
PPH > 1000 ml (VD)	0.65 (0.48-0.88)	0.64 (0.59-0.70)	0.78 (0.75-0.81)	1.27 (1.23-1.31)	1.47 (1.40-1.53)	1.48 (1.26-1.52)
PPH > 1000 ml (CS)	0.52 (0.07-3.74)	1.16 (0.77-1.93)	1.09 (0.93-1.28)	1.04 (0.91-1.18)	0.95 (0.81-1.12)	1.35 (1.05-1.73)

CI = confidence intervals; CS = Caesarean section; GA = gestational age at delivery; N/A = not applicable; aOR = adjusted odds ratio; PPH = postpartum haemorrhage; VD = vaginal delivery.

† Adjusted for maternal BMI and smoking habits at first antenatal care visit and year of delivery. CS and preeclampsia also adjusted for gestational age.

‡ Caesarean section was subdivided into elective and acute CS from 1999.

¥ Forceps, vacuum extraction, epidural analgesia and perineal lacerations among vaginally delivered women.

Table 4. Neonatal outcome data from singleton primiparous women in the period 1992-2010 in relation to maternal age group.

	Age groups					
	< 17 years	17-19 years	20 - 24 years	30 -34 years	35 - 39 years	40+ years
Characteristic	aOR (95%CI) †	aOR (95%CI) †	aOR (95%CI) †	aOR (95%CI) †	aOR (95%CI) †	aOR (95%CI) †
Foetal distress	0.52 (0.22-1.26)	0.63 (0.51-0.79)	0.79 (0.72-0.91)	1.23 (1.13-1.35)	1.51 (1.33-1.72)	1.60 (1.20-2.13)
Aspiration of meconium	N/A	0.46 (0.31-0.70)	0.93 (0.81-1.07)	1.36 (1.20-1.54)	1.48 (1.24-1.77)	1.82 (1.28-2.58)
Shoulder dystocia¥	0.32(0.05-2.29)	0.74 (0.52-1.07)	1.00 (0.86-1.16)	1.13 (0.90-1.41)	1.13 (0.91-1.41)	1.27 (0.76-2.12)
Stillbirth	0.58 (0.19-1.80)	0.97 (0.75-1.25)	0.98 (0.87-1.11)	1.25 (1.12-1.39)	1.72 (1.49-1.99)	2.34 (1.80-3.03)
SGA	1.00 (0.78-1.28)	1.01 (0.94-1.09)	1.00 (0.96-1.04)	1.24 (1.20-1.28)	1.65 (1.58-1.73)	2.06 (1.87-2.26)
LGA	1.08 (0.76-1.53)	1.03 (0.94-1.14)	1.05 (1.00-1.10)	0.94 (0.90-0.98)	0.97 (0.91-1.04)	0.94 (0.81-1.09)
Apgar score < 7 at 5 minutes	1.30 (0.91-1.86)	0.92 (0.81-1.11)	0.93 (0.88-0.98)	1.18 (1.12-1.24)	1.39 (1.29-1.49)	1.51 (1.30-1.75)

Figures denote odds ratios and 95% confidence intervals. Reference group: Maternal age 25-29 years.
LGA = Large for gestational age; N/A = not applicable; aOR = adjusted odds ratio; SGA = Small for gestational age
† Adjusted for maternal BMI and smoking habits at first antenatal care visit and year of delivery
¥ Shoulder dystocia among vaginal delivered women.

The average age of primiparous women increased substantially from 26.2 years in 1992 to 28.5 in 2004; hereafter it has stayed almost constant at that level.

Mode of delivery, obstetric and neonatal outcome of adolescents

Compared with the reference group of women age 25 -29 years the teenagers had a significantly higher likelihood of having spontaneous onset of labour and of having a normal vaginal delivery. Teenagers also demonstrated a significantly higher risk of giving birth prematurely. However, only the group of teenagers younger than 17 years of age had an increased risk of giving birth very prematurely i.e. before 28 weeks of gestational age, and the same group revealed a significantly higher risk of placental abruption. In contrast with these observations the teenagers were delivered instrumentally and by CS significantly less often, and the vaginal deliveries caused significantly fewer perineal lacerations (only evaluated among women who delivered vaginally) and PPH > 1000 ml. Likewise the occurrence of placenta previa was seen less often among teenagers whereas the occurrence of preeclampsia was equal to that seen in adult women age 25-29 years.

Concerning the foetal and neonatal outcomes for adolescents the infants were less likely to show foetal distress and meconium aspiration in spite of a similar occurrence of Apgar score < 7 at 5 minutes. The infants of the adolescents were not more prone to being stillborn or being SGA than the infants of women age 25-29 years. The adjusted mean birth weight of infants of adolescents did not differ significantly from that of women up to 29 years of age (Figure 2).

Mode of delivery, obstetric and neonatal outcome of women 20-24 years of age

The young women, 20 – 24 years of age, differed in some aspects from the reference group (25-29 years) as well as from the adolescents. They were less likely to be delivered prematurely and had a lower frequency of placental abruption. Otherwise the obstetric and neonatal outcomes were similarly favourable as those observed for the adolescents in comparison with the reference group.

Mode of delivery, obstetric and neonatal outcome of women older than 29 years of age

As shown in Table 3 compared with the reference group of women age 25-29 years almost all obstetric outcome variables demonstrated a continuously progressive deterioration with increasing age. The likelihood of normal vaginal deliveries decreased; induced labour, instrumental deliveries and CS increased as well as prematurity including very premature deliveries. The risk of perineal damage increased moderately whereas the risk of PPH > 1000 ml in vaginal deliveries was more pronounced. The likelihood of the pregnancy complications preeclampsia, abruptio placenta and placenta previa was also higher in the older age groups and progressed substantially with increasing age. Similarly, the foetal and neonatal outcome was adversely progressively influenced by increasing maternal age. With increasing maternal age over 30 years significantly more neonates were SGA, showed foetal distress, had Apgar score < 7 at 5 minutes or meconium aspiration, or were stillborn. The mean birth weight of the neonates also decreased significantly with increasing maternal age after the age of 30 (Figure 1).

DISCUSSION

This Swedish nation-wide population-based study with prospectively collected data concerning singleton primiparous women showed that the mode of delivery differed over the maternal age strata. Significantly more normal vaginal deliveries and fewer CS and instrumental vaginal deliveries were seen among the teenagers and among women aged 20-24 compared with women aged 25-29. The opposite was found among older women reaching a 4-fold increased risk for CS compared with women aged 20-24. The teenagers as well as women aged 20-24 were less prone to perineal lacerations and PPH exceeding 1000 ml. Prematurity (< 28 weeks of GA) was associated with very low maternal age (<17 years) among the adolescents although the increased risk was at the same level as among women aged 40 years and above, indicating a u-shaped risk curve. Adolescents were not afflicted more by preeclampsia than women aged 25-29 whereas the risk of preeclampsia increased significantly with advancing maternal age. The risk of placentae praevia increased dramatically with maternal age, actually a 500% increased risk was found after the age of 40 compared with women of 25-29 years of age. Stillbirth, SGA and low Apgar score were exclusively associated with advancing age over 30 years.

The strength of this study is that it deals with the outcomes in the population of an entire country where the antenatal care program is equally available to all pregnant women and is comprehensive. In Sweden pregnant women have completely cost free access to antenatal and obstetric facilities; poverty and malnutrition are practically non-existent and the vast majority of women attends the antenatal care program (99%) independent of socio-economic status and is delivered in obstetric units.[26] This context is valid for the whole study period. Another advantage is the large number of individuals available for evaluation, which makes it possible to divide the study population into subgroups with sufficient numbers in each stratum to provide high statistical power. A sufficient number of study subjects made it possible to evaluate three subgroups of young maternal age. Only primiparous women were included in order to avoid the confounding effects of factors associated with subsequent

deliveries. There are some limitations that should be considered. The external validity is reduced to facilities with similar socio-economic and demographic characteristics and health care systems with comparable standards. The drawback is obvious given the large size of the study and the numbers of health care units involved that the criteria for diagnosis (ICD codes) to define outcomes may not be uniform across the study population but the variation is most likely not related to maternal age. The MBR contain a large body of information concerning the mother and the child which made it possible to adjust the results for confounding factors. At the same time this is a limitation as only the data available in the register could be used for adjustments. We were not able to adjust for some putative confounders such as ethnicity, socio-economic status and medical conditions such as anemia in pregnancy. These factors may theoretically influence the outcomes.

The most prominent difference between finding in the present study and earlier studies [8,9] is that no increased risk for SGA was found among adolescents and young mothers 20-24 years of age compared with women age 25-29.[8-9] It must be kept in mind that the definition of SGA may differ between countries. In the United States and Latin America SGA is usually defined as birth weight below the 10th percentile compared with two SD in the Nordic countries.[3, 9] Adjusted risks for SGA among teenagers, recently presented from Finland, one of the Nordic countries, showed no increased risk among the youngest mothers.[6] In that study the control group was defined in the same way as in the present study. Differences concerning the risk for SGA could also be attributable to differences in socio-economic status. Chen et al. restricted their analysis to white married mothers with age-appropriate education level, adequate prenatal care, without smoking and alcohol use during pregnancy but found the increased risk for SGA to persist.[3] Several studies have shown low infant birth weight for adolescents as well as for mothers with advancing age.[18, 14, 27, 28] We failed to find such association among the adolescents, but in women with advancing age the difference in birth weight was statistically significant although the difference lacked clinical significance.

The finding of a preferable delivery outcome with lower CS rates and lower rates of instrumental delivery among teenagers compared with older women has been pinpointed to a lesser extent than observed adverse outcomes. Earlier studies have shown relatively consistent results concerning a decreased rate of CS in the adolescent group and a higher rate in women with advancing age.[6, 8, 9, 12-18] We were able to evaluate elective and emergency CS separately and the risks among teenagers and mothers age 20-24 years were decreased for both types. This might indicate that the different risks concerning CS among young and old mothers could not exclusively be explained by more CS on maternal request among older mothers but may even be caused by biological factors. A low rate of instrumental deliveries and CS among adolescents and high rate among older women has almost unanimously been shown in several reports from developed as well as developing countries.[5, 7, 12-18, 27-30] Whether this phenomenon depends on differences in handling the delivery, inherent or cultural behavioural, domestic or social attitudes among delivery staff or biological factors has not been investigated. It has previously been suggested that the biological factors could make the uterus and the genital tract of young women more favourable for accomplishing a normal delivery.[31] Advancing age is associated with endothelial dysfunction which theoretically may lead to impaired uterine, utero-placental and vascular function.[32] The fact that adolescents in our study had a lower risk of induction of labour, perineal damage, PPH, abruption (except for the very young women) and placenta previa and women with advancing age had higher risks of all these outcomes including preeclampsia could support a biological explanation. Concerning prematurity the age related risk curve was U shaped. This may also support a biological aetiology; immaturity of the uterus in the very young women that obstruct development of a term pregnancy and uterine dysfunction caused by ageing processes in women with advancing age and consequently deliver prematurely in both situations. The foetal and neonatal outcomes followed almost the same pattern, foetal distress, meconium aspiration, stillbirth, SGA and low Apgar score were exclusively attributed to women older than 29.

In conclusion, in a country with a highly developed social and antenatal maternity health care security system giving cost free maternity and obstetric care to all pregnant women adolescents had a decreased risks for adverse obstetric and neonatal outcome compared with women aged 25-29. In the same social context childbirth at advanced maternal age was associated with a number of serious complications for both the mother and the child. For clinicians counselling young mothers it is of great importance to highlight the positive consequences that less obstetric complications and favorable neonatal outcomes are expected. There is also a need for more information about the consequences of childbearing at advanced maternal age and to develop surveillance programs in antenatal and obstetric care customized for older women.

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Contribution of authorship: The study was planned and conducted by PK, MB and RBT, Data was analysed by all three. All authors contributed to the interpretation of the results, the elaboration of the manuscript and approval of the final version.

Checklist: The manuscript conforms to the STROBE requirement.

Data sharing statement: Technical appendix, statistical code, and dataset available from the corresponding author at Dryad repository, who will provide a permanent, citable and open access home for the dataset.

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LEGENDS

Figure 1. Adjusted mean birth weight of neonates in singleton primiparous women in different maternal age groups. Birth weight adjusted for gestational age, maternal BMI and smoking habits, and year of delivery. Plots indicate means and bars 95% CI.

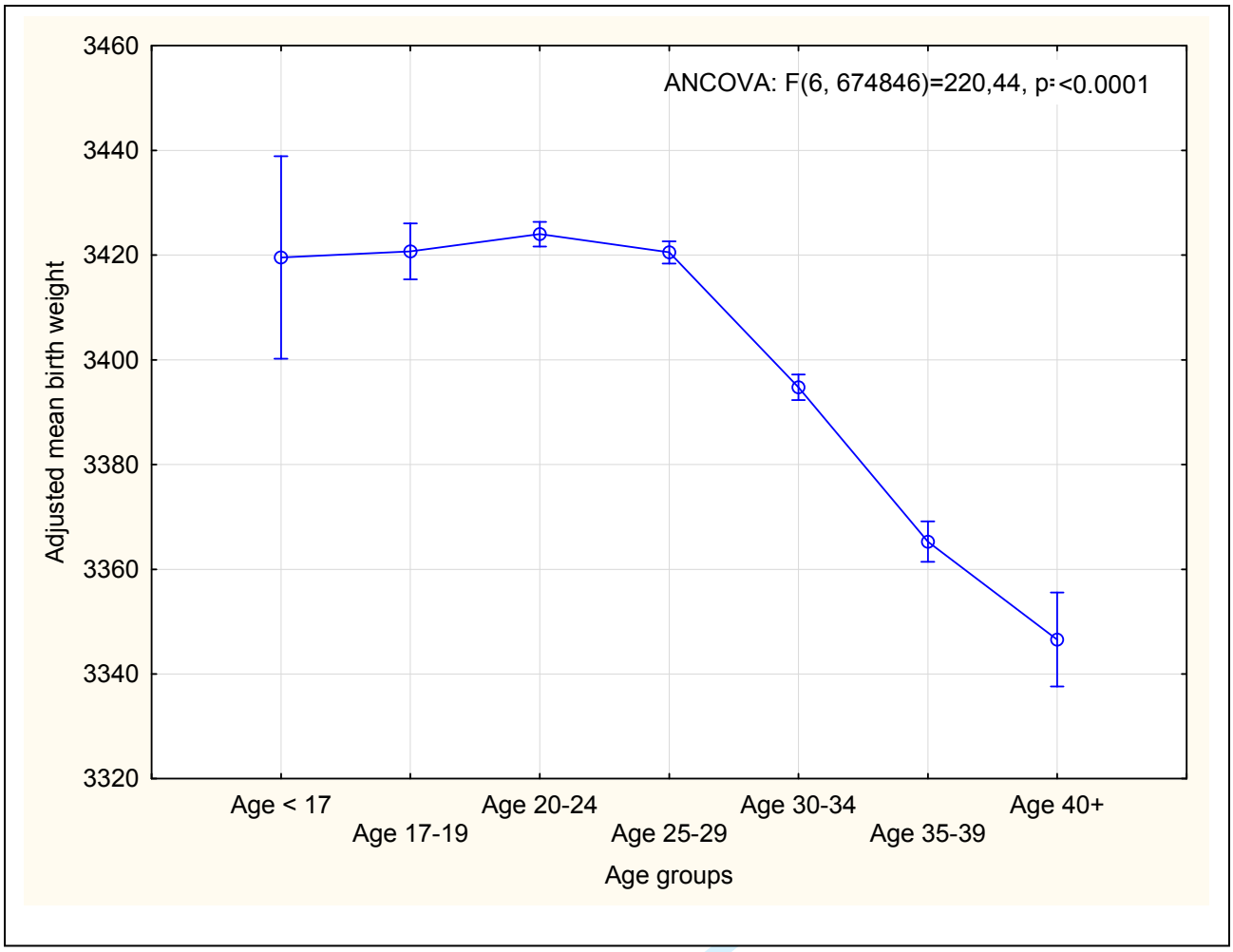

Figure 1.

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract.Done
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found Done
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported. Done
Objectives	3	State specific objectives, including any prespecified hypotheses. Done
Methods		
Study design	4	Present key elements of study design early in the paper.Done
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection. Done
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up. Done *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable. Done
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.Done
Bias	9	Describe any efforts to address potential sources of bias. Done
Study size	10	Explain how the study size was arrived at. All primiparous were included.
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why. Done
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding. Done
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed. Done
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed. Done *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses

Continued on next page

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. Done
		(b) Give reasons for non-participation at each stage
		(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. Tables.
		(b) Indicate number of participants with missing data for each variable of interest
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount). Done
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time. Done
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures
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. Done only Adjusted Ors are given.
		(*b*) Report category boundaries when continuous variables were categorized. Done
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period. Done.
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	18	Summarise key results with reference to study objectives. Done
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias. done
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence. Done
Generalisability	21	Discuss the generalisability (external validity) of the study results. Done
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. Done

*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.

BMJ Open

Impact of maternal age on obstetric and neonatal outcome with emphasis on primiparous adolescents and older women-a Swedish Medical Birth Register Study.

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Secondary Subject Heading:	Epidemiology
Keywords:	maternal age, obstetric outcome, neonatal outcome

Impact of maternal age on obstetric and neonatal outcome with emphasis on primiparous adolescents and older women-a Swedish Medical Birth Register Study.

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Keywords: maternal age, mode of delivery, neonatal outcome, obstetric outcome, adolescents

Word count: 3201 words

Abstract

Objectives: To evaluate the associations between maternal age and obstetric and neonatal outcomes in primiparous women with emphasis on teenagers and older women.

Design: A population-based cohort study.

Setting: The Swedish Medical Birth Register.

Participants: Primiparous women with singleton births from 1992 through 2010 (N=798,674) were divided into seven age groups: <17 years, 17-19 years, and additional five five-year classes. The reference group consisted of the women age 25-29 years.

Primary outcome: Obstetric and neonatal outcome.

Results: The teenager groups had significantly more vaginal births (OR 2.04 (1.79-2.32) and 1.95 (1.88-2.02) for age <17 years and 17–19 years, respectively); fewer caesarean sections (OR 0.57 (0.48-0.67) and 0.55 (0.53-0.58)), and instrumental vaginal births (OR 0.43 (0.36-0.52) and 0.50 (0.48-0.53)) compared with the reference group. The opposite was found among older women reaching a 4-fold increased risk for caesarean section. The teenagers showed no increased risk of adverse neonatal outcome but presented an increased risk of prematurity <32 weeks (OR 1.66 (1.10-2.51) and 1.20 (1.04-1.38)). Women with advancing age (≥ 30 years) revealed significantly increased risk of prematurity, perineal lacerations, preeclampsia, abruption, placenta previa, postpartum haemorrhage and unfavourable neonatal outcomes compared with the reference group.

Conclusions: For clinicians counselling young women it is of importance to highlight the obstetrically positive consequences that fewer maternal complications and favourable neonatal outcomes are expected. There is also a need to develop surveillance programs in antenatal and obstetric care for older women aiming for example to detect preeclampsia earlier or recommending prophylactic uterotonic treatment after birth to avoid extensive postpartum bleeding. Such interventions need to be evaluated in further studies.

Article summary

Impact of maternal age on obstetric and neonatal outcome with emphasis on primiparous adolescents and older women-a Swedish Medical Birth Register Study.

Strengths and limitations of this study:

- A strength of the present study is that it includes primiparous women of an entire country where the antenatal care program is equally available to all pregnant women and is comprehensive.
- Another advantage is the large number of individuals available for evaluation, which makes it possible to divide the study population into subgroups with sufficient numbers in each stratum to provide high statistical power.
- A limitation is that the external validity is reduced to facilities with similar socio-economic and demographic characteristics and health care systems with comparable standards.
- The Swedish medical birth register contain a large body of information concerning the mother and the child but only the available data in the register could be used for outcome evaluation and adjustments for putative confounders.

INTRODUCTION

There are a large number of studies evaluating obstetric and neonatal outcome over the full range of reproductive maternal ages, but especially with a focus on the youngest and the oldest mothers. Young mothers have been shown to be exposed to an increased risk of anaemia, low birth weight, foetal death, eclampsia and preterm birth although they at the same time were more likely to have a spontaneous normal vaginal birth and the risk of preeclampsia and post-partum haemorrhage were significantly decreased.[1-6] These studies evaluated outcomes in low-income countries. Many studies performed in low-income countries presented in recent years on the topic of teenage pregnancies have found similar obstetric and neonatal outcomes.[7-11]

Complications during pregnancy and birth at advanced maternal age (either defined as 35 years and older or 40 years or older) have also been evaluated in high-income countries. Advanced maternal age at birth has been found to be associated with gestational diabetes, preeclampsia, placenta previa, caesarean section (CS), placental abruption, preterm delivery, low birth weight, intrauterine foetal death and an increased perinatal mortality.[12-20] The difference in obstetric and neonatal outcomes between teenagers and women at advanced age seemed to be lower risks for several unwanted and threatening outcomes in the teenage group; thus there were no obvious advantages concerning obstetric and neonatal outcomes at advanced maternal ages. The earlier published studies concerning the impact of maternal age on perinatal outcome differ in many aspects methodologically as well as in the socio-demographic characteristics of the populations and health care systems. All these factors make interpretation of comparisons between data sets difficult.

Sweden has during several decades actively developed strategies in social care, education and health care in order to improve antenatal care and parenthood. In a Swedish state-of-the-art conference held in 1990, the scientific basis of the routine antenatal program was critically evaluated. It was concluded that the scientific evidence to support the timing and contents of routine visits was unsatisfactory.[21] Consequently there is a constant need for evaluation both of single diagnostic procedures and

intervention and of outcomes. An analysis of perinatal outcomes in relation to maternal age in the Swedish population will provide important knowledge that may be used to further improve social, antenatal, obstetric and neonatal care and reveals risk groups that in particular may need more attention in the antenatal care.

The objective of the present study was to assess the impact of maternal age on obstetric and neonatal outcomes among singleton primiparous women in Sweden, with special emphasis on the adolescents and older mothers.

MATERIALS AND METHODS

This study analyses the obstetric and neonatal outcomes of all singleton primiparous women prospectively registered in the Swedish Medical Birth Register (MBR) who gave births from January 1, 1992 through December 31, 2010. MBR has collected information about births in Sweden since 1973. It is compulsory for every health care provider to report to the MBR. Medical and other data on almost all (99%) births in Sweden are listed in the register, which also includes stillbirths. Starting with the first antenatal visit, usually in gestational week 10-12, the information is collected prospectively in standardized medical record forms completed at the maternity health care centers at antenatal care visits, in the birth units, and at the paediatric examination of the newborn. The standardized medical records are identical throughout the country. A description and validation of the register content is available.[22-24]

The study population was grouped according to maternal age into seven subgroups: <17 years; 17-19 years; 20-24 years, 25-29 years, 30-34 years; 35-39 years and 40+ years. In the outcome analyses we selected the group of women age 25-29 years as reference group.

The list of available variables in MBR has been extended throughout the years that the register has been active. The obstetric and neonatal outcome data for the purpose of this study are those that have been available since 1992. From 1992 until June 2008 the MBR includes stillbirths after 28 weeks of gestation and from July 2008 until 2010 all stillbirths after 22 weeks of gestation are included. Each outcome studied was either marked in the MBR or registered according to the International Statistical Classification of Diseases and Related Health Problems (ICD). The obstetric outcome variables studied were gestational age, mode of delivery; normal vaginal birth (defined as neither instrumental vaginal delivery, nor CS), CS, instrumental vaginal delivery divided into forceps and vacuum extraction, mode of onset of labour, perineal laceration, preeclampsia, abruptio placentae, placenta previa, use of epidural analgesia and postpartum haemorrhage (PPH) exceeding 1000 ml. The foetal and neonatal outcomes evaluated were Apgar-score at 5 minutes, foetal distress (ICD code P20.0, P20.1 and P20.9),

aspiration of meconium (ICD code P24.0), shoulder dystocia (ICD code O66.0), and stillbirth. Small-for-gestational age (SGA) newborns were defined as those with birth weight more than 2 standard deviations (SD) below the mean birth weight for gestational age (sex and parity specific) according to a Swedish reference curve.[25] Large-for-gestational age (LGA) newborns were those with a birth weight above 2 SD. All descriptive and background data were extracted from the MBR. The register information on these variables was obtained from the antenatal care center records.

The study was approved by the Regional Ethical Review Board in Linköping, Sweden (Dnr 2011/479-31. Approved January 25; 2012).

Statistical analysis

Data are presented as counts and per cent or mean and one SD. Logistic regression analyses were used for comparison of groups for categorical data. Data on a continuous scale were compared using analysis of covariance (ANCOVA). Multivariate logistic regression models were used in order to adjust comparisons for the confounding factors. Consequently crude and adjusted odds ratios (OR and aOR) and 95% confidence intervals (CIs) are reported. Maternal weight and height (used for calculation of maternal Body Mass Index (BMI)) and smoking habits in early pregnancy (unknown, no smoking, smoking) and year of birth were included as confounders in the adjusted analyses. Gestational age was added to the confounders in the analyses of CS, preeclampsia and birth weight.

The OR for instrumental vaginal delivery was calculated among women with vaginal births only in order to exclude women with an instrumental attempt to deliver followed by an emergency CS. The ORs of perineal lacerations were also estimated among women with vaginal births only. The information concerning use of epidural analgesia was also restricted to vaginal births only. Epidural is an analgesic method that has been widely used in the delivery wards for vaginal births during the entire time period. In contrast the use of epidural analgesia in CS has varied substantially over the time period and has almost exclusively been used in elective CS. Our purpose was to evaluate the odds ratio for

epidural use over the maternal age strata and consequently we selected the mode of delivery that exhibited the least variation in the use of the analgesic method over the time period, i.e. vaginal births. The software STATISTICA 64 version 10 (StatSoft Inc. 2300 East 14th St. Tulsa, OK 74104 USA) was used to carry out the statistical analyses.

RESULTS

In the period 1992 – 2010, 798,732 women were registered in the MBR as giving birth to their first child. The annual number of primiparous women giving birth varied between 34060 and 49417. Information on maternal age was missing in 58 cases leaving 798,674 women for the analyses. The average age of primiparous women increased substantially from 26.2 years in 1992 to 28.5 in 2004; hereafter it has stayed almost constant at that level. The demographic, obstetric and neonatal data subdivided into maternal age groups are presented in Table 1 and 2.

Table 1. Descriptive data of primiparous women with singleton births in the period 1992-2010.

Characteristics	< 17 years (n=2392)		17-19 years (n=29816)		20-24 years (n=185942)		25-29 years (n=300822)		30-34 years (n=205905)		35-39 years (n=63163)		40+ years (n=10634)	
BMI† class														
<18.5 kg/m²	135	5.6%	1815	6.1%	7650	4.1%	7509	2.5%	3847	1.9%	918	1.5%	133	1.3%
18.5-24.9 kg/m²	1352	56.5%	16823	56.4%	104600	56.3%	180163	59.9%	122571	59.5%	34439	54.5%	5381	50.1%
25.0-29.9 kg/m²	315	13.2%	4687	15.7%	33961	18.3%	53896	17.9%	37234	18.1%	13310	21.1%	2442	23.0%
30.0-34-9 kg/m²	81	3.4%	1327	4.5%	10550	5.7%	14401	4.8%	9389	4.6%	3575	5.7%	683	6.4%
35.0-39.9 kg/m²	11	0.5%	337	1.1%	3013	1.6%	4070	1.4%	2724	1.3%	1024	1.6%	188	1.8%
≥ 40.0 kg/m²	4	0.2%	87	0.3%	904	0.5%	1312	0.4%	944	0.5%	342	0.5%	68	0.6%
Missing data	494	20.7%	4740	15.9%	25264	13.6%	39471	13.1%	29196	14.2%	9555	15.1%	1739	16.4%
Smoking†														
Yes	666	27.8%	9012	30.2%	31675	17.0%	24676	8.2%	13971	6.8%	5287	8.4%	958	9.0%
No	1542	64.5%	19154	64.3%	145695	78.4%	261348	86.9%	178792	86.8%	53416	84.6%	8883	83.5%
Missing data	184	7.7%	1650	5.5%	8572	4.6%	14798	4.9%	13142	6.4%	4460	7.0%	793	7.5%
Gestational age														
Information available	2368	99.0%	29715	99.7%	185700	99.9%	300603	99.9%	205719	99.9%	63098	99.9%	10620	99.9%
Missing data	24	1.0%	101	0.3%	242	0.1%	219	0.1%	186	0.1%	65	0.1%	14	0.1%

Figures denote counts and proportions.
BMI = body mass index.
† Reported height, weight and smoking habits at first antenatal visit.

Table 2. Obstetric and neonatal outcome characteristics of primiparous women with singleton births in the period 1992-2010.

	Age groups													
Characteristics	< 17 years (n=2392)		17-19 years (n=29816)		20-24 years (n=185942)		25-29 years (n=300822)		30-34 years (n=205905)		35-39 years (n=63163)		40+ years (n=10634)	
Labour:														
Spontaneous onset labour	2055	85.9%	25853	86.7%	158879	85.4%	251340	83.6%	163876	79.6%	45330	71.2%	6261	58.9%
Induced labour	184	7.7%	2528	8.5%	17433	9.4%	30873	10.3%	25474	12.4%	10065	15.9%	2111	19.9%
Mode of delivery:														
Normal vaginal birth	2030	84.9%	25096	84.2%	147082	79.1%	219993	73.1%	135099	65.6%	35112	55.6%	4724	44.4%
Forceps	7	0.3%	126	0.4%	1143	0.6%	2166	0.7%	1515	0.7%	575	0.9%	84	0.8%
Vacuum extraction	143	6.0%	2090	7.0%	18011	9.7%	36696	12.2%	29811	14.5%	10119	16.0%	1599	15.0%
CS¥	213	8.9%	2500	8.4%	19747	10.6%	42044	14.0%	39534	19.2%	17355	27.5%	4226	39.7%
CS elective 1999-2010 ‡	53	2.2%	373	1.3%	2828	1.5%	6973	2.3%	7656	3.7%	3853	6.1%	1132	10.6%
CS acute 1999-2010 ‡	73	3.1%	882	3.0%	7092	3.8%	16651	5.5%	17953	8.7%	7826	12.4%	1798	16.9%
Gestational age:														
GA < 28 weeks	20	0.8%	107	0.4%	464	0.2%	743	0.2%	640	0.3%	292	0.5%	73	0.7%
GA < 32 weeks	40	1.7%	308	1.0%	1436	0.8%	2415	0.8%	2048	1.0%	900	1.4%	206	1.9%
GA < 37 weeks	213	8.9%	1937	6.5%	11030	5.9%	18005	5.6%	12727	6.2%	4586	7.3%	877	8.2%
GA 37 – 41 weeks	1990	83.2%	25811	86.6%	161043	86.6%	257320	85.5%	172621	83.8%	51494	81.5%	8786	82.6%
GA ≥ 42 weeks	165	6.9%	1967	6.6%	13627	7.3%	25278	8.4%	20371	9.9%	7018	11.1%	957	9.0%
Maternal complications and use of epidural analgesia:														
Perineal laceration gr 1-2*	311	14.3%	3982	14.6%	32602	19.6%	70452	27.3%	55163	33.2%	15477	33.9%	2116	33.1%
Perineal laceration gr 3-4*	23	1.1%	272	1.0%	3030	1.8%	8202	3.2%	6846	4.1%	1856	4.1%	222	3.5%
Preeclampsia	43	1.8%	576	1.9%	4317	2.3%	6520	2.2%	4265	2.1%	1610	2.5%	365	3.4%
Abruptio placentae	16	0.7%	135	0.5%	643	0.3%	1171	0.4%	955	0.5%	390	0.6%	87	0.8%
Placenta previa	2	0.1%	16	0.1%	159	0.1%	505	0.2%	612	0.3%	375	0.6%	89	0.8%
PPH > 1000 ml (VB)	65	3.0%	667	2.4%	5078	3.1%	10931	4.2%	9720	5.9%	3173	6.9%	485	7.6%
PPH > 1000 ml (CS)	2	0.9%	28	1.1%	252	1.3%	541	1.3%	578	1.5%	237	1.4%	80	1.9%
Epidural analgesia*	903	41.4%	11569	42.4%	68332	41.1%	105266	40.7%	70691	42.5%	20151	44.0%	2743	42.9%

Table 2 continued. Obstetric and neonatal outcome characteristics of primiparous women with singleton births in the period 1992-2010.

	Age groups													
Characteristics	< 17 years (n=2392)		17-19 years (n=29816)		20-24 years (n=185942)		25-29 years (n=300822)		30-34 years (n=205905)		35-39 years (n=63163)		40+ years (n=10634)	
Neonatal														
Foetal distress	8	0.3%	122	0.4%	932	0.5%	1621	0.5%	1070	0.5%	388	0.6%	56	0.5%
Aspiration of meconium	0	0%	30	0.1%	363	0.2%	649	0.2%	563	0.3%	193	0.3%	42	0.4%
Shoulder dystocia	6	0.3%	78	0.3%	793	0.4%	1580	0.5%	1382	0.7%	489	0.8%	79	0.7%
Stillbirth	7	0.3%	102	0.3%	571	0.3%	893	0.3%	768	0.4%	347	0.5%	87	0.8%
SGA	91	3.8%	1136	3.8%	6016	3.2%	8831	2.9%	7216	3.5%	2962	4.7%	617	5.8%
LGA	47	2.0%	539	1.8%	3838	2.1%	5943	2.0%	3846	1.9%	1279	2.0%	224	2.1%
Apgar score < 7 at 5	43	1.8%	381	1.3%	2409	1.3%	4158	1.4%	3354	1.6%	1274	2.0%	240	2.3%
Birth weight (gram)	3348	592	3403	565	3453	554	3470	555	3452	572	3415	612	3360	640

Figures denote counts and proportions or mean and one standard deviation.

BMI = body mass index; CS = caesarean section; GA = gestational age at birth; LGA = large for gestational age; PPH = postpartum haemorrhage; SGA = small for gestational age; VB = vaginal birth

[¥]All CS independent of status of performance – acute or elective. [†]Caesarean section was subdivided into elective and acute CS from 1999.

*Epidural analgesia and perineal lacerations in vaginal births only.

The crude odds rates and the results of the multivariate analyses models of obstetric and neonatal outcomes are shown in Table 3 and 4, respectively.

Table 3. Obstetric outcome data in singleton primiparous women in the period 1992-2010 in relation to maternal age group.

Characteristics	Crude OR (95%CI)	aOR (95%CI)†	Crude OR (95%CI)	aOR (95%CI)†	Crude OR (95%CI)	aOR (95%CI)†
Labour	< 17 years		17-19 years		20-24 years	
Spontaneous onset labour	1.20 (1.07-1.35)	1.20 (1.05-1.37)	1.28 (1.24-1.33)	1.26 (1.21-1.31)	1.16 (1.14-1.17)	1.16 (1.14-1.18)
Induced labour	0.73 (0.63-0.85)	0.78 (0.66-0.93)	0.81 (0.78-0.85)	0.86 (0.82-0.90)	0.90 (0.89-0.92)	0.91 (0.90-0.93)
	30 - 34 years		35 - 39 years		40+ years	
Spontaneous onset labour	0.77 (0.76-0.78)	0.78 (0.77-0.79)	0.50 (0.49-0.51)	0.52 (0.51-0.54)	0.29 (0.26-0.30)	0.30 (0.28-0.31)
Induced labour	1.23 (1.21-1.26)	1.19 (1.17-1.21)	1.66 (1.62-1.70)	1.54 (1.50-1.58)	2.17 (2.06-2.27)	1.97 (1.87-2.08)
Mode of delivery	< 17 years		17-19 years		20-24 years	
Normal vaginal birth	2.05 (1.84-2.30)	2.04 (1.79-2.32)	1.95 (1.89-2.02)	1.95 (1.88-2.02)	1.39 (1.37-1.41)	1.39 (1.37-1.41)
Forceps¥	0.38 (0.18-0.81)	0.41 (0.18-0.92)	0.55 (0.46-0.64)	0.48 (0.39-0.59)	0.82 (0.76-0.88)	0.77 (0.71-0.84)
Vacuum extraction¥	0.42 (0.36-0.51)	0.43 (0.36-0.52)	0.50 (0.48-0.53)	0.50 (0.48-0.53)	0.74 (0.72-0.75)	0.74 (0.72-0.75)
CS. all	0.60 (0.52-0.69)	0.57 (0.48-0.67)	0.56 (0.54-0.69)	0.55 (0.53-0.58)	0.73 (0.72-0.74)	0.72 (0.71-0.74)
CS elective 1999-2010 ‡	0.95 (0.73-1.25)	0.83 (0.60-1.14)	0.53 (0.48-0.59)	0.53 (0.47-0.60)	0.65 (0.62-0.68)	0.68 (0.65-0.71)
CS acute 1999-2010 ‡	0.54 (0.43-0.68)	0.53 (0.40-0.69)	0.52 (0.49-0.56)	0.56 (0.52-0.61)	0.68 (0.66-0.70)	0.71 (0.69-0.73)
	30 - 34 years		35 - 39 years		40+ years	
Normal vaginal delivery	0.70 (0.69-0.71)	0.72 (0.71-0.73)	0.46 (0.45-0.47)	0.48 (0.47-0.49)	0.29 (0.28-0.31)	0.31 (0.30-0.32)
Forceps¥	1.08 (1.01-1.15)	1.20 (1.12-1.29)	1.48 (1.35-1.63)	1.66 (1.49-1.84)	1.58 (1.27-1.98)	1.75 (1.37-2.24)
Vacuum extraction¥	1.32 (1.30-1.34)	1.29 (1.27-1.32)	1.72 (1.67-1.76)	1.67 (1.63-1.72)	2.01 (1.90-2.13)	1.92 (1.80-2.04)
CS. all	1.46 (1.44-1.49)	1.44 (1.42-1.47)	2.34 (2.29-2.38)	2.21 (2.16-2.26)	4.07 (3.91-4.23)	3.78 (3.61-3.96)
CS elective 1999-2010 ‡	1.63 (1.57-1.68)	1.44 (1.39-1.49)	2.74 (2.63-2.85)	2.25 (2.15-2.35)	5.03 (4.70-5.36)	3.89 (3.61-4.20)
CS acute 1999-2010 ‡	1.63 (1.59-1.67)	1.44 (1.40-1.47)	2.41 (2.35-2.48)	1.94 (1.88-2.00)	3.47 (3.29-3.66)	2.68 (2.52-2.85)
Gestational age	< 17 years		17-19 years		20-24 years	
GA < 28 weeks	3,44 (2.20-5.37)	2.84 (1.59-5.06)	1.46 (1.19-1.79)	1.25 (0.97-1.62)	1.01 (0.90-1.14)	0.89 (0.77-1.02)
GA < 32 weeks	2.12 (1.55-2.91)	1.66 (1.10-2.51)	1.29 (1.15-1.46)	1.20 (1.04-1.38)	0.96 (0.90-1.03)	0.92 (0.85-0.99)
GA < 37 weeks	1.55 (1.34-1.79)	1.46 (1.24-1.72)	1.09 (1.04-1.15)	1.03 (0.98-1.09)	0.99 (0.97-1.02)	0.97 (0.95-1.00)
GA 37 – 41 weeks	0.89 (0.79-0.99)	0.88 (0.77-0.99)	1.11 (1.07-1.15)	1.14 (1.09-1.18)	1.10 (2.08-1.12)	1.12 (1.10-1.14)
GA ≥ 42 weeks	0.82 (0.70-0.96)	0.89 (0.75-1.06)	0.77 (0.74-0.81)	0.79 (0.74-0.83)	0.86 (0.84-0.88)	0.85 (0.83-0.87)
	30 - 34 years		35 - 39 years		40+ years	
GA < 28 weeks	1.26 (1.13-1.40)	1.17 (1.04-1.33)	1.88 (1.64-2.15)	1.61 (1.40-1.90)	2.79 (2.19-3.56)	2.48 (1.86-3.29)
GA < 32 weeks	1.24 (1-17-1.32)	1.24 (1.16-1.33)	1.79 (1.65-1.93)	1.68 (1.53-1.84)	2.44 (2.12-2.82)	2.25 (1.90-2.66)
GA < 37 weeks	1.04 (1.01-1.06)	1.02 (0.99-1.05)	1.23 (1-19-1.27)	1.19 (1.15-1.24)	1.41 (1.32-1.52)	1.37 (1.26-1.48)
GA 37 – 41 weeks	0.88 (0.86-0.89)	0.89 (0.86-0.89)	0.75 (0.73-0.76)	0.76 (0.74-0.78)	0.81 (0.77-0.85)	0.83 (0.79-0.88)
GA ≥ 42 weeks	1.20 (1.17-1.22)	1.20 (1.18-1.23)	1.36 (1.33-1.40)	1.35 (1.31-1.39)	1.08 (1.01-1.15)	1.06 (0.98-1.14)

Table 3 continued. Obstetric outcome data in singleton primiparous women in the period 1992-2010 in relation to maternal age group.

Characteristics	Crude OR (95%CI)	aOR (95%CI)†	Crude OR (95%CI)	aOR (95%CI)†	Crude OR (95%CI)	aOR (95%CI)†
Maternal complications and use of epidural analgesia:	< 17 years		17-19 years		20-24 years	
Perineal laceration grade 1-2¥	0.44 (0.39-0.50)	0.44 (0.38-0.50)	0.46 (0.44-0.47)	0.47 (0.45-0.49)	0.65 (0.64-0.66)	0.68 (0.67-0.69)
Perineal laceration grade 3-4¥	0.33 (0.22-0.49)	0.39 (0.25-0.60)	0.31 (0.25-0.37)	0.37 (0.32-0.42)	0.57 (0.54-0.59)	0.61 (0.58-0.64)
Preeclampsia	0.83 (0.61-1.12)	0.89 (0.62-1.27)	0.89 (0.82-0.97)	0.93 (0.84-1.02)	1.07 (1.03-1.12)	1.01 (0.96-1.05)
Abruptio placentae	1.72 (1.05-2.83)	1.76 (1.03-3.00)	1.16 (0.97-1.39)	1.02 (0.83-1.26)	0.89 (0.81-0.98)	0.83 (0.74-0.92)
Placenta praevia	0.50 (0.12-2.00)	0.57 (0.14-2.30)	0.32 (0.19-0.53)	0.28 (0.16-0.50)	0.52 (0.43-0.61)	0.52 (0.43-0.63)
PPH > 1000 ml (VB)	0.70 (0.54-0.89)	0.65 (0.48-0.88)	0.57 (0.53-0.61)	0.64 (0.59-0.70)	0.71 (0.69-0.74)	0.78 (0.75-0.81)
PPH > 1000 ml (CS)	0.73 (0.18-2.93)	0.52 (0.07-3.74)	0.87 (0.59-1.27)	1.16 (0.77-1.93)	0.99 (0.92-1.07)	1.09 (0.93-1.28)
Epidural analgesia¥	1.03 (0.95-1.12)	1.03 (0.93-1.13)	1.07 (1.06-1.08)	1.07 (1.04-1.10)	1.02 (1.01-1.03)	1.03 (1.01-1.04)
	30 - 34 years		35 - 39 years		40+ years	
Perineal laceration grade 1-2¥	1.33 (1.31-1.34)	1.11 (1.10-1.13)	1.37 (1-34-1.40)	1.08 (1.05-1.10)	1.32 (1.25-1.39)	1.00 (0.94-1.07)
Perineal laceration grade 3-4¥	1.31 (1.27-1.36)	1.16 (1.12-1.20)	1.29 (1.23-1.36)	1.12 (1.05-1.18)	1.10 (0.96-1.26)	0.88 (0.75-1.02)
Preeclampsia	0.95 (0.92-0.99)	1.07 (1.03-1.12)	1.18 (1.12-1.25)	1.30 (1.22-1.39)	1.60 (1.44-1.79)	1.83 (1.62-2.06)
Abruptio placentae	1.19 (1.09-1.30)	1.27 (1.16-1.40)	1.59 (1.42-1.78)	1.71 (1.50-1.94)	2.11 (1-70-2.63)	2.09 (1.62-2.71)
Placenta praevia	1.77 (1.58-1.99)	1.74 (1.53-2.00)	3.55 (3.11-4.06)	3.47 (2.99-4.03)	5.02 (4.00-6.29)	5.23 (4.08-6.70)
PPH > 1000 ml (VB)	1.41 (1.37-1.45)	1.27 (1.23-1.31)	1.69 (1.62-1.76)	1.47 (1.40-1.53)	1.86 (1.69-2.05)	1.48 (1.26-1.52)
PPH > 1000 ml (CS)	1.14 (1.01-1.28)	1.04 (0.91-1.18)	1.06 (0.91-1.24)	0.95 (0.81-1.12)	1.48 (1.17-1.88)	1.35 (1.05-1.73)
Epidural analgesia¥	1.08 (1.06-1.09)	1.03 (1.02-1.05)	1.14 (1.12-1.17)	1.06 (1.04-1.09)	1.10 (1.04-1.15)	0.98 (0.93-1.03)

Reference group: Maternal age 25-29 years.

CI = confidence intervals; CS = Caesarean section; GA = gestational age at delivery; N/A = not applicable; aOR = adjusted odds ratio; PPH = postpartum haemorrhage; VD = vaginal birth.

† Adjusted for maternal BMI and smoking habits at first antenatal care visit and year of birth. CS and preeclampsia also adjusted for gestational age. ‡ Caesarean section was subdivided into elective and acute CS from 1999. ¥ Forceps, vacuum extraction, epidural analgesia and perineal lacerations among vaginally delivered women.

Table 4. Neonatal outcome data in singleton primiparous women in the period 1992-2010 in relation to maternal age group.

Characteristics	Crude OR (95%CI)	aOR (95%CI)†	Crude OR (95%CI)	aOR (95%CI)†	Crude OR (95%CI)	aOR (95%CI)†
	< 17 years		17-19 years		20-24 years	
Foetal distress	0.62 (0.31-1.24)	0.52 (0.22-1.26)	0.76 (0.63-0.91)	0.63 (0.51-0.79)	0.93 (0.86-1.01)	0.79 (0.72-0.91)
Aspiration of meconium	N/A	N/A	0.47 (0.32-0.67)	0.46 (0.31-0.70)	0.90 (0.80-1.03)	0.93 (0.81-1.07)
Shoulder dystocia¥	0.45 (0.11-1.82)	0.32(0.05-2.29)	0.74 (0.58-0.90)	0.74 (0.52-1.07)	1.01 (0.88-1.16)	1.00 (0.86-1.16)
Stillbirth	0.99 (0.47-2.08)	0.58 (0.19-1.80)	1.15 (0.94-1.42)	0.97 (0.75-1.25)	1.03 (0.93-1.15)	0.98 (0.87-1.11)
SGA	1.32 (1.07-1.63)	1.00 (0.78-1.28)	1.31 (1.23-1.40)	1.01 (0.94-1.09)	1.11 (1.07-1.14)	1.00 (0.96-1.04)
LGA	1.01 (0.75-1.34)	1.08 (0.76-1.53)	0.92 (0.84-1.00)	1.03 (0.94-1.14)	1.05 (1.00-1.09)	1.05 (1.00-1.10)
Apgar score < 7 at 5 minutes	1.31 (0.96-1.77)	1.30 (0.91-1.86)	0.92 (0.83-1.03)	0.92 (0.81-1.11)	0.93 (0.89-0.99)	0.93 (0.88-0.98)
	30 - 34 years		35 - 39 years		40+ years	
Foetal distress	0.96 (0.89-1.04)	1.23 (1.13-1.35)	1.14 (1.02-1.27)	1.51 (1.33-1.72)	0.98 (0.75-1.28)	1.60 (1.20-2.13)
Aspiration of meconium	1.27 (1.13-1.42)	1.36 (1.20-1.54)	1.42 (1.21-1.67)	1.48 (1.24-1.77)	1.83 (1.34-2.51)	1.82 (1.28-2.58)
Shoulder dystocia¥	1.18 (1.04-1.35)	1.13 (0.90-1.41)	1.13 (0.91-1.39)	1.13 (0.91-1.41)	1.47 (0.93-2.33)	1.27 (0.76-2.12)
Stillbirth	1.26 (1.14-1.38)	1.25 (1.12-1.39)	1.85 (1.64-2.10)	1.72 (1.49-1.99)	2.77 (2.22-3.46)	2.34 (1.80-3.03)
SGA	1.20 (1.16-1.24)	1.24 (1.20-1.28)	1.63 (1.56-1.70)	1.65 (1.58-1.73)	2.04 (1.87-2.22)	2.06 (1.87-2.26)
LGA	0.94 (0.91-0.98)	0.94 (0.90-0.98)	1.03 (0.97-1.09)	0.97 (0.91-1.04)	1.07 (0.93-1.22)	0.94 (0.81-1.09)
Apgar score < 7 at 5 minutes	1.18 (1.13-1.24)	1.18 (1.12-1.24)	1.47 (1.38-1.56)	1.39 (1.29-1.49)	1.65 (1.44-1.88)	1.51 (1.30-1.75)

Reference group: Maternal age 25-29 years.

CI = confidence interval; LGA = large for gestational age; N/A = not applicable; aOR = adjusted odds ratio; SGA = small for gestational age

† Adjusted for maternal BMI and smoking habits at first antenatal care visit and year of birth

¥ Shoulder dystocia among vaginal delivered women.

Mode of delivery, obstetric and neonatal outcome of adolescents

Compared with the reference group the teenagers had a significantly higher likelihood of having spontaneous onset of labour and of having a normal vaginal delivery. Teenagers also demonstrated a significantly higher risk of giving birth prematurely. However, only the group of teenagers younger than 17 years of age had an increased risk of giving birth very prematurely i.e. before 28 weeks of gestational age, and the same group revealed a significantly higher risk of placental abruption. In contrast with these observations the teenagers were delivered instrumentally and by CS significantly less often, and the vaginal births caused significantly fewer perineal lacerations (only evaluated among women who delivered vaginally) and PPH > 1000 ml. Likewise the occurrence of placenta previa was seen less often among teenagers whereas the occurrence of preeclampsia was equal to that seen in the reference group.

Concerning the foetal and neonatal outcomes for adolescents the newborns were less likely to show foetal distress and meconium aspiration in spite of a similar occurrence of Apgar score < 7 at 5 minutes. The newborns of the adolescents were not more prone to being stillborn or being SGA than the newborns of women in the reference group. The adjusted mean birth weight of newborns of adolescents did not differ significantly from that of women up to 29 years of age (Figure 1).

Mode of delivery, obstetric and neonatal outcome of women 20-24 years of age

The young women, 20 – 24 years of age, differed in some aspects from the reference group as well as from the adolescents. They were less likely to be delivered prematurely and had a lower frequency of placental abruption. Otherwise the obstetric and neonatal outcomes were similarly favourable as those observed for the adolescents in comparison with the reference group.

Mode of delivery, obstetric and neonatal outcome of women older than 29 years of age

As shown in Table 3 compared with the reference group almost all obstetric outcome variables demonstrated a continuously progressive deterioration with increasing age. The likelihood of normal

vaginal births decreased; induced labour, instrumental deliveries and CS increased as well as prematurity including very premature deliveries. The risk of perineal laceration increased moderately whereas the risk of PPH > 1000 ml in vaginal births was more pronounced. The likelihood of the pregnancy complications preeclampsia, abruptio placenta and placenta previa was also higher in the older age groups and progressed substantially with increasing age. Similarly, the foetal and neonatal outcome was adversely progressively influenced by increasing maternal age. With increasing maternal age over 30 years significantly more neonates were SGA, showed foetal distress, had Apgar score < 7 at 5 minutes or meconium aspiration, or were stillborn. The mean birth weight of the neonates also decreased significantly with increasing maternal age after the age of 30 (Figure 1).

DISCUSSION

This Swedish nation-wide population-based study with prospectively collected data concerning singleton primiparous women showed that the mode of delivery differed over the maternal age strata. Significantly more normal vaginal deliveries and fewer CS and instrumental vaginal deliveries were seen among the teenagers and among women aged 20-24 compared with the reference group of women aged 25-29. The opposite was found among older women reaching a 4-fold increased risk for CS compared with women aged 20-24. The teenagers as well as women aged 20-24 were less prone to perineal lacerations and PPH exceeding 1000 ml. Prematurity (< 28 weeks of GA) was associated with very low maternal age (<17 years) among the adolescents although the increased risk was at the same level as among women aged 40 years and above, indicating a u-shaped risk curve. Adolescents were not afflicted more by preeclampsia than the reference women whereas the risk of preeclampsia increased significantly with advancing maternal age. The risk of placentae praevia increased dramatically with maternal age, actually a 500% increased risk was found after the age of 40 compared with the reference group. There was a significantly increased risk of stillbirth, SGA and low Apgar score only in women aged 30 years and over.

The most prominent difference between the findings in the present study and earlier studies is that no increased risk for SGA was found among the adolescents and young mothers 20-24 years of age compared with the reference women.[8-9] It must be kept in mind that the definition of SGA may differ between countries. In the United States and Latin America SGA is usually defined as birth weight below the 10th percentile compared with two SD in the Nordic countries.[3, 9] Adjusted risks for SGA among teenagers, recently presented from Finland, one of the Nordic countries, showed no increased risk among the youngest mothers.[6] In that study the control group was defined in the same way as in the present study. Differences concerning the risk for SGA could also be attributable to differences in socio-economic status. Chen et al. restricted their analysis to white married mothers with age-appropriate education level, adequate prenatal care, without smoking and alcohol use during pregnancy

but found the increased risk for SGA to persist.[3] Several studies have shown low infant birth weight for adolescents as well as for mothers with advancing age.[18, 14, 26, 27] We failed to find such association among the adolescents, but in women with advancing age the difference in birth weight was statistically significant although the difference lacked clinical significance.

The finding of a preferable birth outcome with lower CS rates and lower rates of instrumental delivery among teenagers compared with older women has been pinpointed to a lesser extent than observed adverse outcomes. Earlier studies have shown relatively consistent results concerning a decreased rate of CS in the adolescent group and a higher rate in women with advancing age.[6, 8, 9, 12-18] We were able to evaluate elective and emergency CS separately and the risks among the teenagers and mothers age 20-24 years were decreased for both types. This might indicate that the different risks concerning CS among young and older mothers could not exclusively be explained by more CS on maternal request among older mothers but may even be caused by biological factors. A low rate of instrumental deliveries and CS among adolescents and a high rate among older women have almost unanimously been shown in several reports from high-income as well as low-income countries.[5, 7, 12-18, 26-29] Whether this phenomenon depends on differences in handling the delivery, inherent or cultural behavioural, domestic or social attitudes among the obstetric staff or biological factors has not been investigated. Advancing age is associated with impaired uterine contractility as well as endothelial dysfunction which theoretically may lead to impaired uterine and utero-placental function.[30, 31] The fact that adolescents in our study had a lower risk of induction of labour, perineal laceration, PPH, abruption (except for the very young women) and placenta previa and women with advancing age had higher risks of all these outcomes including preeclampsia could support a biological explanation. Concerning prematurity the age related risk curve was U shaped. This may also support a biological aetiology; immaturity of the uterus in the very young women that obstruct development of a term pregnancy and uterine dysfunction caused by ageing processes in women with advancing age and consequently deliver prematurely in both situations. The neonatal outcomes followed almost the same

pattern; foetal distress, meconium aspiration, stillbirth, SGA and low Apgar score were exclusively attributed to women older than 29.

The strength of this study is that it deals with the outcomes in the population of an entire country where the antenatal care program is equally available to all pregnant women and is comprehensive. In Sweden pregnant women have completely cost free access to antenatal and obstetric facilities; poverty and malnutrition are practically non-existent and the vast majority of women attends the antenatal care program (99%) independent of socio-economic status and is delivered in obstetric units.[21] This context is valid for the whole study period. Another advantage is the large number of individuals available for evaluation, which makes it possible to divide the study population into subgroups with sufficient numbers in each stratum to provide high statistical power. A sufficient number of study subjects made it possible to evaluate three subgroups of young maternal age. Only primiparous women were included in order to avoid the confounding effects of factors associated with subsequent deliveries. There are limitations that should be considered. The external validity is reduced to facilities with similar socio-economic and demographic characteristics and health care systems with comparable standards. The drawback is obvious given the large size of the study and the numbers of health care units involved that the criteria for diagnosis (ICD codes) to define outcomes may not be uniform across the study population but the variation is most likely not related to maternal age. The MBR contain a large body of information concerning the mother and the child which made it possible to adjust the results for confounding factors. At the same time this is a limitation as only the data available in the register could be used for adjustments. The register lacks information on ethnicity and socio-economic status. Our effort was to evaluate obstetric and neonatal outcome in different maternal age groups compared with women aged 25-29 overall. The only stratifications made were for year of birth, maternal BMI and smoking in early pregnancy. The data on year of birth showed that there is variability in the existence of obstetric and neonatal diagnoses during the observation period. This may be due to true changes but may also be a result of changes in recording, including the expanding use of

computerized medical records. It was therefore necessary to adjust for year of birth. Maternal BMI affects obstetric and neonatal outcome.[32] To demonstrate causality between the different outcomes evaluated in the analyses and maternal age a great number of putative intermediaries could have been considered such as the use of fertility treatment, foetal size, gestational weight gain etc., but that was not the purpose of the study. A true confounder affects both the exposure and the outcome. There may be other variables (which are not intermediaries) but we have not been able to identify them. If we take for instance maternal hypertension as an example, it could be of interest. But as the higher risk of hypertension is a consequence of maternal age, it is not a true confounder but an intermediary, a way in which high maternal age can affect obstetric and neonatal pathology.

Our approach of analysing the data may be a benefit for clinicians interpreting the results when dealing with young and aged mothers. In conclusion, in a country with a highly developed social and antenatal maternity health care security system giving cost free maternity and obstetric care to all pregnant women adolescents had a decreased risk for adverse obstetric and neonatal outcome compared with the reference group. In the same social context childbirth at advanced maternal age was associated with a number of serious complications for both the woman and the child. For clinicians counselling young mothers it is of great importance to highlight the positive consequences that less obstetric complications and favourable neonatal outcomes are expected. There is also a need to develop surveillance programs in antenatal and obstetric care for older women aiming to prevent and protect the increased risks of adverse outcomes for example to earlier detect preeclampsia or recommending prophylactic uterotonic treatment after birth to avoid extensive postpartum bleeding. Such interventions need to be evaluated in well-designed prospective studies.

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Checklist: The manuscript conforms to the STROBE requirement.

Data sharing statement: Technical appendix, statistical code, and dataset available from the corresponding author at Dryad repository, who will provide a permanent, citable and open access home for the dataset.

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LEGENDS

Figure 1. Adjusted mean birth weight of neonates in singleton primiparous women in different maternal age groups. Birth weight adjusted for gestational age, maternal BMI and smoking habits, and year of delivery. Plots indicate means and bars 95% CI.

Impact of maternal age on obstetric and neonatal outcome with emphasis on primiparous adolescents and older women-a Swedish Medical Birth Register Study.

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Abstract

Objectives: To evaluate the associations between maternal age and obstetric and neonatal outcomes in primiparous women with emphasis on teenagers and older women.

Design: A population-based cohort study.

Setting: The Swedish Medical Birth Register.

Participants: Primiparous women with singleton births from 1992 through 2010 (N=798,674) were divided into seven age groups: <17 years, 17-19 years, and additional five five-year classes. The reference group consisted of the women age 25-29 years.

Primary outcome: Obstetric and neonatal outcome.

Results: The teenager groups had significantly more vaginal ~~deliveries~~ births (OR 2.04 (1.79-2.32) and 1.95 (1.88-2.02) for age <17 years and 17–19 years, respectively); fewer caesarean sections (OR 0.57 (0.48-0.67) and 0.55 (0.53-0.58)), and instrumental vaginal ~~deliveries~~ births (OR 0.43 (0.36-0.52) and 0.50 (0.48-0.53)) compared with ~~women age 25-29~~the reference group. The opposite was found among older women reaching a 4-fold increased risk for caesarean section. The teenagers showed no increased risk of adverse neonatal outcome but presented an increased risk of prematurity <32 weeks (OR 1.66 (1.10-2.51) and 1.20 (1.04-1.38)). Women with advancing age (≥ 30 years) revealed significantly increased risk of prematurity, perineal lacerations, preeclampsia, abruption, placenta previa, postpartum haemorrhage and unfavourable neonatal outcomes compared with ~~women age 25-29~~the reference group.

Conclusions: For clinicians counselling young women ~~mothers~~ it is of importance to highlight the obstetrically positive consequences that fewer maternal complications and favourable neonatal outcomes are expected. ~~The average age of primiparous women has increased and women over 30 years seem to be at a higher risk of severe adverse obstetric and neonatal outcome. There is a need to develop surveillance programs in obstetric care customized for older women.~~

There is also a need to develop surveillance programs in antenatal and obstetric care for older women aiming for example to detect preeclampsia earlier or recommending prophylactic uterotonic treatment after birth to avoid extensive postpartum bleeding. Such interventions need to be evaluated in further studies.

Article summary

Impact of maternal age on obstetric and neonatal outcome with emphasis on primiparous adolescents and older women-a Swedish Medical Birth Register Study.

Strengths and limitations of this study:

- A strength of the present study is that it includes primiparous women of an entire country where the antenatal care program is equally available to all pregnant women and is comprehensive.
- Another advantage is the large number of individuals available for evaluation, which makes it possible to divide the study population into subgroups with sufficient numbers in each stratum to provide high statistical power.
- A limitation is that the external validity is reduced to facilities with similar socio-economic and demographic characteristics and health care systems with comparable standards.
- The Swedish medical birth register contain a large body of information concerning the mother and the child but only the available data in the register could be used for outcome evaluation and adjustments for putative confounders.

INTRODUCTION

There are a large number of studies evaluating obstetric and neonatal outcome over the full range of reproductive maternal ages, but especially with a focus on the youngest and the oldest mothers. Young mothers have been shown to be exposed to an increased risk of anaemia, low birth weight, foetal death, eclampsia and preterm birth although they at the same time were more likely to have a spontaneous normal vaginal birth ~~delivery~~ and the risk of preeclampsia and post-partum haemorrhage were significantly decreased.[1-6] These studies evaluated outcomes in low-income~~developed~~ countries. Many studies performed in ~~developing~~ low-income countries presented in recent years on the topic of teenage pregnancies have found similar obstetric and neonatal outcomes.[7-11]

Complications during pregnancy and ~~delivery~~ birth at advanced maternal age (either defined as 35 years and older or 40 years or older) have also been evaluated in high-income~~developed~~ countries. Advanced maternal age at birth has been found to be associated with gestational diabetes, preeclampsia, placenta previa, caesarean section (CS), placental abruption, preterm delivery, low birth weight, intrauterine foetal death and an increased perinatal mortality.[12-20] The difference in obstetric and neonatal outcomes between teenagers and women at advanced age seemed to be lower risks for several unwanted and threatening outcomes in the teenage group; thus there were no obvious ~~benefits~~ advantages concerning obstetric and neonatal outcomes at advanced maternal ages. The earlier published studies concerning the impact of maternal age on perinatal outcome differ in many aspects methodologically as well as in the socio-demographic characteristics of the populations and health care systems. All these factors make interpretation of comparisons between data sets difficult.

Sweden has during several decades actively developed strategies in social care, education and health care in order to improve antenatal care and parenthood. In a Swedish state-of-the-art conference held in 1990, the scientific basis of the routine antenatal program was critically evaluated. It was concluded that the scientific evidence to support the timing and contents of routine visits was unsatisfactory.[21] Consequently there is a constant need for evaluation both of single diagnostic procedures and

intervention and of outcomes. An analysis of perinatal outcomes in relation to maternal age in the Swedish population will provide important knowledge that may be used to further improve social, antenatal, obstetric and neonatal care and reveals risk groups that in particular may need more attention in the antenatal care.

The objective of the present study was to assess the impact of maternal age on obstetric and neonatal outcomes among singleton primiparous women in Sweden, with special emphasis on the adolescents and older mothers.

MATERIALS AND METHODS

This study analyses the obstetric and neonatal outcomes of all singleton primiparous women prospectively registered in the Swedish Medical Birth Register (MBR) who gave births from January 1, 1992 through December 31, 2010. MBR has collected information about births ~~deliveries~~ in Sweden since 1973. It is compulsory for every health care provider to report to the MBR. Medical and other data on almost all (99%) births ~~deliveries~~ in Sweden are listed in the register, which also includes stillbirths. Starting with the first antenatal visit, usually in gestational week 10-12, the information is collected prospectively in standardized medical record forms completed at the maternity health care centers at antenatal care visits, in the birth~~delivery~~ units, and at the paediatric examination of the new-born. The standardized medical records are identical throughout the country. A description and validation of the register content is available.[22-24]

The study population was grouped according to maternal age into seven subgroups: <17 years; 17-19 years; 20-24 years, 25-29 years, 30-34 years; 35-39 years and 40+ years. In the outcome analyses we selected the group of women age 25-29 years as reference group~~, since "the average singleton primiparous woman" with respect to age in the time period of the study fell into this interval (Figure 1)~~.

The list of available variables in MBR has been extended throughout the years that the register has been active. The obstetric and neonatal outcome data for the purpose of this study are those that have been available since 1992. From 1992 until June 2008 the MBR includes stillbirths after 28 weeks of gestation and from July 2008 until 2010 all stillbirths after 22 weeks of gestation are included. Each outcome studied was either marked in the MBR or registered according to the International Statistical Classification of Diseases and Related Health Problems (ICD). The obstetric outcome variables studied were gestational age, mode of delivery; normal vaginal birth (defined as neither instrumental vaginal delivery, nor CS), CS, instrumental vaginal delivery divided into forceps and vacuum extraction, mode of onset of labour, perineal laceration, preeclampsia, abruptio placentae, placenta previa, use of epidural analgesia and postpartum haemorrhage (PPH) exceeding 1000 ml. The foetal and neonatal

outcomes evaluated were Apgar-score at 5 minutes, foetal distress (ICD code P20.0, P20.1 and P20.9), aspiration of meconium (ICD code P24.0), shoulder dystocia (ICD code O66.0), and stillbirth. Small-for-gestational age (SGA) ~~infants~~newborns were defined as those with birth weight more than 2 standard deviations (SD) below the mean birth weight for gestational age (sex and parity specific) according to a Swedish reference curve.[25] Large-for-gestational age (LGA) ~~infants~~newborns were those with a birth weight above 2 SD. All descriptive and background data were extracted from the MBR. The register information on these variables was obtained from the antenatal care center records. The study was approved by the Regional Ethical Review Board in Linköping, Sweden (Dnr 2011/479-31. Approved January 25; 2012).

Statistical analysis

Data are presented as counts and per cent or mean and one SD. Logistic regression analyses were used for comparison of groups for categorical data. Data on a continuous scale were compared using analysis of covariance (ANCOVA). Multivariate logistic regression models were used in order to adjust comparisons for the confounding factors. Consequently crude and adjusted odds ratios (OR and aOR) and 95% confidence intervals (CIs) are reported. Maternal weight and height (used for calculation of maternal Body Mass Index (BMI)) and smoking habits in early pregnancy (unknown, no smoking, smoking) and year of ~~delivery~~birth were included as confounders in the adjusted analyses. Gestational age was added to the confounders in the analyses of CS, preeclampsia and birth weight.

The OR for instrumental vaginal delivery was calculated among women with vaginal births only in order to exclude women with an instrumental attempt to deliver followed by an emergency CS. The ORs of perineal lacerations were also estimated among women with vaginal births only. The information concerning use of epidural analgesia was also restricted to vaginal births only. Epidural is an analgesic method that has been widely used in the delivery wards for vaginal births during the entire time period. In contrast the use of epidural analgesia in CS has varied substantially over the time period and has almost exclusively been used in elective CS. Our purpose was to evaluate the odds ratio for

epidural use over the maternal age strata and consequently we selected the mode of delivery that exhibited the least variation in the use of the analgesic method over the time period, i.e. vaginal births.

The software STATISTICA 64 version 10 (StatSoft Inc. 2300 East 14th St. Tulsa, OK 74104 USA) was used to carry out the statistical analyses.

RESULTS

In the period 1992 – 2010, 798,732 women were registered in the MBR as giving birth to their first child. The annual number of primiparous women giving birth varied between 34060 and 49417. Information on maternal age was missing in 58 cases leaving 798,674 women for the analyses. The average age of primiparous women increased substantially from 26.2 years in 1992 to 28.5 in 2004; hereafter it has stayed almost constant at that level. The demographic, obstetric and neonatal data subdivided into maternal age groups are presented in Table 1 and 2.

Table 1. Descriptive data of primiparous women with singleton births in the period 1992-2010.

Characteristics	< 17 years (n=2392)		17-19 years (n=29816)		20-24 years (n=185942)		25-29 years (n=300822)		30-34 years (n=205905)		35-39 years (n=63163)		40+ years (n=10634)	
BMI† class														
<18.5 kg/m²	135	5.6%	1815	6.1%	7650	4.1%	7509	2.5%	3847	1.9%	918	1.5%	133	1.3%
18.5-24.9 kg/m²	1352	56.5%	16823	56.4%	104600	56.3%	180163	59.9%	122571	59.5%	34439	54.5%	5381	50.1%
25.0-29.9 kg/m²	315	13.2%	4687	15.7%	33961	18.3%	53896	17.9%	37234	18.1%	13310	21.1%	2442	23.0%
30.0-34-9 kg/m²	81	3.4%	1327	4.5%	10550	5.7%	14401	4.8%	9389	4.6%	3575	5.7%	683	6.4%
35.0-39.9 kg/m²	11	0.5%	337	1.1%	3013	1.6%	4070	1.4%	2724	1.3%	1024	1.6%	188	1.8%
≥ 40.0 kg/m²	4	0.2%	87	0.3%	904	0.5%	1312	0.4%	944	0.5%	342	0.5%	68	0.6%
Missing data	494	20.7%	4740	15.9%	25264	13.6%	39471	13.1%	29196	14.2%	9555	15.1%	1739	16.4%
Smoking†														
Yes	666	27.8%	9012	30.2%	31675	17.0%	24676	8.2%	13971	6.8%	5287	8.4%	958	9.0%
No	1542	64.5%	19154	64.3%	145695	78.4%	261348	86.9%	178792	86.8%	53416	84.6%	8883	83.5%
Missing data	184	7.7%	1650	5.5%	8572	4.6%	14798	4.9%	13142	6.4%	4460	7.0%	793	7.5%
Gestational age														
Information available	2368	99.0%	29715	99.7%	185700	99.9%	300603	99.9%	205719	99.9%	63098	99.9%	10620	99.9%
Missing data	24	1.0%	101	0.3%	242	0.1%	219	0.1%	186	0.1%	65	0.1%	14	0.1%

Figures denote counts and proportions.
BMI = body mass index.
† Reported height, weight and smoking habits at first antenatal visit.

Table 2. Obstetric and neonatal outcome characteristics of primiparous women with singleton births in the period 1992-2010.

	Age groups													
Characteristics	< 17 years (n=2392)		17-19 years (n=29816)		20-24 years (n=185942)		25-29 years (n=300822)		30-34 years (n=205905)		35-39 years (n=63163)		40+ years (n=10634)	
Labour:														
Spontaneous onset labour	2055	85.9%	25853	86.7%	158879	85.4%	251340	83.6%	163876	79.6%	45330	71.2%	6261	58.9%
Induced labour	184	7.7%	2528	8.5%	17433	9.4%	30873	10.3%	25474	12.4%	10065	15.9%	2111	19.9%
Mode of delivery:														
Normal vaginal birth	2030	84.9%	25096	84.2%	147082	79.1%	219993	73.1%	135099	65.6%	35112	55.6%	4724	44.4%
Forceps	7	0.3%	126	0.4%	1143	0.6%	2166	0.7%	1515	0.7%	575	0.9%	84	0.8%
Vacuum extraction	143	6.0%	2090	7.0%	18011	9.7%	36696	12.2%	29811	14.5%	10119	16.0%	1599	15.0%
CS¥	213	8.9%	2500	8.4%	19747	10.6%	42044	14.0%	39534	19.2%	17355	27.5%	4226	39.7%
CS elective 1999-2010 ‡	53	2.2%	373	1.3%	2828	1.5%	6973	2.3%	7656	3.7%	3853	6.1%	1132	10.6%
CS acute 1999-2010 ‡	73	3.1%	882	3.0%	7092	3.8%	16651	5.5%	17953	8.7%	7826	12.4%	1798	16.9%
Gestational age:														
GA < 28 weeks	20	0.8%	107	0.4%	464	0.2%	743	0.2%	640	0.3%	292	0.5%	73	0.7%
GA < 32 weeks	40	1.7%	308	1.0%	1436	0.8%	2415	0.8%	2048	1.0%	900	1.4%	206	1.9%
GA < 37 weeks	213	8.9%	1937	6.5%	11030	5.9%	18005	5.6%	12727	6.2%	4586	7.3%	877	8.2%
GA 37 – 41 weeks	1990	83.2%	25811	86.6%	161043	86.6%	257320	85.5%	172621	83.8%	51494	81.5%	8786	82.6%
GA ≥ 42 weeks	165	6.9%	1967	6.6%	13627	7.3%	25278	8.4%	20371	9.9%	7018	11.1%	957	9.0%
Maternal complications and use of epidural analgesia:														
Perineal laceration gr 1-2*	311	14.3%	3982	14.6%	32602	19.6%	70452	27.3%	55163	33.2%	15477	33.9%	2116	33.1%
Perineal laceration gr 3-4*	23	1.1%	272	1.0%	3030	1.8%	8202	3.2%	6846	4.1%	1856	4.1%	222	3.5%
Preeclampsia	43	1.8%	576	1.9%	4317	2.3%	6520	2.2%	4265	2.1%	1610	2.5%	365	3.4%
Abruptio placentae	16	0.7%	135	0.5%	643	0.3%	1171	0.4%	955	0.5%	390	0.6%	87	0.8%
Placenta previa	2	0.1%	16	0.1%	159	0.1%	505	0.2%	612	0.3%	375	0.6%	89	0.8%
PPH > 1000 ml (VB)	65	3.0%	667	2.4%	5078	3.1%	10931	4.2%	9720	5.9%	3173	6.9%	485	7.6%
PPH > 1000 ml (CS)	2	0.9%	28	1.1%	252	1.3%	541	1.3%	578	1.5%	237	1.4%	80	1.9%
Epidural analgesia*	903	41.4%	11569	42.4%	68332	41.1%	105266	40.7%	70691	42.5%	20151	44.0%	2743	42.9%

Table 2 continued. Obstetric and neonatal outcome characteristics of primiparous women with singleton births in the period 1992-2010.

	Age groups													
Characteristics	< 17 years (n=2392)		17-19 years (n=29816)		20-24 years (n=185942)		25-29 years (n=300822)		30-34 years (n=205905)		35-39 years (n=63163)		40+ years (n=10634)	
Neonatal														
Foetal distress	8	0.3%	122	0.4%	932	0.5%	1621	0.5%	1070	0.5%	388	0.6%	56	0.5%
Aspiration of meconium	0	0%	30	0.1%	363	0.2%	649	0.2%	563	0.3%	193	0.3%	42	0.4%
Shoulder dystocia	6	0.3%	78	0.3%	793	0.4%	1580	0.5%	1382	0.7%	489	0.8%	79	0.7%
Stillbirth	7	0.3%	102	0.3%	571	0.3%	893	0.3%	768	0.4%	347	0.5%	87	0.8%
SGA	91	3.8%	1136	3.8%	6016	3.2%	8831	2.9%	7216	3.5%	2962	4.7%	617	5.8%
LGA	47	2.0%	539	1.8%	3838	2.1%	5943	2.0%	3846	1.9%	1279	2.0%	224	2.1%
Apgar score < 7 at 5	43	1.8%	381	1.3%	2409	1.3%	4158	1.4%	3354	1.6%	1274	2.0%	240	2.3%
Birth weight (gram)	3348	592	3403	565	3453	554	3470	555	3452	572	3415	612	3360	640

Figures denote counts and proportions or mean and one standard deviation.
BMI = body mass index; CS = caesarean section; GA = gestational age at birth; LGA = large for gestational age; PPH = postpartum haemorrhage; SGA = small for gestational age; VB = vaginal birth
[¥]All CS independent of status of performance – acute or elective. [†]Caesarean section was subdivided into elective and acute CS from 1999.
*Epidural analgesia and perineal lacerations in vaginal births only.

Table 1. Demographic and descriptive obstetric characteristics of primiparous women with singleton births in the period 1992-2010.

	Age groups													
	< 17 years (n=2392)		17-19 years (n=29816)		20-24 years (n=185942)		25-29 years (n=300822)		30-34 years (n=205905)		35-39 years (n=63163)		40+ years (n=10634)	
Characteristics														
BMI (kg/m²)†	22.8	3.7	23.2	4.1	23.8	4.3	23.7	4.0	23.8	4.0	24.4	4.1	24.7	4.3
Smoking‡	666	27.8%	9012	30.2%	31675	17.0%	24676	8.2%	13971	6.8%	5287	8.4%	958	9.0%
Spontaneous onset labour	2055	85.9%	25853	86.7%	158879	85.4%	251340	83.6%	163876	79.6%	45330	71.2%	6261	58.9%
Induced labour	184	7.7%	2528	8.5%	17433	9.4%	30873	10.3%	25474	12.4%	10065	15.9%	2111	19.9%
Normal vaginal delivery	2030	84.9%	25096	84.2%	147082	79.1%	219993	73.1%	135099	65.6%	35112	55.6%	4724	44.4%
Forceps	7	0.3%	126	0.4%	1143	0.6%	2166	0.7%	1515	0.7%	575	0.9%	84	0.8%
Vacuum extraction	143	6.0%	2090	7.0%	18011	9.7%	36696	12.2%	29811	14.5%	10119	16.0%	1599	15.0%
CS¥	213	8.9%	2500	8.4%	19747	10.6%	42044	14.0%	39534	19.2%	17355	27.5%	4226	39.7%
CS elective 1999-2010 ‡	53	2.2%	373	1.3%	2828	1.5%	6973	2.3%	7656	3.7%	3853	6.1%	1132	10.6%
CS acute 1999-2010 ‡	73	3.1%	882	3.0%	7092	3.8%	16651	5.5%	17953	8.7%	7826	12.4%	1798	16.9%
GA < 28 weeks	20	0.8%	107	0.4%	464	0.2%	743	0.2%	640	0.3%	292	0.5%	73	0.7%
GA < 32 weeks	40	1.7%	308	1.0%	1436	0.8%	2415	0.8%	2048	1.0%	900	1.4%	206	1.9%
GA < 37 weeks	213	8.9%	1937	6.5%	11030	5.9%	18005	5.6%	12727	6.2%	4586	7.3%	877	8,2%
GA 37 – 41 weeks	1990	83.2%	25811	86.6%	161043	86.6%	257320	85.5%	172621	83.8%	51494	81.5%	8786	82.6%
GA ≥ 42 weeks	165	6.9%	1967	6.6%	13627	7.3%	25278	8.4%	20371	9.9%	7018	11.1%	957	9.0%
Epidural analgesia*	903	41.4%	11569	42.4%	68332	41.1%	105266	40.7%	70691	42.5%	20151	44.0%	2743	42.9%
Perineal laceration gr 1-2*	311	14.3%	3982	14.6%	32602	19.6%	70452	27.3%	55163	33.2%	15477	33.9%	2116	33.1%
Perineal laceration gr 3-4*	23	1.1%	272	1.0%	3030	1.8%	8202	3.2%	6846	4.1%	1856	4.1%	222	3.5%
Preeclampsia	43	1.8%	576	1.9%	4317	2.3%	6520	2.2%	4265	2.1%	1610	2.5%	365	3.4%
Abruptio placentae	16	0.7%	135	0.5%	643	0.3%	1171	0.4%	955	0.5%	390	0.6%	87	0.8%
Placenta previa	2	0.1%	16	0.1%	159	0.1%	505	0.2%	612	0.3%	375	0.6%	89	0.8%
Bleeding > 1000 ml (VD)	65	3.0%	667	2.4%	5078	3.1%	10931	4.2%	9720	5.9%	3173	6.9%	485	7.6%

Bleeding > 1000 ml (CS)	2	0.9%	28	1.1%	252	1.3%	541	1.3%	578	1.5%	237	1.4%	80	1.9%

Figures denote means and one standard deviation or counts and proportions.
BMI = body mass index; CS = caesarean section; GA = gestational age at delivery; VD = vaginal delivery
[†] Reported height, weight and smoking habits at first antenatal visit. [¥] All CS independent of status of performance – acute or elective.
*Epidural analgesia and perineal lacerations in vaginal deliveries. [‡] Caesarean section was subdivided into elective and acute CS from 1999.

Table 2: Descriptive neonatal outcome among primiparous women with singleton births in the period 1992-2010.

	Age groups													
	< 17 years (n=2392)		17-19 years (n=29816)		20-24 years (n=185942)		25-29 years (n=300822)		30-34 years (n=205905)		35-39 years (n=63163)		40+ years (n=10634)	
Characteristics														
Birth weight (gram)	3348	592	3403	565	3453	554	3470	555	3452	572	3415	612	3360	640
Foetal distress	8	0.3%	122	0.4%	932	0.5%	1621	0.5%	1070	0.5%	388	0.6%	56	0.5%
Aspiration of meconium	0	0%	30	0.1%	363	0.2%	649	0.2%	563	0.3%	193	0.3%	42	0.4%
Shoulder dystocia	6	0.3%	78	0.3%	793	0.4%	1580	0.5%	1382	0.7%	489	0.8%	79	0.7%
Stillbirth	7	0.3%	102	0.3%	571	0.3%	893	0.3%	768	0.4%	347	0.5%	87	0.8%
SGA	91	3.8%	1136	3.8%	6016	3.2%	8831	2.9%	7216	3.5%	2962	4.7%	617	5.8%
LGA	47	2.0%	539	1.8%	3838	2.1%	5943	2.0%	3846	1.9%	1279	2.0%	224	2.1%
Apgar score < 7 at 5 minutes	43	1.8%	381	1.3%	2409	1.3%	4158	1.4%	3354	1.6%	1274	2.0%	240	2.3%

Figures denote means and one standard deviation or counts and proportions.
LGA = Large for gestational age; SGA = Small for gestational age

The crude odds rates and the results of the multivariate analyses models of obstetric and neonatal outcomes are shown in Table 3 and 4, respectively.

Table 3. Obstetric outcome data in singleton primiparous women in the period 1992-2010 in relation to maternal age group.

Characteristics	Crude OR (95%CI)	aOR (95%CI)†	Crude OR (95%CI)	aOR (95%CI)†	Crude OR (95%CI)	aOR (95%CI)†
Labour	< 17 years		17-19 years		20-24 years	
Spontaneous onset labour	1.20 (1.07-1.35)	1.20 (1.05-1.37)	1.28 (1.24-1.33)	1.26 (1.21-1.31)	1.16 (1.14-1.17)	1.16 (1.14-1.18)
Induced labour	0.73 (0.63-0.85)	0.78 (0.66-0.93)	0.81 (0.78-0.85)	0.86 (0.82-0.90)	0.90 (0.89-0.92)	0.91 (0.90-0.93)
	30 - 34 years		35 - 39 years		40+ years	
Spontaneous onset labour	0.77 (0.76-0.78)	0.78 (0.77-0.79)	0.50 (0.49-0.51)	0.52 (0.51-0.54)	0.29 (0.26-0.30)	0.30 (0.28-0.31)
Induced labour	1.23 (1.21-1.26)	1.19 (1.17-1.21)	1.66 (1.62-1.70)	1.54 (1.50-1.58)	2.17 (2.06-2.27)	1.97 (1.87-2.08)
Mode of delivery	< 17 years		17-19 years		20-24 years	
Normal vaginal birth	2.05 (1.84-2.30)	2.04 (1.79-2.32)	1.95 (1.89-2.02)	1.95 (1.88-2.02)	1.39 (1.37-1.41)	1.39 (1.37-1.41)
Forceps¥	0.38 (0.18-0.81)	0.41 (0.18-0.92)	0.55 (0.46-0.64)	0.48 (0.39-0.59)	0.82 (0.76-0.88)	0.77 (0.71-0.84)
Vacuum extraction¥	0.42 (0.36-0.51)	0.43 (0.36-0.52)	0.50 (0.48-0.53)	0.50 (0.48-0.53)	0.74 (0.72-0.75)	0.74 (0.72-0.75)
CS. all	0.60 (0.52-0.69)	0.57 (0.48-0.67)	0.56 (0.54-0.69)	0.55 (0.53-0.58)	0.73 (0.72-0.74)	0.72 (0.71-0.74)
CS elective 1999-2010 ‡	0.95 (0.73-1.25)	0.83 (0.60-1.14)	0.53 (0.48-0.59)	0.53 (0.47-0.60)	0.65 (0.62-0.68)	0.68 (0.65-0.71)
CS acute 1999-2010 ‡	0.54 (0.43-0.68)	0.53 (0.40-0.69)	0.52 (0.49-0.56)	0.56 (0.52-0.61)	0.68 (0.66-0.70)	0.71 (0.69-0.73)
	30 - 34 years		35 - 39 years		40+ years	
Normal vaginal delivery	0.70 (0.69-0.71)	0.72 (0.71-0.73)	0.46 (0.45-0.47)	0.48 (0.47-0.49)	0.29 (0.28-0.31)	0.31 (0.30-0.32)
Forceps¥	1.08 (1.01-1.15)	1.20 (1.12-1.29)	1.48 (1.35-1.63)	1.66 (1.49-1.84)	1.58 (1.27-1.98)	1.75 (1.37-2.24)
Vacuum extraction¥	1.32 (1.30-1.34)	1.29 (1.27-1.32)	1.72 (1.67-1.76)	1.67 (1.63-1.72)	2.01 (1.90-2.13)	1.92 (1.80-2.04)
CS. all	1.46 (1.44-1.49)	1.44 (1.42-1.47)	2.34 (2.29-2.38)	2.21 (2.16-2.26)	4.07 (3.91-4.23)	3.78 (3.61-3.96)
CS elective 1999-2010 ‡	1.63 (1.57-1.68)	1.44 (1.39-1.49)	2.74 (2.63-2.85)	2.25 (2.15-2.35)	5.03 (4.70-5.36)	3.89 (3.61-4.20)
CS acute 1999-2010 ‡	1.63 (1.59-1.67)	1.44 (1.40-1.47)	2.41 (2.35-2.48)	1.94 (1.88-2.00)	3.47 (3.29-3.66)	2.68 (2.52-2.85)
Gestational age	< 17 years		17-19 years		20-24 years	
GA < 28 weeks	3,44 (2.20-5.37)	2.84 (1.59-5.06)	1.46 (1.19-1.79)	1.25 (0.97-1.62)	1.01 (0.90-1.14)	0.89 (0.77-1.02)
GA < 32 weeks	2.12 (1.55-2.91)	1.66 (1.10-2.51)	1.29 (1.15-1.46)	1.20 (1.04-1.38)	0.96 (0.90-1.03)	0.92 (0.85-0.99)
GA < 37 weeks	1.55 (1.34-1.79)	1.46 (1.24-1.72)	1.09 (1.04-1.15)	1.03 (0.98-1.09)	0.99 (0.97-1.02)	0.97 (0.95-1.00)
GA 37 – 41 weeks	0.89 (0.79-0.99)	0.88 (0.77-0.99)	1.11 (1.07-1.15)	1.14 (1.09-1.18)	1.10 (2.08-1.12)	1.12 (1.10-1.14)
GA ≥ 42 weeks	0.82 (0.70-0.96)	0.89 (0.75-1.06)	0.77 (0.74-0.81)	0.79 (0.74-0.83)	0.86 (0.84-0.88)	0.85 (0.83-0.87)
	30 - 34 years		35 - 39 years		40+ years	
GA < 28 weeks	1.26 (1.13-1.40)	1.17 (1.04-1.33)	1.88 (1.64-2.15)	1.61 (1.40-1.90)	2.79 (2.19-3.56)	2.48 (1.86-3.29)
GA < 32 weeks	1.24 (1-17-1.32)	1.24 (1.16-1.33)	1.79 (1.65-1.93)	1.68 (1.53-1.84)	2.44 (2.12-2.82)	2.25 (1.90-2.66)
GA < 37 weeks	1.04 (1.01-1.06)	1.02 (0.99-1.05)	1.23 (1-19-1.27)	1.19 (1.15-1.24)	1.41 (1.32-1.52)	1.37 (1.26-1.48)
GA 37 – 41 weeks	0.88 (0.86-0.89)	0.89 (0.86-0.89)	0.75 (0.73-0.76)	0.76 (0.74-0.78)	0.81 (0.77-0.85)	0.83 (0.79-0.88)
GA ≥ 42 weeks	1.20 (1.17-1.22)	1.20 (1.18-1.23)	1.36 (1.33-1.40)	1.35 (1.31-1.39)	1.08 (1.01-1.15)	1.06 (0.98-1.14)

Table 3 continued. Obstetric outcome data in singleton primiparous women in the period 1992-2010 in relation to maternal age group.

Characteristics	Crude OR (95%CI)	aOR (95%CI)†	Crude OR (95%CI)	aOR (95%CI)†	Crude OR (95%CI)	aOR (95%CI)†
Maternal complications and use of epidural analgesia:	< 17 years		17-19 years		20-24 years	
Perineal laceration grade 1-2¥	0.44 (0.39-0.50)	0.44 (0.38-0.50)	0.46 (0.44-0.47)	0.47 (0.45-0.49)	0.65 (0.64-0.66)	0.68 (0.67-0.69)
Perineal laceration grade 3-4¥	0.33 (0.22-0.49)	0.39 (0.25-0.60)	0.31 (0.25-0.37)	0.37 (0.32-0.42)	0.57 (0.54-0.59)	0.61 (0.58-0.64)
Preeclampsia	0.83 (0.61-1.12)	0.89 (0.62-1.27)	0.89 (0.82-0.97)	0.93 (0.84-1.02)	1.07 (1.03-1.12)	1.01 (0.96-1.05)
Abruptio placentae	1.72 (1.05-2.83)	1.76 (1.03-3.00)	1.16 (0.97-1.39)	1.02 (0.83-1.26)	0.89 (0.81-0.98)	0.83 (0.74-0.92)
Placenta praevia	0.50 (0.12-2.00)	0.57 (0.14-2.30)	0.32 (0.19-0.53)	0.28 (0.16-0.50)	0.52 (0.43-0.61)	0.52 (0.43-0.63)
PPH > 1000 ml (VB)	0.70 (0.54-0.89)	0.65 (0.48-0.88)	0.57 (0.53-0.61)	0.64 (0.59-0.70)	0.71 (0.69-0.74)	0.78 (0.75-0.81)
PPH > 1000 ml (CS)	0.73 (0.18-2.93)	0.52 (0.07-3.74)	0.87 (0.59-1.27)	1.16 (0.77-1.93)	0.99 (0.92-1.07)	1.09 (0.93-1.28)
Epidural analgesia¥	1.03 (0.95-1.12)	1.03 (0.93-1.13)	1.07 (1.06-1.08)	1.07 (1.04-1.10)	1.02 (1.01-1.03)	1.03 (1.01-1.04)
	30 - 34 years		35 - 39 years		40+ years	
Perineal laceration grade 1-2¥	1.33 (1.31-1.34)	1.11 (1.10-1.13)	1.37 (1-34-1.40)	1.08 (1.05-1.10)	1.32 (1.25-1.39)	1.00 (0.94-1.07)
Perineal laceration grade 3-4¥	1.31 (1.27-1.36)	1.16 (1.12-1.20)	1.29 (1.23-1.36)	1.12 (1.05-1.18)	1.10 (0.96-1.26)	0.88 (0.75-1.02)
Preeclampsia	0.95 (0.92-0.99)	1.07 (1.03-1.12)	1.18 (1.12-1.25)	1.30 (1.22-1.39)	1.60 (1.44-1.79)	1.83 (1.62-2.06)
Abruptio placentae	1.19 (1.09-1.30)	1.27 (1.16-1.40)	1.59 (1.42-1.78)	1.71 (1.50-1.94)	2.11 (1-70-2.63)	2.09 (1.62-2.71)
Placenta praevia	1.77 (1.58-1.99)	1.74 (1.53-2.00)	3.55 (3.11-4.06)	3.47 (2.99-4.03)	5.02 (4.00-6.29)	5.23 (4.08-6.70)
PPH > 1000 ml (VB)	1.41 (1.37-1.45)	1.27 (1.23-1.31)	1.69 (1.62-1.76)	1.47 (1.40-1.53)	1.86 (1.69-2.05)	1.48 (1.26-1.52)
PPH > 1000 ml (CS)	1.14 (1.01-1.28)	1.04 (0.91-1.18)	1.06 (0.91-1.24)	0.95 (0.81-1.12)	1.48 (1.17-1.88)	1.35 (1.05-1.73)
Epidural analgesia¥	1.08 (1.06-1.09)	1.03 (1.02-1.05)	1.14 (1.12-1.17)	1.06 (1.04-1.09)	1.10 (1.04-1.15)	0.98 (0.93-1.03)

Reference group: Maternal age 25-29 years.

CI = confidence intervals; CS = Caesarean section; GA = gestational age at delivery; N/A = not applicable; aOR = adjusted odds ratio; PPH = postpartum haemorrhage; VD = vaginal birth.

† Adjusted for maternal BMI and smoking habits at first antenatal care visit and year of birth. CS and preeclampsia also adjusted for gestational age. ‡ Caesarean section was subdivided into elective and acute CS from 1999. ¥ Forceps, vacuum extraction, epidural analgesia and perineal lacerations among vaginally delivered women.

Table 3. Mode of delivery and obstetric data among primiparous women with singleton births in the period 1992–2010 in relation to maternal age group. Maternal age 25–29 was set as reference.

	Age groups					
	< 17 years	17–19 years	20–24 years	30 – 34 years	35 – 39 years	40+ years
Characteristics	aOR (95%CI)‡	aOR (95%CI)‡	aOR (95%CI)‡	aOR (95%CI)‡	aOR (95%CI)‡	aOR (95%CI)‡
Spontaneous onset labour	1.20 (1.05-1.37)	1.26 (1.21-1.31)	1.16 (1.14-1.18)	0.78 (0.77-0.79)	0.52 (0.51-0.54)	0.30 (0.28-0.31)
Induced labour	0.78 (0.66-0.93)	0.86 (0.82-0.90)	0.91 (0.90-0.93)	1.19 (1.17-1.21)	1.54 (1.50-1.58)	1.97 (1.87-2.08)
Normal vaginal delivery	2.04 (1.79-2.32)	1.95 (1.88-2.02)	1.39 (1.37-1.41)	0.72 (0.71-0.73)	0.48 (0.47-0.49)	0.31 (0.30-0.32)
Forceps¥	0.41 (0.18-0.92)	0.48 (0.39-0.59)	0.77 (0.71-0.84)	1.20 (1.12-1.29)	1.66 (1.49-1.84)	1.75 (1.37-2.24)
Vacuum extraction¥	0.43 (0.36-0.52)	0.50 (0.48-0.53)	0.74 (0.72-0.75)	1.29 (1.27-1.32)	1.67 (1.63-1.72)	1.92 (1.80-2.04)
CS, all	0.57 (0.48-0.67)	0.55 (0.53-0.58)	0.72 (0.71-0.74)	1.44 (1.42-1.47)	2.21 (2.16-2.26)	3.78 (3.61-3.96)
CS elective 1999-2010 ‡	0.83 (0.60-1.14)	0.53 (0.47-0.60)	0.68 (0.65-0.71)	1.44 (1.39-1.49)	2.25 (2.15-2.35)	3.89 (3.61-4.20)
CS acute 1999-2010 ‡	0.53 (0.40-0.69)	0.56 (0.52-0.61)	0.71 (0.69-0.73)	1.44 (1.40-1.47)	1.94 (1.88-2.00)	2.68 (2.52-2.85)
GA < 28 weeks	2.84 (1.59-5.06)	1.25 (0.97-1.62)	0.89 (0.77-1.02)	1.17 (1.04-1.33)	1.61 (1.40-1.90)	2.48 (1.86-3.29)
GA < 32 weeks	1.66 (1.10-2.51)	1.20 (1.04-1.38)	0.92 (0.85-0.99)	1.24 (1.16-1.33)	1.68 (1.53-1.84)	2.25 (1.90-2.66)
GA < 37 weeks	1.46 (1.24-1.72)	1.03 (0.98-1.09)	0.97 (0.95-1.00)	1.02 (0.99-1.05)	1.19 (1.15-1.24)	1.37 (1.26-1.48)
GA 37 – 41 weeks	0.88 (0.77-0.99)	1.14 (1.09-1.18)	1.12 (1.10-1.14)	0.89 (0.86-0.89)	0.76 (0.74-0.78)	0.83 (0.79-0.88)
GA ≥42 weeks	0.89 (0.75-1.06)	0.79 (0.74-0.83)	0.85 (0.83-0.87)	1.20 (1.18-1.23)	1.35 (1.31-1.39)	1.06 (0.98-1.14)
Epidural analgesia¥	1.03 (0.93-1.13)	1.07 (1.04-1.10)	1.03 (1.01-1.04)	1.03 (1.02-1.05)	1.06 (1.04-1.09)	0.98 (0.93-1.03)
Perineal laceration grade 1-2¥	0.44 (0.38-0.50)	0.47 (0.45-0.49)	0.68 (0.67-0.69)	1.11 (1.10-1.13)	1.08 (1.05-1.10)	1.00 (0.94-1.07)
Perineal laceration grade 3-4¥	0.39 (0.25-0.60)	0.37 (0.32-0.42)	0.61 (0.58-0.64)	1.16 (1.12-1.20)	1.12 (1.05-1.18)	0.88 (0.75-1.02)
Preeclampsia	0.89 (0.62-1.27)	0.93 (0.84-1.02)	1.01 (0.96-1.05)	1.07 (1.03-1.12)	1.30 (1.22-1.39)	1.83 (1.62-2.06)
Abruptio placentae	1.76 (1.03-3.00)	1.02 (0.83-1.26)	0.83 (0.74-0.92)	1.27 (1.16-1.40)	1.71 (1.50-1.94)	2.09 (1.62-2.71)
Placenta praevia	0.57 (0.14-2.30)	0.28 (0.16-0.50)	0.52 (0.43-0.63)	1.74 (1.53-2.00)	3.47 (2.99-4.03)	5.23 (4.08-6.70)
PPH > 1000 ml (VD)	0.65 (0.48-0.88)	0.64 (0.59-0.70)	0.78 (0.75-0.81)	1.27 (1.23-1.31)	1.47 (1.40-1.53)	1.48 (1.26-1.52)
PPH > 1000 ml (CS)	0.52 (0.07-3.74)	1.16 (0.77-1.93)	1.09 (0.93-1.28)	1.04 (0.91-1.18)	0.95 (0.81-1.12)	1.35 (1.05-1.73)

CI = confidence intervals; CS = Caesarean section; GA = gestational age at delivery; N/A = not applicable; aOR = adjusted odds ratio; PPH = postpartum haemorrhage; VD = vaginal delivery.

† Adjusted for maternal BMI and smoking habits at first antenatal care visit and year of delivery. CS and preeclampsia also adjusted for gestational age.

‡ Caesarean section was subdivided into elective and acute CS from 1999.

¥ Forceps, vacuum extraction, epidural analgesia and perineal lacerations among vaginally delivered women.

Table 4. Neonatal outcome data in singleton primiparous women in the period 1992-2010 in relation to maternal age group.

Characteristics	Crude OR (95%CI)	aOR (95%CI)†	Crude OR (95%CI)	aOR (95%CI)†	Crude OR (95%CI)	aOR (95%CI)†
	< 17 years		17-19 years		20-24 years	
Foetal distress	0.62 (0.31-1.24)	0.52 (0.22-1.26)	0.76 (0.63-0.91)	0.63 (0.51-0.79)	0.93 (0.86-1.01)	0.79 (0.72-0.91)
Aspiration of meconium	N/A	N/A	0.47 (0.32-0.67)	0.46 (0.31-0.70)	0.90 (0.80-1.03)	0.93 (0.81-1.07)
Shoulder dystocia¥	0.45 (0.11-1.82)	0.32(0.05-2.29)	0.74 (0.58-0.90)	0.74 (0.52-1.07)	1.01 (0.88-1.16)	1.00 (0.86-1.16)
Stillbirth	0.99 (0.47-2.08)	0.58 (0.19-1.80)	1.15 (0.94-1.42)	0.97 (0.75-1.25)	1.03 (0.93-1.15)	0.98 (0.87-1.11)
SGA	1.32 (1.07-1.63)	1.00 (0.78-1.28)	1.31 (1.23-1.40)	1.01 (0.94-1.09)	1.11 (1.07-1.14)	1.00 (0.96-1.04)
LGA	1.01 (0.75-1.34)	1.08 (0.76-1.53)	0.92 (0.84-1.00)	1.03 (0.94-1.14)	1.05 (1.00-1.09)	1.05 (1.00-1.10)
Apgar score < 7 at 5 minutes	1.31 (0.96-1.77)	1.30 (0.91-1.86)	0.92 (0.83-1.03)	0.92 (0.81-1.11)	0.93 (0.89-0.99)	0.93 (0.88-0.98)
	30 - 34 years		35 - 39 years		40+ years	
Foetal distress	0.96 (0.89-1.04)	1.23 (1.13-1.35)	1.14 (1.02-1.27)	1.51 (1.33-1.72)	0.98 (0.75-1.28)	1.60 (1.20-2.13)
Aspiration of meconium	1.27 (1.13-1.42)	1.36 (1.20-1.54)	1.42 (1.21-1.67)	1.48 (1.24-1.77)	1.83 (1.34-2.51)	1.82 (1.28-2.58)
Shoulder dystocia¥	1.18 (1.04-1.35)	1.13 (0.90-1.41)	1.13 (0.91-1.39)	1.13 (0.91-1.41)	1.47 (0.93-2.33)	1.27 (0.76-2.12)
Stillbirth	1.26 (1.14-1.38)	1.25 (1.12-1.39)	1.85 (1.64-2.10)	1.72 (1.49-1.99)	2.77 (2.22-3.46)	2.34 (1.80-3.03)
SGA	1.20 (1.16-1.24)	1.24 (1.20-1.28)	1.63 (1.56-1.70)	1.65 (1.58-1.73)	2.04 (1.87-2.22)	2.06 (1.87-2.26)
LGA	0.94 (0.91-0.98)	0.94 (0.90-0.98)	1.03 (0.97-1.09)	0.97 (0.91-1.04)	1.07 (0.93-1.22)	0.94 (0.81-1.09)
Apgar score < 7 at 5 minutes	1.18 (1.13-1.24)	1.18 (1.12-1.24)	1.47 (1.38-1.56)	1.39 (1.29-1.49)	1.65 (1.44-1.88)	1.51 (1.30-1.75)

Reference group: Maternal age 25-29 years.

CI = confidence interval; LGA = large for gestational age; N/A = not applicable; aOR = adjusted odds ratio; SGA = small for gestational age

† Adjusted for maternal BMI and smoking habits at first antenatal care visit and year of birth

¥ Shoulder dystocia among vaginal delivered women.

~~Table 4. Neonatal outcome data from singleton primiparous women in the period 1992-2010 in relation to maternal age group.~~

	~~Age groups~~					
	~~< 17 years~~	~~17-19 years~~	~~20 - 24 years~~	~~30 - 34 years~~	~~35 - 39 years~~	~~40+ years~~
~~Characteristic~~	~~aOR (95%CI)†~~	~~aOR (95%CI)†~~	~~aOR (95%CI)†~~	~~aOR (95%CI)†~~	~~aOR (95%CI)†~~	~~aOR (95%CI)†~~
~~Foetal distress~~	~~0.52 (0.22-1.26)~~	~~0.63 (0.51-0.79)~~	~~0.79 (0.72-0.91)~~	~~1.23 (1.13-1.35)~~	~~1.51 (1.33-1.72)~~	~~1.60 (1.20-2.13)~~
~~Aspiration of meconium~~	~~N/A~~	~~0.46 (0.31-0.70)~~	~~0.93 (0.81-1.07)~~	~~1.36 (1.20-1.54)~~	~~1.48 (1.24-1.77)~~	~~1.82 (1.28-2.58)~~
~~Shoulder dystocia¥~~	~~0.32(0.05-2.29)~~	~~0.74 (0.52-1.07)~~	~~1.00 (0.86-1.16)~~	~~1.13 (0.90-1.41)~~	~~1.13 (0.91-1.41)~~	~~1.27 (0.76-2.12)~~

Stillbirth	0.58 (0.19-1.80)	0.97 (0.75-1.25)	0.98 (0.87-1.11)	1.25 (1.12-1.39)	1.72 (1.49-1.99)	2.34 (1.80-3.03)
SGA	1.00 (0.78-1.28)	1.01 (0.94-1.09)	1.00 (0.96-1.04)	1.24 (1.20-1.28)	1.65 (1.58-1.73)	2.06 (1.87-2.26)
LGA	1.08 (0.76-1.53)	1.03 (0.94-1.14)	1.05 (1.00-1.10)	0.94 (0.90-0.98)	0.97 (0.91-1.04)	0.94 (0.81-1.09)
Apgar score < 7 at 5 minutes	1.30 (0.91-1.86)	0.92 (0.81-1.11)	0.93 (0.88-0.98)	1.18 (1.12-1.24)	1.39 (1.29-1.49)	1.51 (1.30-1.75)

Figures denote odds ratios and 95% confidence intervals. Reference group: Maternal age 25-29 years.
LGA = Large for gestational age; N/A = not applicable; aOR = adjusted odds ratio; SGA = Small for gestational age
[†]Adjusted for maternal BMI and smoking habits at first antenatal care visit and year of delivery
¥ Shoulder dystocia among vaginal delivered women.

Mode of delivery, obstetric and neonatal outcome of adolescents

Compared with the reference group ~~of women age 25–29 years~~ the teenagers had a significantly higher likelihood of having spontaneous onset of labour and of having a normal vaginal delivery. Teenagers also demonstrated a significantly higher risk of giving birth prematurely. However, only the group of teenagers younger than 17 years of age had an increased risk of giving birth very prematurely i.e. before 28 weeks of gestational age, and the same group revealed a significantly higher risk of placental abruption. In contrast with these observations the teenagers were delivered instrumentally and by CS significantly less often, and the vaginal ~~deliveries~~ births caused significantly fewer perineal lacerations (only evaluated among women who delivered vaginally) and PPH > 1000 ml. Likewise the occurrence of placenta previa was seen less often among teenagers whereas the occurrence of preeclampsia was equal to that seen in ~~adult women age 25–29 years~~the reference group.

Concerning the foetal and neonatal outcomes for adolescents the ~~infants~~newborns were less likely to show foetal distress and meconium aspiration in spite of a similar occurrence of Apgar score < 7 at 5 minutes. The ~~infants~~newborns of the adolescents were not more prone to being stillborn or being SGA than the ~~infants~~newborns of women ~~age 25–29 years~~in the reference group. The adjusted mean birth weight of ~~infants~~newborns of adolescents did not differ significantly from that of women up to 29 years of age (Figure ~~2~~1).

Mode of delivery, obstetric and neonatal outcome of women 20-24 years of age

The young women, 20 – 24 years of age, differed in some aspects from the reference group ~~(25–29 years)~~ as well as from the adolescents. They were less likely to be delivered prematurely and had a lower frequency of placental abruption. Otherwise the obstetric and neonatal outcomes were similarly favourable as those observed for the adolescents in comparison with the reference group.

Mode of delivery, obstetric and neonatal outcome of women older than 29 years of age

As shown in Table 3 compared with the reference group ~~of women age 25-29 years~~ almost all obstetric outcome variables demonstrated a continuously progressive deterioration with increasing age. The likelihood of normal vaginal births ~~deliveries~~ decreased; induced labour, instrumental deliveries and CS increased as well as prematurity including very premature deliveries. The risk of perineal ~~damage~~ laceration increased moderately whereas the risk of PPH > 1000 ml in vaginal births ~~deliveries~~ was more pronounced. The likelihood of the pregnancy complications preeclampsia, abruptio placenta and placenta previa was also higher in the older age groups and progressed substantially with increasing age. Similarly, the foetal and neonatal outcome was adversely progressively influenced by increasing maternal age. With increasing maternal age over 30 years significantly more neonates were SGA, showed foetal distress, had Apgar score < 7 at 5 minutes or meconium aspiration, or were stillborn. The mean birth weight of the neonates also decreased significantly with increasing maternal age after the age of 30 (Figure 1).

DISCUSSION

This Swedish nation-wide population-based study with prospectively collected data concerning singleton primiparous women showed that the mode of delivery differed over the maternal age strata. Significantly more normal vaginal deliveries and fewer CS and instrumental vaginal deliveries were seen among the teenagers and among women aged 20-24 compared with the reference group of women aged 25-29. The opposite was found among older women reaching a 4-fold increased risk for CS compared with women aged 20-24. The teenagers as well as women aged 20-24 were less prone to perineal lacerations and PPH exceeding 1000 ml. Prematurity (< 28 weeks of GA) was associated with very low maternal age (<17 years) among the adolescents although the increased risk was at the same level as among women aged 40 years and above, indicating a u-shaped risk curve. Adolescents were not afflicted more by preeclampsia than the reference women ~~aged 25-29~~ whereas the risk of preeclampsia increased significantly with advancing maternal age. The risk of placentae praevia increased dramatically with maternal age, actually a 500% increased risk was found after the age of 40 compared with ~~women of 25-29 years of age~~the reference group. There was a significantly increased risk of stillbirth, SGA and low Apgar score only in women aged 30 years and over.

~~The strength of this study is that it deals with the outcomes in the population of an entire country where the antenatal care program is equally available to all pregnant women and is comprehensive. In Sweden pregnant women have completely cost free access to antenatal and obstetric facilities; poverty and malnutrition are practically non-existent and the vast majority of women attends the antenatal care program (99%) independent of socio-economic status and is delivered in obstetric units.[26] This context is valid for the whole study period. Another advantage is the large number of individuals available for evaluation, which makes it possible to divide the study population into subgroups with sufficient numbers in each stratum to provide high statistical power. A sufficient number of study subjects made it possible to evaluate three subgroups of young maternal age. Only primiparous women were included in order to avoid the confounding effects of factors associated with subsequent~~

~~deliveries. There are some limitations that should be considered. The external validity is reduced to facilities with similar socio-economic and demographic characteristics and health care systems with comparable standards. The drawback is obvious given the large size of the study and the numbers of health care units involved that the criteria for diagnosis (ICD codes) to define outcomes may not be uniform across the study population but the variation is most likely not related to maternal age. The MBR contain a large body of information concerning the mother and the child which made it possible to adjust the results for confounding factors. At the same time this is a limitation as only the data available in the register could be used for adjustments. We were not able to adjust for some putative confounders such as ethnicity, socio-economic status and medical conditions such as anemia in pregnancy. These factors may theoretically influence the outcomes.~~

The most prominent difference between the findings in the present study and earlier studies is that no increased risk for SGA was found among the adolescents and young mothers 20-24 years of age compared with the reference women ~~age 25-29~~.[8-9] It must be kept in mind that the definition of SGA may differ between countries. In the United States and Latin America SGA is usually defined as birth weight below the 10th percentile compared with two SD in the Nordic countries.[3, 9] Adjusted risks for SGA among teenagers, recently presented from Finland, one of the Nordic countries, showed no increased risk among the youngest mothers.[6] In that study the control group was defined in the same way as in the present study. Differences concerning the risk for SGA could also be attributable to differences in socio-economic status. Chen et al. restricted their analysis to white married mothers with age-appropriate education level, adequate prenatal care, without smoking and alcohol use during pregnancy but found the increased risk for SGA to persist.[3] Several studies have shown low infant birth weight for adolescents as well as for mothers with advancing age.[18, 14, 26, 27] We failed to find such association among the adolescents, but in women with advancing age the difference in birth weight was statistically significant although the difference lacked clinical significance.

The finding of a preferable ~~delivery~~birth outcome with lower CS rates and lower rates of instrumental delivery among teenagers compared with older women has been pinpointed to a lesser extent than observed adverse outcomes. Earlier studies have shown relatively consistent results concerning a decreased rate of CS in the adolescent group and a higher rate in women with advancing age.[6, 8, 9, 12-18] We were able to evaluate elective and emergency CS separately and the risks among the teenagers and mothers age 20-24 years were decreased for both types. This might indicate that the different risks concerning CS among young and older mothers could not exclusively be explained by more CS on maternal request among older mothers but may even be caused by biological factors. A low rate of instrumental deliveries and CS among adolescents and a high rate among older women have almost unanimously been shown in several reports from high-income ~~developed~~ as well as low-income ~~developing~~ countries.[5, 7, 12-18, 26-29] Whether this phenomenon depends on differences in handling the delivery, inherent or cultural behavioural, domestic or social attitudes among the obstetric staff or biological factors has not been investigated. Advancing age is associated with impaired uterine contractility as well as endothelial dysfunction which theoretically may lead to impaired uterine and utero-placental function.[30, 31] The fact that adolescents in our study had a lower risk of induction of labour, perineal ~~damage~~laceration, PPH, abruption (except for the very young women) and placenta previa and women with advancing age had higher risks of all these outcomes including preeclampsia could support a biological explanation. Concerning prematurity the age related risk curve was U shaped. This may also support a biological aetiology; immaturity of the uterus in the very young women that obstruct development of a term pregnancy and uterine dysfunction caused by ageing processes in women with advancing age and consequently deliver prematurely in both situations. The neonatal outcomes followed almost the same pattern; foetal distress, meconium aspiration, stillbirth, SGA and low Apgar score were exclusively attributed to women older than 29.

The strength of this study is that it deals with the outcomes in the population of an entire country where the antenatal care program is equally available to all pregnant women and is comprehensive. In Sweden pregnant women have completely cost free access to antenatal and obstetric facilities; poverty and malnutrition are practically non-existent and the vast majority of women attends the antenatal care program (99%) independent of socio-economic status and is delivered in obstetric units.[21] This context is valid for the whole study period. Another advantage is the large number of individuals available for evaluation, which makes it possible to divide the study population into subgroups with sufficient numbers in each stratum to provide high statistical power. A sufficient number of study subjects made it possible to evaluate three subgroups of young maternal age. Only primiparous women were included in order to avoid the confounding effects of factors associated with subsequent deliveries. There are limitations that should be considered. The external validity is reduced to facilities with similar socio-economic and demographic characteristics and health care systems with comparable standards. The drawback is obvious given the large size of the study and the numbers of health care units involved that the criteria for diagnosis (ICD codes) to define outcomes may not be uniform across the study population but the variation is most likely not related to maternal age. The MBR contain a large body of information concerning the mother and the child which made it possible to adjust the results for confounding factors. At the same time this is a limitation as only the data available in the register could be used for adjustments. The register lacks information on ethnicity and socio-economic status. Our effort was to evaluate obstetric and neonatal outcome in different maternal age groups compared with women aged 25-29 overall. The only stratifications made were for year of birth, maternal BMI and smoking in early pregnancy. The data on year of birth showed that there is variability in the existence of obstetric and neonatal diagnoses during the observation period. This may be due to true changes but may also be a result of changes in recording, including the expanding use of computerized medical records. It was therefore necessary to adjust for year of birth. Maternal BMI affects obstetric and neonatal outcome.[32] To demonstrate causality between the different outcomes

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evaluated in the analyses and maternal age a great number of putative intermediaries could have been considered such as the use of fertility treatment, foetal size, gestational weight gain etc., but that was not the purpose of the study. A true confounder affects both the exposure and the outcome. There may be other variables (which are not intermediaries) but we have not been able to identify them. If we take for instance maternal hypertension -as an example, it could be of interest. But as the higher risk of hypertension is a consequence of maternal age, it is not a true confounder but an intermediary, a way in which high maternal age can affect obstetric and neonatal pathology.

Our approach of analysing the data may be a benefit for clinicians interpreting the results when dealing with young and aged mothers.

In conclusion, in a country with a highly developed social and antenatal maternity health care security system giving cost free maternity and obstetric care to all pregnant women adolescents had a decreased risk for adverse obstetric and neonatal outcome compared with ~~women aged 25-29~~the reference group. In the same social context childbirth at advanced maternal age was associated with a number of serious complications for both the woman and the child. For clinicians counselling young mothers it is of great importance to highlight the positive consequences that less obstetric complications and favourable neonatal outcomes are expected. There is also a need ~~for more information about the consequences of childbearing at advanced maternal age and~~ to develop surveillance programs in antenatal and obstetric care ~~customized~~ for older women aiming to prevent and protect the increased risks of adverse outcomes for example to earlier detect preeclampsia or recommending prophylactic uterotonic treatment after birth to avoid extensive postpartum bleeding. Such interventions need to be evaluated in well-designed prospective studies.

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Checklist: The manuscript conforms to the STROBE requirement.

Data sharing statement: Technical appendix, statistical code, and dataset available from the corresponding author at Dryad repository, who will provide a permanent, citable and open access home for the dataset.

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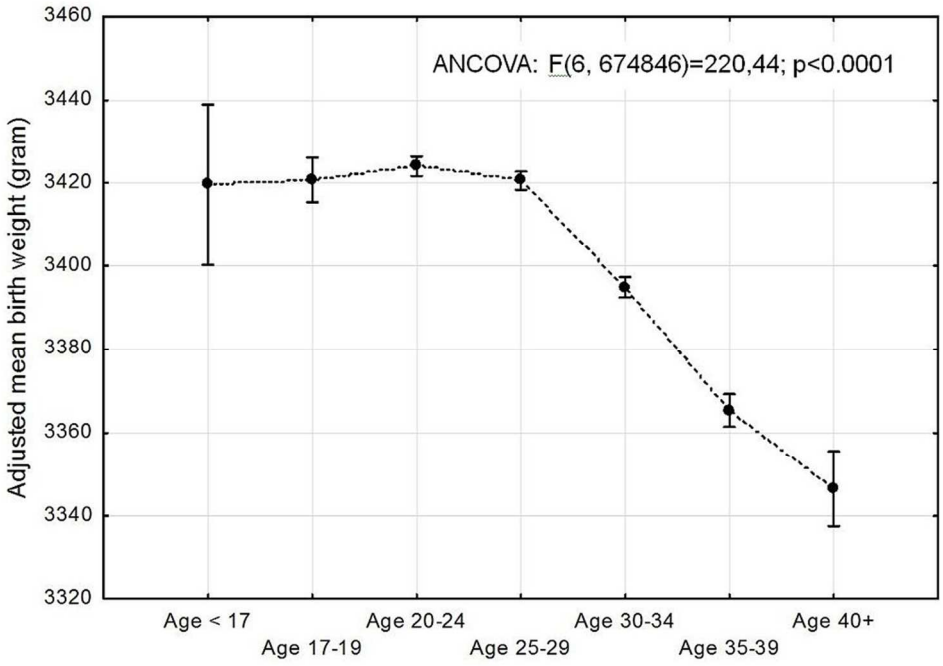
LEGENDS

Figure 1. Adjusted mean birth weight of neonates in singleton primiparous women in different maternal age groups. Birth weight adjusted for gestational age, maternal BMI and smoking habits, and year of delivery. Plots indicate means and bars 95% CI.



90x66mm (300 x 300 DPI)

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract.Done
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found Done
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported. Done
Objectives	3	State specific objectives, including any prespecified hypotheses. Done
Methods		
Study design	4	Present key elements of study design early in the paper.Done
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection. Done
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up. Done *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable. Done
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.Done
Bias	9	Describe any efforts to address potential sources of bias. Done
Study size	10	Explain how the study size was arrived at. All primiparous were included.
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why. Done
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding. Done
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed. Done
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed. Done *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses

Continued on next page

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. Done
		(b) Give reasons for non-participation at each stage
		(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. Tables.
		(b) Indicate number of participants with missing data for each variable of interest
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount). Done
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time. Done
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures
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. Done only Adjusted Ors are given.
		(*b*) Report category boundaries when continuous variables were categorized. Done
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period. Done.
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	18	Summarise key results with reference to study objectives. Done
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias. done
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence. Done
Generalisability	21	Discuss the generalisability (external validity) of the study results. Done
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. Done

*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.

BMJ Open

Impact of maternal age on obstetric and neonatal outcome with emphasis on primiparous adolescents and older women-a Swedish Medical Birth Register Study.

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Keywords:	maternal age, obstetric outcome, neonatal outcome

Impact of maternal age on obstetric and neonatal outcome with emphasis on primiparous adolescents and older women-a Swedish Medical Birth Register Study.

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Keywords: maternal age, mode of delivery, neonatal outcome, obstetric outcome, adolescents

Word count: 3607 words

Abstract

Objectives: To evaluate the associations between maternal age and obstetric and neonatal outcomes in primiparous women with emphasis on teenagers and older women.

Design: A population-based cohort study.

Setting: The Swedish Medical Birth Register.

Participants: Primiparous women with singleton births from 1992 through 2010 (N=798,674) were divided into seven age groups: <17 years, 17-19 years, and additional five five-year classes. The reference group consisted of the women age 25-29 years.

Primary outcome: Obstetric and neonatal outcome.

Results: The teenager groups had significantly more vaginal births (aOR 2.04 (1.79-2.32) and 1.95 (1.88-2.02) for age <17 years and 17–19 years, respectively); fewer caesarean sections (aOR 0.57 (0.48-0.67) and 0.55 (0.53-0.58)), and instrumental vaginal births (aOR 0.43 (0.36-0.52) and 0.50 (0.48-0.53)) compared with the reference group. The opposite was found among older women reaching a 4-fold increased odds ratio for caesarean section. The teenagers showed no increased risk of adverse neonatal outcome but presented an increased risk of prematurity <32 weeks (aOR 1.66 (1.10-2.51) and 1.20 (1.04-1.38)). Women with advancing age (≥ 30 years) revealed significantly increased risk of prematurity, perineal lacerations, preeclampsia, abruption, placenta previa, postpartum haemorrhage and unfavourable neonatal outcomes compared with the reference group.

Conclusions: For clinicians counselling young women it is of importance to highlight the obstetrically positive consequences that fewer maternal complications and favourable neonatal outcomes are expected. The results imply that there is a need for individualizing the antenatal surveillance programs and obstetric care based on age grouping in order to attempt to improve the outcomes in the age groups with less favourable obstetric and neonatal outcomes. Such changes in surveillance programs and obstetric interventions need to be evaluated in further studies.

Article summary

Impact of maternal age on obstetric and neonatal outcome with emphasis on primiparous adolescents and older women-a Swedish Medical Birth Register Study.

Strengths and limitations of this study:

- A strength of the present study is that it includes primiparous women of an entire country where the antenatal care program is equally available to all pregnant women and is comprehensive.
- Another advantage is the large number of individuals available for evaluation, which makes it possible to divide the study population into subgroups with sufficient numbers in each stratum to provide high statistical power.
- A limitation is that the external validity is reduced to facilities with similar socio-economic and demographic characteristics and health care systems with comparable standards.
- The Swedish medical birth register contain a large body of information concerning the mother and the child but only the available data in the register could be used for outcome evaluation and adjustments for putative confounders.

INTRODUCTION

There are a large number of studies evaluating obstetric and neonatal outcome over the full range of reproductive maternal ages, but especially with a focus on the youngest and the oldest mothers. Young mothers have been shown to be exposed to an increased risk of anaemia, low birth weight, foetal death, eclampsia and preterm birth although they at the same time were more likely to have a spontaneous normal vaginal birth and the risk of preeclampsia and post-partum haemorrhage were significantly decreased.[1-6] These studies evaluated outcomes in low-income countries. Many studies performed in low-income countries presented in recent years on the topic of teenage pregnancies have found similar obstetric and neonatal outcomes.[7-11]

Complications during pregnancy and birth at advanced maternal age (either defined as 35 years and older or 40 years or older) have also been evaluated in high-income countries. Advanced maternal age at birth has been found to be associated with gestational diabetes, preeclampsia, placenta previa, caesarean section (CS), placental abruption, preterm delivery, low birth weight, intrauterine foetal death and an increased perinatal mortality.[12-20] The difference in obstetric and neonatal outcomes between teenagers and women at advanced age seemed to be lower risks for several unwanted and threatening outcomes in the teenage group; thus there were no obvious advantages concerning obstetric and neonatal outcomes at advanced maternal ages. The earlier published studies concerning the impact of maternal age on perinatal outcome differ in many aspects methodologically as well as in the socio-demographic characteristics of the populations and health care systems. All these factors make interpretation of comparisons between data sets difficult.

Sweden has during several decades actively developed strategies in social care, education and health care in order to improve antenatal care and parenthood. In a Swedish state-of-the-art conference held in 1990, the scientific basis of the routine antenatal program was critically evaluated. It was concluded that the scientific evidence to support the timing and contents of routine visits was unsatisfactory.[21] Consequently there is a constant need for evaluation both of single diagnostic procedures and

intervention and of outcomes. An analysis of perinatal outcomes in relation to maternal age in the Swedish population will provide important knowledge that may be used to further improve social, antenatal, obstetric and neonatal care and reveals risk groups that in particular may need more attention in the antenatal care.

The objective of the present study was to assess the impact of maternal age on obstetric and neonatal outcomes among singleton primiparous women in Sweden, with special emphasis on the adolescents and older mothers.

MATERIALS AND METHODS

This study analyses the obstetric and neonatal outcomes of all singleton primiparous women prospectively registered in the Swedish Medical Birth Register (MBR) who gave births from January 1, 1992 through December 31, 2010. MBR has collected information about births in Sweden since 1973. It is compulsory for every health care provider to report to the MBR. Medical and other data on almost all (99%) births in Sweden are listed in the register, which also includes stillbirths. Starting with the first antenatal visit, usually in gestational week 10-12, the information is collected prospectively in standardized medical record forms completed at the maternity health care centers at antenatal care visits, in the birth units, and at the paediatric examination of the newborn. The standardized medical records are identical throughout the country. A description and validation of the register content is available.[22-24]

The study population was grouped according to maternal age into seven subgroups: <17 years; 17-19 years; 20-24 years, 25-29 years, 30-34 years; 35-39 years and 40+ years. In the outcome analyses we selected the group of women age 25-29 years as reference group.

The list of available variables in MBR has been extended throughout the years that the register has been active. The obstetric and neonatal outcome data for the purpose of this study are those that have been available since 1992. From 1992 until June 2008 the MBR includes stillbirths after 28 weeks of gestation and from July 2008 until 2010 all stillbirths after 22 weeks of gestation are included. Each outcome studied was either marked in the MBR or registered according to the International Statistical Classification of Diseases and Related Health Problems (ICD). The obstetric outcome variables studied were gestational age, mode of delivery; normal vaginal birth (defined as neither instrumental vaginal delivery, nor CS), CS, instrumental vaginal delivery divided into forceps and vacuum extraction, mode of onset of labour, perineal laceration, preeclampsia, abruptio placentae, placenta previa, use of epidural analgesia and postpartum haemorrhage (PPH) exceeding 1000 ml. The foetal and neonatal outcomes evaluated were Apgar-score at 5 minutes, foetal distress (ICD code P20.0, P20.1 and P20.9),

aspiration of meconium (ICD code P24.0), shoulder dystocia (ICD code O66.0), and stillbirth. Small-for-gestational age (SGA) newborns were defined as those with birth weight more than 2 standard deviations (SD) below the mean birth weight for gestational age (sex and parity specific) according to a Swedish reference curve.[25] Large-for-gestational age (LGA) newborns were those with a birth weight above 2 SD. All descriptive and background data were extracted from the MBR. The register information on these variables was obtained from the antenatal care center records.

The study was approved by the Regional Ethical Review Board in Linköping, Sweden (Dnr 2011/479-31. Approved January 25; 2012).

Statistical analysis

Data are presented as counts and per cent or mean and one SD. Logistic regression analyses were used for comparison of groups for categorical data. Data on a continuous scale were compared using analysis of covariance (ANCOVA). Multivariate logistic regression models were used in order to adjust comparisons for the confounding factors. Consequently crude and adjusted odds ratios (OR and aOR) and 95% confidence intervals (CIs) are reported. Maternal weight and height (used for calculation of maternal Body Mass Index (BMI)) and smoking habits in early pregnancy (unknown, no smoking, smoking) and year of birth were included as confounders in the adjusted analyses. The simultaneous model of including independent variables in the multivariate logistic regression was used since we found it most appropriate for the relevance of the research goal of the study. The rationale for including year of birth as an independent variable was that there was variability in the occurrence of obstetric and neonatal diagnoses during the observation period. This may be due to true changes but may also be a result of changes in recording with expanding use of computerized medical records. Maternal BMI and smoking was included as covariates in the adjusted analyses based on their well-known associations with maternal and foetal outcome and their unequal distribution over the maternal age strata.[26,27] BMI was included as a continuous variable as the distribution of maternal BMI was almost uniform over the maternal age strata and the association between BMI and maternal age was almost linear

(presented as means and standard deviations in Table 1). For the purpose of this study gestational age was added to the confounders in the analyses of CS, preeclampsia and birth weight based on their clinically well-known associations. The OR for instrumental vaginal delivery was calculated among women with vaginal births only in order to exclude women with an instrumental attempt to deliver followed by an emergency CS. The ORs of perineal lacerations were also estimated among women with vaginal births only. The information concerning use of epidural analgesia was also restricted to vaginal births only. Epidural is an analgesic method that has been widely used in the delivery wards for vaginal births during the entire time period. In contrast the use of epidural analgesia in CS has varied substantially over the time period and has almost exclusively been used in elective CS. Our purpose was to evaluate the odds ratio for epidural use over the maternal age strata and consequently we selected the mode of delivery that exhibited the least variation in the use of the analgesic method over the time period, i.e. vaginal births.

The software STATISTICA 64 version 10 (StatSoft Inc. 2300 East 14th St. Tulsa, OK 74104 USA) was used to carry out the statistical analyses.

RESULTS

In the period 1992 – 2010, 798,732 women were registered in the MBR as giving birth to their first child. The annual number of primiparous women giving birth varied between 34060 and 49417. Information on maternal age was missing in 58 cases leaving 798,674 women for the analyses. The average age of primiparous women increased substantially from 26.2 years in 1992 to 28.5 in 2004; hereafter it has stayed almost constant at that level. The demographic, obstetric and neonatal data subdivided into maternal age groups are presented in Table 1 and 2.

Table 1. Descriptive data of primiparous women with singleton births in the period 1992-2010.

Characteristics	< 17 years (n=2392)		17-19 years (n=29816)		20-24 years (n=185942)		25-29 years (n=300822)		30-34 years (n=205905)		35-39 years (n=63163)		40+ years (n=10634)	
BMI (kg/m²)	22.8	3.7	23.2	4.1	23.8	4.3	23.7	4.0	23.8	4.0	24.4	4.1	24.7	4.3
BMI† class														
<18.5 kg/m²	135	5.6%	1815	6.1%	7650	4.1%	7509	2.5%	3847	1.9%	918	1.5%	133	1.3%
18.5-24.9 kg/m²	1352	56.5%	16823	56.4%	104600	56.3%	180163	59.9%	122571	59.5%	34439	54.5%	5381	50.1%
25.0-29.9 kg/m²	315	13.2%	4687	15.7%	33961	18.3%	53896	17.9%	37234	18.1%	13310	21.1%	2442	23.0%
30.0-34-9 kg/m²	81	3.4%	1327	4.5%	10550	5.7%	14401	4.8%	9389	4.6%	3575	5.7%	683	6.4%
35.0-39.9 kg/m²	11	0.5%	337	1.1%	3013	1.6%	4070	1.4%	2724	1.3%	1024	1.6%	188	1.8%
≥ 40.0 kg/m²	4	0.2%	87	0.3%	904	0.5%	1312	0.4%	944	0.5%	342	0.5%	68	0.6%
Missing data	494	20.7%	4740	15.9%	25264	13.6%	39471	13.1%	29196	14.2%	9555	15.1%	1739	16.4%
Smoking†														
Yes	666	27.8%	9012	30.2%	31675	17.0%	24676	8.2%	13971	6.8%	5287	8.4%	958	9.0%
No	1542	64.5%	19154	64.3%	145695	78.4%	261348	86.9%	178792	86.8%	53416	84.6%	8883	83.5%
Missing data	184	7.7%	1650	5.5%	8572	4.6%	14798	4.9%	13142	6.4%	4460	7.0%	793	7.5%
Gestational age														
Information available	2368	99.0%	29715	99.7%	185700	99.9%	300603	99.9%	205719	99.9%	63098	99.9%	10620	99.9%
Missing data	24	1.0%	101	0.3%	242	0.1%	219	0.1%	186	0.1%	65	0.1%	14	0.1%

Figures denote mean and standard deviation or counts and proportions.
BMI = body mass index.
† Reported height, weight and smoking habits at first antenatal visit.

Table 2. Obstetric and neonatal outcome characteristics of primiparous women with singleton births in the period 1992-2010.

	Age groups													
Characteristics	< 17 years (n=2392)		17-19 years (n=29816)		20-24 years (n=185942)		25-29 years (n=300822)		30-34 years (n=205905)		35-39 years (n=63163)		40+ years (n=10634)	
Labour:														
Spontaneous onset labour	2055	85.9%	25853	86.7%	158879	85.4%	251340	83.6%	163876	79.6%	45330	71.2%	6261	58.9%
Induced labour	184	7.7%	2528	8.5%	17433	9.4%	30873	10.3%	25474	12.4%	10065	15.9%	2111	19.9%
Mode of delivery:														
Normal vaginal birth	2030	84.9%	25096	84.2%	147082	79.1%	219993	73.1%	135099	65.6%	35112	55.6%	4724	44.4%
Forceps	7	0.3%	126	0.4%	1143	0.6%	2166	0.7%	1515	0.7%	575	0.9%	84	0.8%
Vacuum extraction	143	6.0%	2090	7.0%	18011	9.7%	36696	12.2%	29811	14.5%	10119	16.0%	1599	15.0%
CS¥	213	8.9%	2500	8.4%	19747	10.6%	42044	14.0%	39534	19.2%	17355	27.5%	4226	39.7%
CS elective 1999-2010 ‡	53	2.2%	373	1.3%	2828	1.5%	6973	2.3%	7656	3.7%	3853	6.1%	1132	10.6%
CS acute 1999-2010 ‡	73	3.1%	882	3.0%	7092	3.8%	16651	5.5%	17953	8.7%	7826	12.4%	1798	16.9%
Gestational age:														
GA < 28 weeks	20	0.8%	107	0.4%	464	0.2%	743	0.2%	640	0.3%	292	0.5%	73	0.7%
GA < 32 weeks	40	1.7%	308	1.0%	1436	0.8%	2415	0.8%	2048	1.0%	900	1.4%	206	1.9%
GA < 37 weeks	213	8.9%	1937	6.5%	11030	5.9%	18005	5.6%	12727	6.2%	4586	7.3%	877	8.2%
GA 37 – 41 weeks	1990	83.2%	25811	86.6%	161043	86.6%	257320	85.5%	172621	83.8%	51494	81.5%	8786	82.6%
GA ≥ 42 weeks	165	6.9%	1967	6.6%	13627	7.3%	25278	8.4%	20371	9.9%	7018	11.1%	957	9.0%
Maternal complications and use of epidural analgesia:														
Perineal laceration gr 1-2*	311	14.3%	3982	14.6%	32602	19.6%	70452	27.3%	55163	33.2%	15477	33.9%	2116	33.1%
Perineal laceration gr 3-4*	23	1.1%	272	1.0%	3030	1.8%	8202	3.2%	6846	4.1%	1856	4.1%	222	3.5%
Preeclampsia	43	1.8%	576	1.9%	4317	2.3%	6520	2.2%	4265	2.1%	1610	2.5%	365	3.4%
Abruptio placentae	16	0.7%	135	0.5%	643	0.3%	1171	0.4%	955	0.5%	390	0.6%	87	0.8%
Placenta previa	2	0.1%	16	0.1%	159	0.1%	505	0.2%	612	0.3%	375	0.6%	89	0.8%
PPH > 1000 ml (VB)	65	3.0%	667	2.4%	5078	3.1%	10931	4.2%	9720	5.9%	3173	6.9%	485	7.6%
PPH > 1000 ml (CS)	2	0.9%	28	1.1%	252	1.3%	541	1.3%	578	1.5%	237	1.4%	80	1.9%
Epidural analgesia*	903	41.4%	11569	42.4%	68332	41.1%	105266	40.7%	70691	42.5%	20151	44.0%	2743	42.9%

Table 2 continued. Obstetric and neonatal outcome characteristics of primiparous women with singleton births in the period 1992-2010.

	Age groups													
Characteristics	< 17 years (n=2392)		17-19 years (n=29816)		20-24 years (n=185942)		25-29 years (n=300822)		30-34 years (n=205905)		35-39 years (n=63163)		40+ years (n=10634)	
Neonatal														
Foetal distress	8	0.3%	122	0.4%	932	0.5%	1621	0.5%	1070	0.5%	388	0.6%	56	0.5%
Aspiration of meconium	0	0%	30	0.1%	363	0.2%	649	0.2%	563	0.3%	193	0.3%	42	0.4%
Shoulder dystocia	6	0.3%	78	0.3%	793	0.4%	1580	0.5%	1382	0.7%	489	0.8%	79	0.7%
Stillbirth	7	0.3%	102	0.3%	571	0.3%	893	0.3%	768	0.4%	347	0.5%	87	0.8%
SGA	91	3.8%	1136	3.8%	6016	3.2%	8831	2.9%	7216	3.5%	2962	4.7%	617	5.8%
LGA	47	2.0%	539	1.8%	3838	2.1%	5943	2.0%	3846	1.9%	1279	2.0%	224	2.1%
Apgar score < 7 at 5	43	1.8%	381	1.3%	2409	1.3%	4158	1.4%	3354	1.6%	1274	2.0%	240	2.3%
Birth weight (gram)	3348	592	3403	565	3453	554	3470	555	3452	572	3415	612	3360	640

Figures denote counts and proportions or mean and one standard deviation.

BMI = body mass index; CS = caesarean section; GA = gestational age at birth; LGA = large for gestational age; PPH = postpartum haemorrhage; SGA = small for gestational age; VB = vaginal birth

[¥]All CS independent of status of performance – acute or elective. [†]Caesarean section was subdivided into elective and acute CS from 1999.

*Epidural analgesia and perineal lacerations in vaginal births only.

The crude odds rates and the results of the multivariate analyses models of obstetric and neonatal outcomes are shown in Table 3 and 4, respectively.

Table 3. Obstetric outcome data in singleton primiparous women in the period 1992-2010 in relation to maternal age group.

Characteristics	Crude OR (95%CI)	aOR (95%CI)†	Crude OR (95%CI)	aOR (95%CI)†	Crude OR (95%CI)	aOR (95%CI)†
Labour	< 17 years		17-19 years		20-24 years	
Spontaneous onset labour	1.20 (1.07-1.35)	1.20 (1.05-1.37)	1.28 (1.24-1.33)	1.26 (1.21-1.31)	1.16 (1.14-1.17)	1.16 (1.14-1.18)
Induced labour	0.73 (0.63-0.85)	0.78 (0.66-0.93)	0.81 (0.78-0.85)	0.86 (0.82-0.90)	0.90 (0.89-0.92)	0.91 (0.90-0.93)
	30 - 34 years		35 - 39 years		40+ years	
Spontaneous onset labour	0.77 (0.76-0.78)	0.78 (0.77-0.79)	0.50 (0.49-0.51)	0.52 (0.51-0.54)	0.29 (0.26-0.30)	0.30 (0.28-0.31)
Induced labour	1.23 (1.21-1.26)	1.19 (1.17-1.21)	1.66 (1.62-1.70)	1.54 (1.50-1.58)	2.17 (2.06-2.27)	1.97 (1.87-2.08)
Mode of delivery	< 17 years		17-19 years		20-24 years	
Normal vaginal birth	2.05 (1.84-2.30)	2.04 (1.79-2.32)	1.95 (1.89-2.02)	1.95 (1.88-2.02)	1.39 (1.37-1.41)	1.39 (1.37-1.41)
Forceps¥	0.38 (0.18-0.81)	0.41 (0.18-0.92)	0.55 (0.46-0.64)	0.48 (0.39-0.59)	0.82 (0.76-0.88)	0.77 (0.71-0.84)
Vacuum extraction¥	0.42 (0.36-0.51)	0.43 (0.36-0.52)	0.50 (0.48-0.53)	0.50 (0.48-0.53)	0.74 (0.72-0.75)	0.74 (0.72-0.75)
CS. all	0.60 (0.52-0.69)	0.57 (0.48-0.67)	0.56 (0.54-0.69)	0.55 (0.53-0.58)	0.73 (0.72-0.74)	0.72 (0.71-0.74)
CS elective 1999-2010 ‡	0.95 (0.73-1.25)	0.83 (0.60-1.14)	0.53 (0.48-0.59)	0.53 (0.47-0.60)	0.65 (0.62-0.68)	0.68 (0.65-0.71)
CS acute 1999-2010 ‡	0.54 (0.43-0.68)	0.53 (0.40-0.69)	0.52 (0.49-0.56)	0.56 (0.52-0.61)	0.68 (0.66-0.70)	0.71 (0.69-0.73)
	30 - 34 years		35 - 39 years		40+ years	
Normal vaginal delivery	0.70 (0.69-0.71)	0.72 (0.71-0.73)	0.46 (0.45-0.47)	0.48 (0.47-0.49)	0.29 (0.28-0.31)	0.31 (0.30-0.32)
Forceps¥	1.08 (1.01-1.15)	1.20 (1.12-1.29)	1.48 (1.35-1.63)	1.66 (1.49-1.84)	1.58 (1.27-1.98)	1.75 (1.37-2.24)
Vacuum extraction¥	1.32 (1.30-1.34)	1.29 (1.27-1.32)	1.72 (1.67-1.76)	1.67 (1.63-1.72)	2.01 (1.90-2.13)	1.92 (1.80-2.04)
CS. all	1.46 (1.44-1.49)	1.44 (1.42-1.47)	2.34 (2.29-2.38)	2.21 (2.16-2.26)	4.07 (3.91-4.23)	3.78 (3.61-3.96)
CS elective 1999-2010 ‡	1.63 (1.57-1.68)	1.44 (1.39-1.49)	2.74 (2.63-2.85)	2.25 (2.15-2.35)	5.03 (4.70-5.36)	3.89 (3.61-4.20)
CS acute 1999-2010 ‡	1.63 (1.59-1.67)	1.44 (1.40-1.47)	2.41 (2.35-2.48)	1.94 (1.88-2.00)	3.47 (3.29-3.66)	2.68 (2.52-2.85)
Gestational age	< 17 years		17-19 years		20-24 years	
GA < 28 weeks	3,44 (2.20-5.37)	2.84 (1.59-5.06)	1.46 (1.19-1.79)	1.25 (0.97-1.62)	1.01 (0.90-1.14)	0.89 (0.77-1.02)
GA < 32 weeks	2.12 (1.55-2.91)	1.66 (1.10-2.51)	1.29 (1.15-1.46)	1.20 (1.04-1.38)	0.96 (0.90-1.03)	0.92 (0.85-0.99)
GA < 37 weeks	1.55 (1.34-1.79)	1.46 (1.24-1.72)	1.09 (1.04-1.15)	1.03 (0.98-1.09)	0.99 (0.97-1.02)	0.97 (0.95-1.00)
GA 37 – 41 weeks	0.89 (0.79-0.99)	0.88 (0.77-0.99)	1.11 (1.07-1.15)	1.14 (1.09-1.18)	1.10 (2.08-1.12)	1.12 (1.10-1.14)
GA ≥ 42 weeks	0.82 (0.70-0.96)	0.89 (0.75-1.06)	0.77 (0.74-0.81)	0.79 (0.74-0.83)	0.86 (0.84-0.88)	0.85 (0.83-0.87)
	30 - 34 years		35 - 39 years		40+ years	
GA < 28 weeks	1.26 (1.13-1.40)	1.17 (1.04-1.33)	1.88 (1.64-2.15)	1.61 (1.40-1.90)	2.79 (2.19-3.56)	2.48 (1.86-3.29)
GA < 32 weeks	1.24 (1-17-1.32)	1.24 (1.16-1.33)	1.79 (1.65-1.93)	1.68 (1.53-1.84)	2.44 (2.12-2.82)	2.25 (1.90-2.66)
GA < 37 weeks	1.04 (1.01-1.06)	1.02 (0.99-1.05)	1.23 (1-19-1.27)	1.19 (1.15-1.24)	1.41 (1.32-1.52)	1.37 (1.26-1.48)
GA 37 – 41 weeks	0.88 (0.86-0.89)	0.89 (0.86-0.89)	0.75 (0.73-0.76)	0.76 (0.74-0.78)	0.81 (0.77-0.85)	0.83 (0.79-0.88)
GA ≥ 42 weeks	1.20 (1.17-1.22)	1.20 (1.18-1.23)	1.36 (1.33-1.40)	1.35 (1.31-1.39)	1.08 (1.01-1.15)	1.06 (0.98-1.14)

Table 3 continued. Obstetric outcome data in singleton primiparous women in the period 1992-2010 in relation to maternal age group.

Characteristics	Crude OR (95%CI)	aOR (95%CI)†	Crude OR (95%CI)	aOR (95%CI)†	Crude OR (95%CI)	aOR (95%CI)†
Maternal complications and use of epidural analgesia:	< 17 years		17-19 years		20-24 years	
Perineal laceration grade 1-2¥	0.44 (0.39-0.50)	0.44 (0.38-0.50)	0.46 (0.44-0.47)	0.47 (0.45-0.49)	0.65 (0.64-0.66)	0.68 (0.67-0.69)
Perineal laceration grade 3-4¥	0.33 (0.22-0.49)	0.39 (0.25-0.60)	0.31 (0.25-0.37)	0.37 (0.32-0.42)	0.57 (0.54-0.59)	0.61 (0.58-0.64)
Preeclampsia	0.83 (0.61-1.12)	0.89 (0.62-1.27)	0.89 (0.82-0.97)	0.93 (0.84-1.02)	1.07 (1.03-1.12)	1.01 (0.96-1.05)
Abruptio placentae	1.72 (1.05-2.83)	1.76 (1.03-3.00)	1.16 (0.97-1.39)	1.02 (0.83-1.26)	0.89 (0.81-0.98)	0.83 (0.74-0.92)
Placenta praevia	0.50 (0.12-2.00)	0.57 (0.14-2.30)	0.32 (0.19-0.53)	0.28 (0.16-0.50)	0.52 (0.43-0.61)	0.52 (0.43-0.63)
PPH > 1000 ml (VB)	0.70 (0.54-0.89)	0.65 (0.48-0.88)	0.57 (0.53-0.61)	0.64 (0.59-0.70)	0.71 (0.69-0.74)	0.78 (0.75-0.81)
PPH > 1000 ml (CS)	0.73 (0.18-2.93)	0.52 (0.07-3.74)	0.87 (0.59-1.27)	1.16 (0.77-1.93)	0.99 (0.92-1.07)	1.09 (0.93-1.28)
Epidural analgesia¥	1.03 (0.95-1.12)	1.03 (0.93-1.13)	1.07 (1.06-1.08)	1.07 (1.04-1.10)	1.02 (1.01-1.03)	1.03 (1.01-1.04)
	30 - 34 years		35 - 39 years		40+ years	
Perineal laceration grade 1-2¥	1.33 (1.31-1.34)	1.11 (1.10-1.13)	1.37 (1-34-1.40)	1.08 (1.05-1.10)	1.32 (1.25-1.39)	1.00 (0.94-1.07)
Perineal laceration grade 3-4¥	1.31 (1.27-1.36)	1.16 (1.12-1.20)	1.29 (1.23-1.36)	1.12 (1.05-1.18)	1.10 (0.96-1.26)	0.88 (0.75-1.02)
Preeclampsia	0.95 (0.92-0.99)	1.07 (1.03-1.12)	1.18 (1.12-1.25)	1.30 (1.22-1.39)	1.60 (1.44-1.79)	1.83 (1.62-2.06)
Abruptio placentae	1.19 (1.09-1.30)	1.27 (1.16-1.40)	1.59 (1.42-1.78)	1.71 (1.50-1.94)	2.11 (1-70-2.63)	2.09 (1.62-2.71)
Placenta praevia	1.77 (1.58-1.99)	1.74 (1.53-2.00)	3.55 (3.11-4.06)	3.47 (2.99-4.03)	5.02 (4.00-6.29)	5.23 (4.08-6.70)
PPH > 1000 ml (VB)	1.41 (1.37-1.45)	1.27 (1.23-1.31)	1.69 (1.62-1.76)	1.47 (1.40-1.53)	1.86 (1.69-2.05)	1.48 (1.26-1.52)
PPH > 1000 ml (CS)	1.14 (1.01-1.28)	1.04 (0.91-1.18)	1.06 (0.91-1.24)	0.95 (0.81-1.12)	1.48 (1.17-1.88)	1.35 (1.05-1.73)
Epidural analgesia¥	1.08 (1.06-1.09)	1.03 (1.02-1.05)	1.14 (1.12-1.17)	1.06 (1.04-1.09)	1.10 (1.04-1.15)	0.98 (0.93-1.03)

Reference group: Maternal age 25-29 years.

CI = confidence intervals; CS = Caesarean section; GA = gestational age at delivery; N/A = not applicable; aOR = adjusted odds ratio; PPH = postpartum haemorrhage; VD = vaginal birth.

† Adjusted for maternal BMI and smoking habits at first antenatal care visit and year of birth. CS and preeclampsia also adjusted for gestational age. ‡ Caesarean section was subdivided into elective and acute CS from 1999. ¥ Forceps, vacuum extraction, epidural analgesia and perineal lacerations among vaginally delivered women.

Table 4. Neonatal outcome data in singleton primiparous women in the period 1992-2010 in relation to maternal age group.

Characteristics	Crude OR (95%CI)	aOR (95%CI)†	Crude OR (95%CI)	aOR (95%CI)†	Crude OR (95%CI)	aOR (95%CI)†
	< 17 years		17-19 years		20-24 years	
Foetal distress	0.62 (0.31-1.24)	0.52 (0.22-1.26)	0.76 (0.63-0.91)	0.63 (0.51-0.79)	0.93 (0.86-1.01)	0.79 (0.72-0.91)
Aspiration of meconium	N/A	N/A	0.47 (0.32-0.67)	0.46 (0.31-0.70)	0.90 (0.80-1.03)	0.93 (0.81-1.07)
Shoulder dystocia¥	0.45 (0.11-1.82)	0.32(0.05-2.29)	0.74 (0.58-0.90)	0.74 (0.52-1.07)	1.01 (0.88-1.16)	1.00 (0.86-1.16)
Stillbirth	0.99 (0.47-2.08)	0.58 (0.19-1.80)	1.15 (0.94-1.42)	0.97 (0.75-1.25)	1.03 (0.93-1.15)	0.98 (0.87-1.11)
SGA	1.32 (1.07-1.63)	1.00 (0.78-1.28)	1.31 (1.23-1.40)	1.01 (0.94-1.09)	1.11 (1.07-1.14)	1.00 (0.96-1.04)
LGA	1.01 (0.75-1.34)	1.08 (0.76-1.53)	0.92 (0.84-1.00)	1.03 (0.94-1.14)	1.05 (1.00-1.09)	1.05 (1.00-1.10)
Apgar score < 7 at 5 minutes	1.31 (0.96-1.77)	1.30 (0.91-1.86)	0.92 (0.83-1.03)	0.92 (0.81-1.11)	0.93 (0.89-0.99)	0.93 (0.88-0.98)
	30 - 34 years		35 - 39 years		40+ years	
Foetal distress	0.96 (0.89-1.04)	1.23 (1.13-1.35)	1.14 (1.02-1.27)	1.51 (1.33-1.72)	0.98 (0.75-1.28)	1.60 (1.20-2.13)
Aspiration of meconium	1.27 (1.13-1.42)	1.36 (1.20-1.54)	1.42 (1.21-1.67)	1.48 (1.24-1.77)	1.83 (1.34-2.51)	1.82 (1.28-2.58)
Shoulder dystocia¥	1.18 (1.04-1.35)	1.13 (0.90-1.41)	1.13 (0.91-1.39)	1.13 (0.91-1.41)	1.47 (0.93-2.33)	1.27 (0.76-2.12)
Stillbirth	1.26 (1.14-1.38)	1.25 (1.12-1.39)	1.85 (1.64-2.10)	1.72 (1.49-1.99)	2.77 (2.22-3.46)	2.34 (1.80-3.03)
SGA	1.20 (1.16-1.24)	1.24 (1.20-1.28)	1.63 (1.56-1.70)	1.65 (1.58-1.73)	2.04 (1.87-2.22)	2.06 (1.87-2.26)
LGA	0.94 (0.91-0.98)	0.94 (0.90-0.98)	1.03 (0.97-1.09)	0.97 (0.91-1.04)	1.07 (0.93-1.22)	0.94 (0.81-1.09)
Apgar score < 7 at 5 minutes	1.18 (1.13-1.24)	1.18 (1.12-1.24)	1.47 (1.38-1.56)	1.39 (1.29-1.49)	1.65 (1.44-1.88)	1.51 (1.30-1.75)

Reference group: Maternal age 25-29 years.

CI = confidence interval; LGA = large for gestational age; N/A = not applicable; aOR = adjusted odds ratio; SGA = small for gestational age

† Adjusted for maternal BMI and smoking habits at first antenatal care visit and year of birth

¥ Shoulder dystocia among vaginal delivered women.

Mode of delivery, obstetric and neonatal outcome of adolescents

Compared with the reference group the teenagers had a significantly higher likelihood of having spontaneous onset of labour and of having a normal vaginal delivery. Teenagers also demonstrated a significantly higher risk of giving birth prematurely. However, only the group of teenagers younger than 17 years of age had an increased risk of giving birth very prematurely i.e. before 28 weeks of gestational age, and the same group revealed a significantly higher risk of placental abruption. In contrast with these observations the teenagers were delivered instrumentally and by CS significantly less often, and the vaginal births caused significantly fewer perineal lacerations (only evaluated among women who delivered vaginally) and PPH > 1000 ml. Likewise the occurrence of placenta previa was seen less often among teenagers whereas the occurrence of preeclampsia was equal to that seen in the reference group.

Concerning the foetal and neonatal outcomes for adolescents the newborns were less likely to show foetal distress and meconium aspiration in spite of a similar occurrence of Apgar score < 7 at 5 minutes. The newborns of the adolescents were not more prone to being stillborn or being SGA than the newborns of women in the reference group. The adjusted mean birth weight of newborns of adolescents did not differ significantly from that of women up to 29 years of age (Figure 1).

Mode of delivery, obstetric and neonatal outcome of women 20-24 years of age

The young women, 20 – 24 years of age, differed in some aspects from the reference group as well as from the adolescents. They were less likely to be delivered prematurely and had a lower frequency of placental abruption. Otherwise the obstetric and neonatal outcomes were similarly favourable as those observed for the adolescents in comparison with the reference group.

Mode of delivery, obstetric and neonatal outcome of women older than 29 years of age

As shown in Table 3 compared with the reference group almost all obstetric outcome variables demonstrated a continuously progressive deterioration with increasing age. The likelihood of normal

vaginal births decreased; induced labour, instrumental deliveries and CS increased as well as prematurity including very premature deliveries. The risk of perineal laceration increased moderately whereas the risk of PPH > 1000 ml in vaginal births was more pronounced. The likelihood of the pregnancy complications preeclampsia, abruptio placenta and placenta previa was also higher in the older age groups and progressed substantially with increasing age. Similarly, the foetal and neonatal outcome was adversely progressively influenced by increasing maternal age. With increasing maternal age over 30 years significantly more neonates were SGA, showed foetal distress, had Apgar score < 7 at 5 minutes or meconium aspiration, or were stillborn. The mean birth weight of the neonates also decreased significantly with increasing maternal age after the age of 30 (Figure 1).

DISCUSSION

This Swedish nation-wide population-based study with prospectively collected data concerning singleton primiparous women showed that the mode of delivery differed over the maternal age strata. Significantly more normal vaginal deliveries and fewer CS and instrumental vaginal deliveries were seen among the teenagers and among women aged 20-24 compared with the reference group of women aged 25-29. The opposite was found among older women reaching a 4-fold increased risk for CS compared with women aged 20-24. The teenagers as well as women aged 20-24 were less prone to perineal lacerations and PPH exceeding 1000 ml. Prematurity (< 28 weeks of GA) was associated with very low maternal age (<17 years) among the adolescents although the increased risk was at the same level as among women aged 40 years and above, indicating a u-shaped risk curve. Adolescents were not afflicted more by preeclampsia than the reference women whereas the risk of preeclampsia increased significantly with advancing maternal age. The risk of placentae praevia increased dramatically with maternal age, actually a 500% increased risk was found after the age of 40 compared with the reference group. There was a significantly increased risk of stillbirth, SGA and low Apgar score only in women aged 30 years and over.

The most prominent difference between the findings in the present study and earlier studies is that no increased risk for SGA was found among the adolescents and young mothers 20-24 years of age compared with the reference women.[8-9] It must be kept in mind that the definition of SGA may differ between countries. In the United States and Latin America SGA is usually defined as birth weight below the 10th percentile compared with two SD in the Nordic countries.[3, 9] Adjusted risks for SGA among teenagers, recently presented from Finland, one of the Nordic countries, showed no increased risk among the youngest mothers.[6] In that study the control group was defined in the same way as in the present study but the Finnish study did not adjust for smoking habits. We found that smoking in early pregnancy was a significant independent risk factor for SGA in all age groups but it was only in the young women below 25 years of age that the adjustment of smoking turned the statistically

significant crude ORs into non-significant adjusted OR values. The contrary was found for the older women where the already significant crude ORs for SGA even became increased. This observation may support a biological explanation for SGA in the older women. Differences concerning the risk for SGA could also be attributable to differences in socio-economic status. Chen et al. restricted their analysis to white married mothers with age-appropriate education level, adequate prenatal care, without smoking and alcohol use during pregnancy but found the increased risk for SGA to persist.[3] Several studies have shown low infant birth weight for adolescents as well as for mothers with advancing age.[18, 14, 28, 29] We failed to find such association among the adolescents, but in women with advancing age the difference in birth weight was statistically significant although the difference lacked clinical significance.

The finding of a preferable birth outcome with lower CS rates and lower rates of instrumental delivery among teenagers compared with older women has been pinpointed to a lesser extent than observed adverse outcomes. Earlier studies have shown relatively consistent results concerning a decreased rate of CS in the adolescent group and a higher rate in women with advancing age.[6, 8, 9, 12-18] We were able to evaluate elective and emergency CS separately and the risks among the teenagers and mothers age 20-24 years were decreased for both types. This might indicate that the different risks concerning CS among young and older mothers could not exclusively be explained by more CS on maternal request among older mothers but may even be caused by biological factors. A low rate of instrumental deliveries and CS among adolescents and a high rate among older women have almost unanimously been shown in several reports from high-income as well as low-income countries.[5, 7, 12-18, 28-31] Whether this phenomenon depends on differences in handling the delivery, inherent or cultural behavioural, domestic or social attitudes among the obstetric staff or biological factors has not been investigated. Advancing age is associated with impaired uterine contractility as well as endothelial dysfunction which theoretically may lead to impaired uterine and utero-placental function.[32, 33] The fact that adolescents in our study had a lower risk of induction of labour, perineal laceration, PPH,

abruption (except for the very young women) and placenta previa and women with advancing age had higher risks of all these outcomes including preeclampsia could support a biological explanation. Concerning prematurity the age related risk curve was U shaped. This may also support a biological aetiology; immaturity of the uterus in the very young women that obstruct development of a term pregnancy and uterine dysfunction caused by ageing processes in women with advancing age and consequently deliver prematurely in both situations. The neonatal outcomes followed almost the same pattern; foetal distress, meconium aspiration, stillbirth, SGA and low Apgar score were exclusively attributed to women older than 29.

The strength of this study is that it deals with the outcomes in the population of an entire country where the antenatal care program is equally available to all pregnant women and is comprehensive. In Sweden pregnant women have completely cost free access to antenatal and obstetric facilities; poverty and malnutrition are practically non-existent and the vast majority of women attends the antenatal care program (99%) independent of socio-economic status and is delivered in obstetric units.[21] This context is valid for the whole study period. Another advantage is the large number of individuals available for evaluation, which makes it possible to divide the study population into subgroups with sufficient numbers in each stratum to provide high statistical power. A sufficient number of study subjects made it possible to evaluate three subgroups of young maternal age. Only primiparous women were included in order to avoid the confounding effects of factors associated with subsequent deliveries. There are limitations that should be considered. The external validity is reduced to facilities with similar socio-economic and demographic characteristics and health care systems with comparable standards. The drawback is obvious given the large size of the study and the numbers of health care units involved that the criteria for diagnosis (ICD codes) to define outcomes may not be uniform across the study population but the variation is most likely not related to maternal age. The MBR contain a large body of information concerning the mother and the child which made it possible to adjust the results for confounding factors. At the same time this is a limitation as only the data available in the

register could be used for adjustments. The register lacks information on ethnicity and socio-economic status. Our effort was to evaluate obstetric and neonatal outcome in different maternal age groups compared with women aged 25-29 overall. The only stratifications made were for year of birth, maternal BMI and smoking in early pregnancy. The data on year of birth showed that there is variability in the existence of obstetric and neonatal diagnoses during the observation period. This may be due to true changes but may also be a result of changes in recording, including the expanding use of computerized medical records. It was therefore necessary to adjust for year of birth. Maternal BMI, maternal smoking and gestational age (for some relevant outcomes) were included in the adjusted analyses based on their well known association with maternal and foetal outcome.[26,27] Putative confounders and intermediaries were not identified with statistical analysis. To demonstrate causality between the different outcomes evaluated in the analyses and maternal age a great number of putative intermediaries could have been considered such as the use of fertility treatment, foetal size, gestational weight gain etc., but that was not the purpose of the study. A true confounder affects both the exposure and the outcome. There may be other variables (which are not intermediaries) but we have not been able to identify them. If we take for instance maternal hypertension as an example, it could be of interest. But as the higher risk of hypertension is a consequence of maternal age, it is not a true confounder but an intermediary, a way in which high maternal age can affect obstetric and neonatal pathology. The proportion of missing data concerning the included confounders could have affected the results. The youngest age group had the highest frequency of missing data on BMI (20.7%) and smoking (7.7%) compared with the reference group (13.1% and 4.9%, respectively). The distribution of BMI in the youngest age group was almost equal to the other maternal age groups. One explanation for a higher proportion of missing data in the youngest age group could be a later detection of their pregnancies and attendance to the antenatal care and questions concerning exposure in early pregnancy were not raised. Gestational age could be calculated for more than 99% of the study subjects in this study with just minimal variations between maternal age groups.

Our approach of analysing the data may be a benefit for clinicians interpreting the results when dealing with young and aged mothers.

In conclusion, in a country with a highly developed social and antenatal maternity health care security system giving cost free maternity and obstetric care to all pregnant women adolescents had a decreased risk for adverse obstetric and neonatal outcome compared with the reference group. In the same social context childbirth at advanced maternal age was associated with a number of serious complications for both the woman and the child. For clinicians counselling young mothers it is of great importance to highlight the positive consequences that less obstetric complications and favourable neonatal outcomes are expected. The results imply that there is a need for individualizing the antenatal surveillance programs and obstetric care based on age grouping in order to attempt to improve the outcomes in the age groups with less favourable obstetric and neonatal outcomes. Such changes in surveillance programs and obstetric interventions need to be evaluated in further studies.

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Checklist: The manuscript conforms to the STROBE requirement.

Data sharing statement: Technical appendix, statistical code, and dataset available from the corresponding author at Dryad repository, who will provide a permanent, citable and open access home for the dataset.

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LEGENDS

Figure 1. Adjusted mean birth weight of neonates in singleton primiparous women in different maternal age groups. Birth weight adjusted for gestational age, maternal BMI and smoking habits, and year of delivery. Plots indicate means and bars 95% CI.

Impact of maternal age on obstetric and neonatal outcome with emphasis on primiparous adolescents and older women-a Swedish Medical Birth Register Study.

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Abstract

Objectives: To evaluate the associations between maternal age and obstetric and neonatal outcomes in primiparous women with emphasis on teenagers and older women.

Design: A population-based cohort study.

Setting: The Swedish Medical Birth Register.

Participants: Primiparous women with singleton births from 1992 through 2010 (N=798,674) were divided into seven age groups: <17 years, 17-19 years, and additional five five-year classes. The reference group consisted of the women age 25-29 years.

Primary outcome: Obstetric and neonatal outcome.

Results: The teenager groups had significantly more vaginal births (aOR 2.04 (1.79-2.32) and 1.95 (1.88-2.02) for age <17 years and 17–19 years, respectively); fewer caesarean sections (aOR 0.57 (0.48-0.67) and 0.55 (0.53-0.58)), and instrumental vaginal births (aOR 0.43 (0.36-0.52) and 0.50 (0.48-0.53)) compared with the reference group. The opposite was found among older women reaching a 4-fold increased ~~risk~~ odds ratio for caesarean section. The teenagers showed no increased risk of adverse neonatal outcome but presented an increased risk of prematurity <32 weeks (aOR 1.66 (1.10-2.51) and 1.20 (1.04-1.38)). Women with advancing age (≥ 30 years) revealed significantly increased risk of prematurity, perineal lacerations, preeclampsia, abruption, placenta previa, postpartum haemorrhage and unfavourable neonatal outcomes compared with the reference group.

Conclusions: For clinicians counselling young women it is of importance to highlight the obstetrically positive consequences that fewer maternal complications and favourable neonatal outcomes are expected. -The results imply that there is a need for individualizing the antenatal surveillance programs and obstetric care based on age grouping in order to attempt to improve the outcomes in the age groups with less favourable obstetric and neonatal outcomes. Such changes in surveillance programs and obstetric interventions need to be evaluated in further studies.

~~There is also a need to develop surveillance programs in antenatal and obstetric care for older women aiming for example to detect preeclampsia earlier or recommending prophylactic uterotonic treatment after birth to avoid extensive postpartum bleeding. Such interventions need to be evaluated in further studies.~~

Article summary

Impact of maternal age on obstetric and neonatal outcome with emphasis on primiparous adolescents and older women-a Swedish Medical Birth Register Study.

Strengths and limitations of this study:

- A strength of the present study is that it includes primiparous women of an entire country where the antenatal care program is equally available to all pregnant women and is comprehensive.
- Another advantage is the large number of individuals available for evaluation, which makes it possible to divide the study population into subgroups with sufficient numbers in each stratum to provide high statistical power.
- A limitation is that the external validity is reduced to facilities with similar socio-economic and demographic characteristics and health care systems with comparable standards.
- The Swedish medical birth register contain a large body of information concerning the mother and the child but only the available data in the register could be used for outcome evaluation and adjustments for putative confounders.

INTRODUCTION

There are a large number of studies evaluating obstetric and neonatal outcome over the full range of reproductive maternal ages, but especially with a focus on the youngest and the oldest mothers. Young mothers have been shown to be exposed to an increased risk of anaemia, low birth weight, foetal death, eclampsia and preterm birth although they at the same time were more likely to have a spontaneous normal vaginal birth and the risk of preeclampsia and post-partum haemorrhage were significantly decreased.[1-6] These studies evaluated outcomes in low-income countries. Many studies performed in low-income countries presented in recent years on the topic of teenage pregnancies have found similar obstetric and neonatal outcomes.[7-11]

Complications during pregnancy and birth at advanced maternal age (either defined as 35 years and older or 40 years or older) have also been evaluated in high-income countries. Advanced maternal age at birth has been found to be associated with gestational diabetes, preeclampsia, placenta previa, caesarean section (CS), placental abruption, preterm delivery, low birth weight, intrauterine foetal death and an increased perinatal mortality.[12-20] The difference in obstetric and neonatal outcomes between teenagers and women at advanced age seemed to be lower risks for several unwanted and threatening outcomes in the teenage group; thus there were no obvious advantages concerning obstetric and neonatal outcomes at advanced maternal ages. The earlier published studies concerning the impact of maternal age on perinatal outcome differ in many aspects methodologically as well as in the socio-demographic characteristics of the populations and health care systems. All these factors make interpretation of comparisons between data sets difficult.

Sweden has during several decades actively developed strategies in social care, education and health care in order to improve antenatal care and parenthood. In a Swedish state-of-the-art conference held in 1990, the scientific basis of the routine antenatal program was critically evaluated. It was concluded that the scientific evidence to support the timing and contents of routine visits was unsatisfactory.[21] Consequently there is a constant need for evaluation both of single diagnostic procedures and

intervention and of outcomes. An analysis of perinatal outcomes in relation to maternal age in the Swedish population will provide important knowledge that may be used to further improve social, antenatal, obstetric and neonatal care and reveals risk groups that in particular may need more attention in the antenatal care.

The objective of the present study was to assess the impact of maternal age on obstetric and neonatal outcomes among singleton primiparous women in Sweden, with special emphasis on the adolescents and older mothers.

MATERIALS AND METHODS

This study analyses the obstetric and neonatal outcomes of all singleton primiparous women prospectively registered in the Swedish Medical Birth Register (MBR) who gave births from January 1, 1992 through December 31, 2010. MBR has collected information about births in Sweden since 1973. It is compulsory for every health care provider to report to the MBR. Medical and other data on almost all (99%) births in Sweden are listed in the register, which also includes stillbirths. Starting with the first antenatal visit, usually in gestational week 10-12, the information is collected prospectively in standardized medical record forms completed at the maternity health care centers at antenatal care visits, in the birth units, and at the paediatric examination of the newborn. The standardized medical records are identical throughout the country. A description and validation of the register content is available.[22-24]

The study population was grouped according to maternal age into seven subgroups: <17 years; 17-19 years; 20-24 years, 25-29 years, 30-34 years; 35-39 years and 40+ years. In the outcome analyses we selected the group of women age 25-29 years as reference group.

The list of available variables in MBR has been extended throughout the years that the register has been active. The obstetric and neonatal outcome data for the purpose of this study are those that have been available since 1992. From 1992 until June 2008 the MBR includes stillbirths after 28 weeks of gestation and from July 2008 until 2010 all stillbirths after 22 weeks of gestation are included. Each outcome studied was either marked in the MBR or registered according to the International Statistical Classification of Diseases and Related Health Problems (ICD). The obstetric outcome variables studied were gestational age, mode of delivery; normal vaginal birth (defined as neither instrumental vaginal delivery, nor CS), CS, instrumental vaginal delivery divided into forceps and vacuum extraction, mode of onset of labour, perineal laceration, preeclampsia, abruptio placentae, placenta previa, use of epidural analgesia and postpartum haemorrhage (PPH) exceeding 1000 ml. The foetal and neonatal outcomes evaluated were Apgar-score at 5 minutes, foetal distress (ICD code P20.0, P20.1 and P20.9),

aspiration of meconium (ICD code P24.0), shoulder dystocia (ICD code O66.0), and stillbirth. Small-for-gestational age (SGA) newborns were defined as those with birth weight more than 2 standard deviations (SD) below the mean birth weight for gestational age (sex and parity specific) according to a Swedish reference curve.[25] Large-for-gestational age (LGA) newborns were those with a birth weight above 2 SD. All descriptive and background data were extracted from the MBR. The register information on these variables was obtained from the antenatal care center records.

The study was approved by the Regional Ethical Review Board in Linköping, Sweden (Dnr 2011/479-31. Approved January 25; 2012).

Statistical analysis

Data are presented as counts and per cent or mean and one SD. Logistic regression analyses were used for comparison of groups for categorical data. Data on a continuous scale were compared using analysis of covariance (ANCOVA). Multivariate logistic regression models were used in order to adjust comparisons for the confounding factors. Consequently crude and adjusted odds ratios (OR and aOR) and 95% confidence intervals (CIs) are reported. Maternal weight and height (used for calculation of maternal Body Mass Index (BMI)) and smoking habits in early pregnancy (unknown, no smoking, smoking) and year of birth were included as confounders in the adjusted analyses. The simultaneous model of including independent variables in the multivariate logistic regression was used since we found it most appropriate for the relevance of the research goal of the study. The rationale for including year of birth as an independent variable was that there was variability in the occurrence of obstetric and neonatal diagnoses during the observation period. This may be due to true changes but may also be a result of changes in recording, with expanding use of computerized medical records. Maternal BMI and smoking was included as covariates in the adjusted analyses based on their well-known associations with maternal and foetal outcome and their unequal distribution over the maternal age strata.[26,27] BMI was included as a continuous variable as the distribution of maternal BMI was almost uniform over the maternal age strata and the association between BMI and maternal age was almost linear

(presented as means and standard deviations in Table 1). For the purpose of this study ~~G~~gestational age was added to the confounders in the analyses of CS, preeclampsia and birth weight based on their clinically well-known associations. The OR for instrumental vaginal delivery was calculated among women with vaginal births only in order to exclude women with an instrumental attempt to deliver followed by an emergency CS. The ORs of perineal lacerations were also estimated among women with vaginal births only. The information concerning use of epidural analgesia was also restricted to vaginal births only. Epidural is an analgesic method that has been widely used in the delivery wards for vaginal births during the entire time period. In contrast the use of epidural analgesia in CS has varied substantially over the time period and has almost exclusively been used in elective CS. Our purpose was to evaluate the odds ratio for epidural use over the maternal age strata and consequently we selected the mode of delivery that exhibited the least variation in the use of the analgesic method over the time period, i.e. vaginal births.

The software STATISTICA 64 version 10 (StatSoft Inc. 2300 East 14th St. Tulsa, OK 74104 USA) was used to carry out the statistical analyses.

RESULTS

In the period 1992 – 2010, 798,732 women were registered in the MBR as giving birth to their first child. The annual number of primiparous women giving birth varied between 34060 and 49417. Information on maternal age was missing in 58 cases leaving 798,674 women for the analyses. The average age of primiparous women increased substantially from 26.2 years in 1992 to 28.5 in 2004; hereafter it has stayed almost constant at that level. The demographic, obstetric and neonatal data subdivided into maternal age groups are presented in Table 1 and 2.

Table 1. Descriptive data of primiparous women with singleton births in the period 1992-2010.

Characteristics	< 17 years (n=2392)		17-19 years (n=29816)		20-24 years (n=185942)		25-29 years (n=300822)		30-34 years (n=205905)		35-39 years (n=63163)		40+ years (n=10634)	
BMI (kg/m²)	22.8	3.7	23.2	4.1	23.8	4.3	23.7	4.0	23.8	4.0	24.4	4.1	24.7	4.3
BMI† class														
<18.5 kg/m²	135	5.6%	1815	6.1%	7650	4.1%	7509	2.5%	3847	1.9%	918	1.5%	133	1.3%
18.5-24.9 kg/m²	1352	56.5%	16823	56.4%	104600	56.3%	180163	59.9%	122571	59.5%	34439	54.5%	5381	50.1%
25.0-29.9 kg/m²	315	13.2%	4687	15.7%	33961	18.3%	53896	17.9%	37234	18.1%	13310	21.1%	2442	23.0%
30.0-34-9 kg/m²	81	3.4%	1327	4.5%	10550	5.7%	14401	4.8%	9389	4.6%	3575	5.7%	683	6.4%
35.0-39.9 kg/m²	11	0.5%	337	1.1%	3013	1.6%	4070	1.4%	2724	1.3%	1024	1.6%	188	1.8%
≥ 40.0 kg/m²	4	0.2%	87	0.3%	904	0.5%	1312	0.4%	944	0.5%	342	0.5%	68	0.6%
Missing data	494	20.7%	4740	15.9%	25264	13.6%	39471	13.1%	29196	14.2%	9555	15.1%	1739	16.4%
Smoking†														
Yes	666	27.8%	9012	30.2%	31675	17.0%	24676	8.2%	13971	6.8%	5287	8.4%	958	9.0%
No	1542	64.5%	19154	64.3%	145695	78.4%	261348	86.9%	178792	86.8%	53416	84.6%	8883	83.5%
Missing data	184	7.7%	1650	5.5%	8572	4.6%	14798	4.9%	13142	6.4%	4460	7.0%	793	7.5%
Gestational age														
Information available	2368	99.0%	29715	99.7%	185700	99.9%	300603	99.9%	205719	99.9%	63098	99.9%	10620	99.9%
Missing data	24	1.0%	101	0.3%	242	0.1%	219	0.1%	186	0.1%	65	0.1%	14	0.1%

Figures denote mean and standard deviation or counts and proportions.
BMI = body mass index.
† Reported height, weight and smoking habits at first antenatal visit.

Table 2. Obstetric and neonatal outcome characteristics of primiparous women with singleton births in the period 1992-2010.

	Age groups													
Characteristics	< 17 years (n=2392)		17-19 years (n=29816)		20-24 years (n=185942)		25-29 years (n=300822)		30-34 years (n=205905)		35-39 years (n=63163)		40+ years (n=10634)	
Labour:														
Spontaneous onset labour	2055	85.9%	25853	86.7%	158879	85.4%	251340	83.6%	163876	79.6%	45330	71.2%	6261	58.9%
Induced labour	184	7.7%	2528	8.5%	17433	9.4%	30873	10.3%	25474	12.4%	10065	15.9%	2111	19.9%
Mode of delivery:														
Normal vaginal birth	2030	84.9%	25096	84.2%	147082	79.1%	219993	73.1%	135099	65.6%	35112	55.6%	4724	44.4%
Forceps	7	0.3%	126	0.4%	1143	0.6%	2166	0.7%	1515	0.7%	575	0.9%	84	0.8%
Vacuum extraction	143	6.0%	2090	7.0%	18011	9.7%	36696	12.2%	29811	14.5%	10119	16.0%	1599	15.0%
CS¥	213	8.9%	2500	8.4%	19747	10.6%	42044	14.0%	39534	19.2%	17355	27.5%	4226	39.7%
CS elective 1999-2010 ‡	53	2.2%	373	1.3%	2828	1.5%	6973	2.3%	7656	3.7%	3853	6.1%	1132	10.6%
CS acute 1999-2010 ‡	73	3.1%	882	3.0%	7092	3.8%	16651	5.5%	17953	8.7%	7826	12.4%	1798	16.9%
Gestational age:														
GA < 28 weeks	20	0.8%	107	0.4%	464	0.2%	743	0.2%	640	0.3%	292	0.5%	73	0.7%
GA < 32 weeks	40	1.7%	308	1.0%	1436	0.8%	2415	0.8%	2048	1.0%	900	1.4%	206	1.9%
GA < 37 weeks	213	8.9%	1937	6.5%	11030	5.9%	18005	5.6%	12727	6.2%	4586	7.3%	877	8.2%
GA 37 – 41 weeks	1990	83.2%	25811	86.6%	161043	86.6%	257320	85.5%	172621	83.8%	51494	81.5%	8786	82.6%
GA ≥ 42 weeks	165	6.9%	1967	6.6%	13627	7.3%	25278	8.4%	20371	9.9%	7018	11.1%	957	9.0%
Maternal complications and use of epidural analgesia:														
Perineal laceration gr 1-2*	311	14.3%	3982	14.6%	32602	19.6%	70452	27.3%	55163	33.2%	15477	33.9%	2116	33.1%
Perineal laceration gr 3-4*	23	1.1%	272	1.0%	3030	1.8%	8202	3.2%	6846	4.1%	1856	4.1%	222	3.5%
Preeclampsia	43	1.8%	576	1.9%	4317	2.3%	6520	2.2%	4265	2.1%	1610	2.5%	365	3.4%
Abruptio placentae	16	0.7%	135	0.5%	643	0.3%	1171	0.4%	955	0.5%	390	0.6%	87	0.8%
Placenta previa	2	0.1%	16	0.1%	159	0.1%	505	0.2%	612	0.3%	375	0.6%	89	0.8%
PPH > 1000 ml (VB)	65	3.0%	667	2.4%	5078	3.1%	10931	4.2%	9720	5.9%	3173	6.9%	485	7.6%
PPH > 1000 ml (CS)	2	0.9%	28	1.1%	252	1.3%	541	1.3%	578	1.5%	237	1.4%	80	1.9%
Epidural analgesia*	903	41.4%	11569	42.4%	68332	41.1%	105266	40.7%	70691	42.5%	20151	44.0%	2743	42.9%

Table 2 continued. Obstetric and neonatal outcome characteristics of primiparous women with singleton births in the period 1992-2010.

	Age groups													
Characteristics	< 17 years (n=2392)		17-19 years (n=29816)		20-24 years (n=185942)		25-29 years (n=300822)		30-34 years (n=205905)		35-39 years (n=63163)		40+ years (n=10634)	
Neonatal														
Foetal distress	8	0.3%	122	0.4%	932	0.5%	1621	0.5%	1070	0.5%	388	0.6%	56	0.5%
Aspiration of meconium	0	0%	30	0.1%	363	0.2%	649	0.2%	563	0.3%	193	0.3%	42	0.4%
Shoulder dystocia	6	0.3%	78	0.3%	793	0.4%	1580	0.5%	1382	0.7%	489	0.8%	79	0.7%
Stillbirth	7	0.3%	102	0.3%	571	0.3%	893	0.3%	768	0.4%	347	0.5%	87	0.8%
SGA	91	3.8%	1136	3.8%	6016	3.2%	8831	2.9%	7216	3.5%	2962	4.7%	617	5.8%
LGA	47	2.0%	539	1.8%	3838	2.1%	5943	2.0%	3846	1.9%	1279	2.0%	224	2.1%
Apgar score < 7 at 5	43	1.8%	381	1.3%	2409	1.3%	4158	1.4%	3354	1.6%	1274	2.0%	240	2.3%
Birth weight (gram)	3348	592	3403	565	3453	554	3470	555	3452	572	3415	612	3360	640

Figures denote counts and proportions or mean and one standard deviation.
BMI = body mass index; CS = caesarean section; GA = gestational age at birth; LGA = large for gestational age; PPH = postpartum haemorrhage; SGA = small for gestational age; VB = vaginal birth
[¥]All CS independent of status of performance – acute or elective. [†]Caesarean section was subdivided into elective and acute CS from 1999.
*Epidural analgesia and perineal lacerations in vaginal births only.

The crude odds rates and the results of the multivariate analyses models of obstetric and neonatal outcomes are shown in Table 3 and 4, respectively.

Table 3. Obstetric outcome data in singleton primiparous women in the period 1992-2010 in relation to maternal age group.

Characteristics	Crude OR (95%CI)	aOR (95%CI)†	Crude OR (95%CI)	aOR (95%CI)†	Crude OR (95%CI)	aOR (95%CI)†
Labour	< 17 years		17-19 years		20-24 years	
Spontaneous onset labour	1.20 (1.07-1.35)	1.20 (1.05-1.37)	1.28 (1.24-1.33)	1.26 (1.21-1.31)	1.16 (1.14-1.17)	1.16 (1.14-1.18)
Induced labour	0.73 (0.63-0.85)	0.78 (0.66-0.93)	0.81 (0.78-0.85)	0.86 (0.82-0.90)	0.90 (0.89-0.92)	0.91 (0.90-0.93)
	30 - 34 years		35 - 39 years		40+ years	
Spontaneous onset labour	0.77 (0.76-0.78)	0.78 (0.77-0.79)	0.50 (0.49-0.51)	0.52 (0.51-0.54)	0.29 (0.26-0.30)	0.30 (0.28-0.31)
Induced labour	1.23 (1.21-1.26)	1.19 (1.17-1.21)	1.66 (1.62-1.70)	1.54 (1.50-1.58)	2.17 (2.06-2.27)	1.97 (1.87-2.08)
Mode of delivery	< 17 years		17-19 years		20-24 years	
Normal vaginal birth	2.05 (1.84-2.30)	2.04 (1.79-2.32)	1.95 (1.89-2.02)	1.95 (1.88-2.02)	1.39 (1.37-1.41)	1.39 (1.37-1.41)
Forceps¥	0.38 (0.18-0.81)	0.41 (0.18-0.92)	0.55 (0.46-0.64)	0.48 (0.39-0.59)	0.82 (0.76-0.88)	0.77 (0.71-0.84)
Vacuum extraction¥	0.42 (0.36-0.51)	0.43 (0.36-0.52)	0.50 (0.48-0.53)	0.50 (0.48-0.53)	0.74 (0.72-0.75)	0.74 (0.72-0.75)
CS. all	0.60 (0.52-0.69)	0.57 (0.48-0.67)	0.56 (0.54-0.69)	0.55 (0.53-0.58)	0.73 (0.72-0.74)	0.72 (0.71-0.74)
CS elective 1999-2010 ‡	0.95 (0.73-1.25)	0.83 (0.60-1.14)	0.53 (0.48-0.59)	0.53 (0.47-0.60)	0.65 (0.62-0.68)	0.68 (0.65-0.71)
CS acute 1999-2010 ‡	0.54 (0.43-0.68)	0.53 (0.40-0.69)	0.52 (0.49-0.56)	0.56 (0.52-0.61)	0.68 (0.66-0.70)	0.71 (0.69-0.73)
	30 - 34 years		35 - 39 years		40+ years	
Normal vaginal delivery	0.70 (0.69-0.71)	0.72 (0.71-0.73)	0.46 (0.45-0.47)	0.48 (0.47-0.49)	0.29 (0.28-0.31)	0.31 (0.30-0.32)
Forceps¥	1.08 (1.01-1.15)	1.20 (1.12-1.29)	1.48 (1.35-1.63)	1.66 (1.49-1.84)	1.58 (1.27-1.98)	1.75 (1.37-2.24)
Vacuum extraction¥	1.32 (1.30-1.34)	1.29 (1.27-1.32)	1.72 (1.67-1.76)	1.67 (1.63-1.72)	2.01 (1.90-2.13)	1.92 (1.80-2.04)
CS. all	1.46 (1.44-1.49)	1.44 (1.42-1.47)	2.34 (2.29-2.38)	2.21 (2.16-2.26)	4.07 (3.91-4.23)	3.78 (3.61-3.96)
CS elective 1999-2010 ‡	1.63 (1.57-1.68)	1.44 (1.39-1.49)	2.74 (2.63-2.85)	2.25 (2.15-2.35)	5.03 (4.70-5.36)	3.89 (3.61-4.20)
CS acute 1999-2010 ‡	1.63 (1.59-1.67)	1.44 (1.40-1.47)	2.41 (2.35-2.48)	1.94 (1.88-2.00)	3.47 (3.29-3.66)	2.68 (2.52-2.85)
Gestational age	< 17 years		17-19 years		20-24 years	
GA < 28 weeks	3,44 (2.20-5.37)	2.84 (1.59-5.06)	1.46 (1.19-1.79)	1.25 (0.97-1.62)	1.01 (0.90-1.14)	0.89 (0.77-1.02)
GA < 32 weeks	2.12 (1.55-2.91)	1.66 (1.10-2.51)	1.29 (1.15-1.46)	1.20 (1.04-1.38)	0.96 (0.90-1.03)	0.92 (0.85-0.99)
GA < 37 weeks	1.55 (1.34-1.79)	1.46 (1.24-1.72)	1.09 (1.04-1.15)	1.03 (0.98-1.09)	0.99 (0.97-1.02)	0.97 (0.95-1.00)
GA 37 – 41 weeks	0.89 (0.79-0.99)	0.88 (0.77-0.99)	1.11 (1.07-1.15)	1.14 (1.09-1.18)	1.10 (2.08-1.12)	1.12 (1.10-1.14)
GA ≥ 42 weeks	0.82 (0.70-0.96)	0.89 (0.75-1.06)	0.77 (0.74-0.81)	0.79 (0.74-0.83)	0.86 (0.84-0.88)	0.85 (0.83-0.87)
	30 - 34 years		35 - 39 years		40+ years	
GA < 28 weeks	1.26 (1.13-1.40)	1.17 (1.04-1.33)	1.88 (1.64-2.15)	1.61 (1.40-1.90)	2.79 (2.19-3.56)	2.48 (1.86-3.29)
GA < 32 weeks	1.24 (1-17-1.32)	1.24 (1.16-1.33)	1.79 (1.65-1.93)	1.68 (1.53-1.84)	2.44 (2.12-2.82)	2.25 (1.90-2.66)
GA < 37 weeks	1.04 (1.01-1.06)	1.02 (0.99-1.05)	1.23 (1-19-1.27)	1.19 (1.15-1.24)	1.41 (1.32-1.52)	1.37 (1.26-1.48)
GA 37 – 41 weeks	0.88 (0.86-0.89)	0.89 (0.86-0.89)	0.75 (0.73-0.76)	0.76 (0.74-0.78)	0.81 (0.77-0.85)	0.83 (0.79-0.88)
GA ≥ 42 weeks	1.20 (1.17-1.22)	1.20 (1.18-1.23)	1.36 (1.33-1.40)	1.35 (1.31-1.39)	1.08 (1.01-1.15)	1.06 (0.98-1.14)

Table 3 continued. Obstetric outcome data in singleton primiparous women in the period 1992-2010 in relation to maternal age group.

Characteristics	Crude OR (95%CI)	aOR (95%CI)†	Crude OR (95%CI)	aOR (95%CI)†	Crude OR (95%CI)	aOR (95%CI)†
Maternal complications and use of epidural analgesia:	< 17 years		17-19 years		20-24 years	
Perineal laceration grade 1-2¥	0.44 (0.39-0.50)	0.44 (0.38-0.50)	0.46 (0.44-0.47)	0.47 (0.45-0.49)	0.65 (0.64-0.66)	0.68 (0.67-0.69)
Perineal laceration grade 3-4¥	0.33 (0.22-0.49)	0.39 (0.25-0.60)	0.31 (0.25-0.37)	0.37 (0.32-0.42)	0.57 (0.54-0.59)	0.61 (0.58-0.64)
Preeclampsia	0.83 (0.61-1.12)	0.89 (0.62-1.27)	0.89 (0.82-0.97)	0.93 (0.84-1.02)	1.07 (1.03-1.12)	1.01 (0.96-1.05)
Abruptio placentae	1.72 (1.05-2.83)	1.76 (1.03-3.00)	1.16 (0.97-1.39)	1.02 (0.83-1.26)	0.89 (0.81-0.98)	0.83 (0.74-0.92)
Placenta praevia	0.50 (0.12-2.00)	0.57 (0.14-2.30)	0.32 (0.19-0.53)	0.28 (0.16-0.50)	0.52 (0.43-0.61)	0.52 (0.43-0.63)
PPH > 1000 ml (VB)	0.70 (0.54-0.89)	0.65 (0.48-0.88)	0.57 (0.53-0.61)	0.64 (0.59-0.70)	0.71 (0.69-0.74)	0.78 (0.75-0.81)
PPH > 1000 ml (CS)	0.73 (0.18-2.93)	0.52 (0.07-3.74)	0.87 (0.59-1.27)	1.16 (0.77-1.93)	0.99 (0.92-1.07)	1.09 (0.93-1.28)
Epidural analgesia¥	1.03 (0.95-1.12)	1.03 (0.93-1.13)	1.07 (1.06-1.08)	1.07 (1.04-1.10)	1.02 (1.01-1.03)	1.03 (1.01-1.04)
	30 - 34 years		35 - 39 years		40+ years	
Perineal laceration grade 1-2¥	1.33 (1.31-1.34)	1.11 (1.10-1.13)	1.37 (1-34-1.40)	1.08 (1.05-1.10)	1.32 (1.25-1.39)	1.00 (0.94-1.07)
Perineal laceration grade 3-4¥	1.31 (1.27-1.36)	1.16 (1.12-1.20)	1.29 (1.23-1.36)	1.12 (1.05-1.18)	1.10 (0.96-1.26)	0.88 (0.75-1.02)
Preeclampsia	0.95 (0.92-0.99)	1.07 (1.03-1.12)	1.18 (1.12-1.25)	1.30 (1.22-1.39)	1.60 (1.44-1.79)	1.83 (1.62-2.06)
Abruptio placentae	1.19 (1.09-1.30)	1.27 (1.16-1.40)	1.59 (1.42-1.78)	1.71 (1.50-1.94)	2.11 (1-70-2.63)	2.09 (1.62-2.71)
Placenta praevia	1.77 (1.58-1.99)	1.74 (1.53-2.00)	3.55 (3.11-4.06)	3.47 (2.99-4.03)	5.02 (4.00-6.29)	5.23 (4.08-6.70)
PPH > 1000 ml (VB)	1.41 (1.37-1.45)	1.27 (1.23-1.31)	1.69 (1.62-1.76)	1.47 (1.40-1.53)	1.86 (1.69-2.05)	1.48 (1.26-1.52)
PPH > 1000 ml (CS)	1.14 (1.01-1.28)	1.04 (0.91-1.18)	1.06 (0.91-1.24)	0.95 (0.81-1.12)	1.48 (1.17-1.88)	1.35 (1.05-1.73)
Epidural analgesia¥	1.08 (1.06-1.09)	1.03 (1.02-1.05)	1.14 (1.12-1.17)	1.06 (1.04-1.09)	1.10 (1.04-1.15)	0.98 (0.93-1.03)

Reference group: Maternal age 25-29 years.

CI = confidence intervals; CS = Caesarean section; GA = gestational age at delivery; N/A = not applicable; aOR = adjusted odds ratio; PPH = postpartum haemorrhage; VD = vaginal birth.

† Adjusted for maternal BMI and smoking habits at first antenatal care visit and year of birth. CS and preeclampsia also adjusted for gestational age. ‡ Caesarean section was subdivided into elective and acute CS from 1999. ¥ Forceps, vacuum extraction, epidural analgesia and perineal lacerations among vaginally delivered women.

Table 4. Neonatal outcome data in singleton primiparous women in the period 1992-2010 in relation to maternal age group.

Characteristics	Crude OR (95%CI)	aOR (95%CI)†	Crude OR (95%CI)	aOR (95%CI)†	Crude OR (95%CI)	aOR (95%CI)†
	< 17 years		17-19 years		20-24 years	
Foetal distress	0.62 (0.31-1.24)	0.52 (0.22-1.26)	0.76 (0.63-0.91)	0.63 (0.51-0.79)	0.93 (0.86-1.01)	0.79 (0.72-0.91)
Aspiration of meconium	N/A	N/A	0.47 (0.32-0.67)	0.46 (0.31-0.70)	0.90 (0.80-1.03)	0.93 (0.81-1.07)
Shoulder dystocia¥	0.45 (0.11-1.82)	0.32(0.05-2.29)	0.74 (0.58-0.90)	0.74 (0.52-1.07)	1.01 (0.88-1.16)	1.00 (0.86-1.16)
Stillbirth	0.99 (0.47-2.08)	0.58 (0.19-1.80)	1.15 (0.94-1.42)	0.97 (0.75-1.25)	1.03 (0.93-1.15)	0.98 (0.87-1.11)
SGA	1.32 (1.07-1.63)	1.00 (0.78-1.28)	1.31 (1.23-1.40)	1.01 (0.94-1.09)	1.11 (1.07-1.14)	1.00 (0.96-1.04)
LGA	1.01 (0.75-1.34)	1.08 (0.76-1.53)	0.92 (0.84-1.00)	1.03 (0.94-1.14)	1.05 (1.00-1.09)	1.05 (1.00-1.10)
Apgar score < 7 at 5 minutes	1.31 (0.96-1.77)	1.30 (0.91-1.86)	0.92 (0.83-1.03)	0.92 (0.81-1.11)	0.93 (0.89-0.99)	0.93 (0.88-0.98)
	30 - 34 years		35 - 39 years		40+ years	
Foetal distress	0.96 (0.89-1.04)	1.23 (1.13-1.35)	1.14 (1.02-1.27)	1.51 (1.33-1.72)	0.98 (0.75-1.28)	1.60 (1.20-2.13)
Aspiration of meconium	1.27 (1.13-1.42)	1.36 (1.20-1.54)	1.42 (1.21-1.67)	1.48 (1.24-1.77)	1.83 (1.34-2.51)	1.82 (1.28-2.58)
Shoulder dystocia¥	1.18 (1.04-1.35)	1.13 (0.90-1.41)	1.13 (0.91-1.39)	1.13 (0.91-1.41)	1.47 (0.93-2.33)	1.27 (0.76-2.12)
Stillbirth	1.26 (1.14-1.38)	1.25 (1.12-1.39)	1.85 (1.64-2.10)	1.72 (1.49-1.99)	2.77 (2.22-3.46)	2.34 (1.80-3.03)
SGA	1.20 (1.16-1.24)	1.24 (1.20-1.28)	1.63 (1.56-1.70)	1.65 (1.58-1.73)	2.04 (1.87-2.22)	2.06 (1.87-2.26)
LGA	0.94 (0.91-0.98)	0.94 (0.90-0.98)	1.03 (0.97-1.09)	0.97 (0.91-1.04)	1.07 (0.93-1.22)	0.94 (0.81-1.09)
Apgar score < 7 at 5 minutes	1.18 (1.13-1.24)	1.18 (1.12-1.24)	1.47 (1.38-1.56)	1.39 (1.29-1.49)	1.65 (1.44-1.88)	1.51 (1.30-1.75)

Reference group: Maternal age 25-29 years.

CI = confidence interval; LGA = large for gestational age; N/A = not applicable; aOR = adjusted odds ratio; SGA = small for gestational age

† Adjusted for maternal BMI and smoking habits at first antenatal care visit and year of birth

¥ Shoulder dystocia among vaginal delivered women.

Mode of delivery, obstetric and neonatal outcome of adolescents

Compared with the reference group the teenagers had a significantly higher likelihood of having spontaneous onset of labour and of having a normal vaginal delivery. Teenagers also demonstrated a significantly higher risk of giving birth prematurely. However, only the group of teenagers younger than 17 years of age had an increased risk of giving birth very prematurely i.e. before 28 weeks of gestational age, and the same group revealed a significantly higher risk of placental abruption. In contrast with these observations the teenagers were delivered instrumentally and by CS significantly less often, and the vaginal births caused significantly fewer perineal lacerations (only evaluated among women who delivered vaginally) and PPH > 1000 ml. Likewise the occurrence of placenta previa was seen less often among teenagers whereas the occurrence of preeclampsia was equal to that seen in the reference group.

Concerning the foetal and neonatal outcomes for adolescents the newborns were less likely to show foetal distress and meconium aspiration in spite of a similar occurrence of Apgar score < 7 at 5 minutes. The newborns of the adolescents were not more prone to being stillborn or being SGA than the newborns of women in the reference group. The adjusted mean birth weight of newborns of adolescents did not differ significantly from that of women up to 29 years of age (Figure 1).

Mode of delivery, obstetric and neonatal outcome of women 20-24 years of age

The young women, 20 – 24 years of age, differed in some aspects from the reference group as well as from the adolescents. They were less likely to be delivered prematurely and had a lower frequency of placental abruption. Otherwise the obstetric and neonatal outcomes were similarly favourable as those observed for the adolescents in comparison with the reference group.

Mode of delivery, obstetric and neonatal outcome of women older than 29 years of age

As shown in Table 3 compared with the reference group almost all obstetric outcome variables demonstrated a continuously progressive deterioration with increasing age. The likelihood of normal

vaginal births decreased; induced labour, instrumental deliveries and CS increased as well as prematurity including very premature deliveries. The risk of perineal laceration increased moderately whereas the risk of PPH > 1000 ml in vaginal births was more pronounced. The likelihood of the pregnancy complications preeclampsia, abruptio placenta and placenta previa was also higher in the older age groups and progressed substantially with increasing age. Similarly, the foetal and neonatal outcome was adversely progressively influenced by increasing maternal age. With increasing maternal age over 30 years significantly more neonates were SGA, showed foetal distress, had Apgar score < 7 at 5 minutes or meconium aspiration, or were stillborn. The mean birth weight of the neonates also decreased significantly with increasing maternal age after the age of 30 (Figure 1).

DISCUSSION

This Swedish nation-wide population-based study with prospectively collected data concerning singleton primiparous women showed that the mode of delivery differed over the maternal age strata. Significantly more normal vaginal deliveries and fewer CS and instrumental vaginal deliveries were seen among the teenagers and among women aged 20-24 compared with the reference group of women aged 25-29. The opposite was found among older women reaching a 4-fold increased risk for CS compared with women aged 20-24. The teenagers as well as women aged 20-24 were less prone to perineal lacerations and PPH exceeding 1000 ml. Prematurity (< 28 weeks of GA) was associated with very low maternal age (<17 years) among the adolescents although the increased risk was at the same level as among women aged 40 years and above, indicating a u-shaped risk curve. Adolescents were not afflicted more by preeclampsia than the reference women whereas the risk of preeclampsia increased significantly with advancing maternal age. The risk of placentae praevia increased dramatically with maternal age, actually a 500% increased risk was found after the age of 40 compared with the reference group. There was a significantly increased risk of stillbirth, SGA and low Apgar score only in women aged 30 years and over.

The most prominent difference between the findings in the present study and earlier studies is that no increased risk for SGA was found among the adolescents and young mothers 20-24 years of age compared with the reference women.[8-9] It must be kept in mind that the definition of SGA may differ between countries. In the United States and Latin America SGA is usually defined as birth weight below the 10th percentile compared with two SD in the Nordic countries.[3, 9] Adjusted risks for SGA among teenagers, recently presented from Finland, one of the Nordic countries, showed no increased risk among the youngest mothers.[6] In that study the control group was defined in the same way as in the present study but the Finnish study did not adjust for smoking habits. We found that smoking in early pregnancy was a significant independent risk factor for SGA in all age groups but it was only in the young women below 25 years of age that the adjustment of smoking turned the statistically

significant crude ORs into non-significant adjusted OR values. The contrary was found for the older women where the already significant crude ORs for SGA even became increased. This observation may support a biological explanation for SGA in the older women. Differences concerning the risk for SGA could also be attributable to differences in socio-economic status. Chen et al. restricted their analysis to white married mothers with age-appropriate education level, adequate prenatal care, without smoking and alcohol use during pregnancy but found the increased risk for SGA to persist.[3] Several studies have shown low infant birth weight for adolescents as well as for mothers with advancing age.[18, 14, ~~26~~28, ~~27~~29] We failed to find such association among the adolescents, but in women with advancing age the difference in birth weight was statistically significant although the difference lacked clinical significance.

The finding of a preferable birth outcome with lower CS rates and lower rates of instrumental delivery among teenagers compared with older women has been pinpointed to a lesser extent than observed adverse outcomes. Earlier studies have shown relatively consistent results concerning a decreased rate of CS in the adolescent group and a higher rate in women with advancing age.[6, 8, 9, 12-18] We were able to evaluate elective and emergency CS separately and the risks among the teenagers and mothers age 20-24 years were decreased for both types. This might indicate that the different risks concerning CS among young and older mothers could not exclusively be explained by more CS on maternal request among older mothers but may even be caused by biological factors. A low rate of instrumental deliveries and CS among adolescents and a high rate among older women have almost unanimously been shown in several reports from high-income as well as low-income countries.[5, 7, 12-18, ~~26~~28-~~29~~31] Whether this phenomenon depends on differences in handling the delivery, inherent or cultural behavioural, domestic or social attitudes among the obstetric staff or biological factors has not been investigated. Advancing age is associated with impaired uterine contractility as well as endothelial dysfunction which theoretically may lead to impaired uterine and utero-placental function.[~~30~~32, ~~31~~33] The fact that adolescents in our study had a lower risk of induction of labour, perineal laceration, PPH,

abruption (except for the very young women) and placenta previa and women with advancing age had higher risks of all these outcomes including preeclampsia could support a biological explanation. Concerning prematurity the age related risk curve was U shaped. This may also support a biological aetiology; immaturity of the uterus in the very young women that obstruct development of a term pregnancy and uterine dysfunction caused by ageing processes in women with advancing age and consequently deliver prematurely in both situations. The neonatal outcomes followed almost the same pattern; foetal distress, meconium aspiration, stillbirth, SGA and low Apgar score were exclusively attributed to women older than 29.

The strength of this study is that it deals with the outcomes in the population of an entire country where the antenatal care program is equally available to all pregnant women and is comprehensive. In Sweden pregnant women have completely cost free access to antenatal and obstetric facilities; poverty and malnutrition are practically non-existent and the vast majority of women attends the antenatal care program (99%) independent of socio-economic status and is delivered in obstetric units.[21] This context is valid for the whole study period. Another advantage is the large number of individuals available for evaluation, which makes it possible to divide the study population into subgroups with sufficient numbers in each stratum to provide high statistical power. A sufficient number of study subjects made it possible to evaluate three subgroups of young maternal age. Only primiparous women were included in order to avoid the confounding effects of factors associated with subsequent deliveries. There are limitations that should be considered. The external validity is reduced to facilities with similar socio-economic and demographic characteristics and health care systems with comparable standards. The drawback is obvious given the large size of the study and the numbers of health care units involved that the criteria for diagnosis (ICD codes) to define outcomes may not be uniform across the study population but the variation is most likely not related to maternal age. The MBR contain a large body of information concerning the mother and the child which made it possible to adjust the results for confounding factors. At the same time this is a limitation as only the data available in the

register could be used for adjustments. The register lacks information on ethnicity and socio-economic status. Our effort was to evaluate obstetric and neonatal outcome in different maternal age groups compared with women aged 25-29 overall. The only stratifications made were for year of birth, maternal BMI and smoking in early pregnancy. The data on year of birth showed that there is variability in the existence of obstetric and neonatal diagnoses during the observation period. This may be due to true changes but may also be a result of changes in recording, including the expanding use of computerized medical records. It was therefore necessary to adjust for year of birth. Maternal BMI, maternal smoking and gestational age (for some relevant outcomes) were included in the adjusted analyses based on their well known association with maternal and foetal outcome.[~~32~~ 26,27] Putative confounders and intermediaries were not identified with statistical analysis. -To demonstrate causality between the different outcomes evaluated in the analyses and maternal age a great number of putative intermediaries could have been considered such as the use of fertility treatment, foetal size, gestational weight gain etc., but that was not the purpose of the study. A true confounder affects both the exposure and the outcome. There may be other variables (which are not intermediaries) but we have not been able to identify them. If we take for instance maternal hypertension as an example, it could be of interest. But as the higher risk of hypertension is a consequence of maternal age, it is not a true confounder but an intermediary, a way in which high maternal age can affect obstetric and neonatal pathology. The proportion of missing data concerning the included confounders could have affected the results. The youngest age group had the highest frequency of missing data on BMI (20.7%) and smoking (7.7%) compared with the reference group (13.1% and 4.9%, respectively). The distribution of BMI in the youngest age group was almost equal to the other maternal age groups. One explanation for a higher proportion of missing data in the youngest age group could be a later detection of their pregnancies and attendance to the antenatal care and questions concerning exposure in early pregnancy were not raised. Gestational age could be calculated for more than 99% of the study subjects in this study with just minimal variations between maternal age groups.

Our approach of analysing the data may be a benefit for clinicians interpreting the results when dealing with young and aged mothers.

In conclusion, in a country with a highly developed social and antenatal maternity health care security system giving cost free maternity and obstetric care to all pregnant women adolescents had a decreased risk for adverse obstetric and neonatal outcome compared with the reference group. In the same social context childbirth at advanced maternal age was associated with a number of serious complications for both the woman and the child. For clinicians counselling young mothers it is of great importance to highlight the positive consequences that less obstetric complications and favourable neonatal outcomes are expected. The results imply that there is a need for individualizing the antenatal surveillance programs and obstetric care based on age grouping in order to attempt to improve the outcomes in the age groups with less favourable obstetric and neonatal outcomes. Such changes in surveillance programs and obstetric interventions need to be evaluated in further studies. ~~There is also a need to develop surveillance programs in antenatal and obstetric care for older women aiming to prevent and protect the increased risks of adverse outcomes for example to earlier detect preeclampsia or recommending prophylactic uterotonic treatment after birth to avoid extensive postpartum bleeding. Such interventions need to be evaluated in well-designed prospective studies.~~

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Contribution of authorship: The study was planned and conducted by PK, MB and RBT, Data was analysed by all three. All authors contributed to the interpretation of the results, the elaboration of the manuscript and approval of the final version.

Checklist: The manuscript conforms to the STROBE requirement.

Data sharing statement: Technical appendix, statistical code, and dataset available from the corresponding author at Dryad repository, who will provide a permanent, citable and open access home for the dataset.

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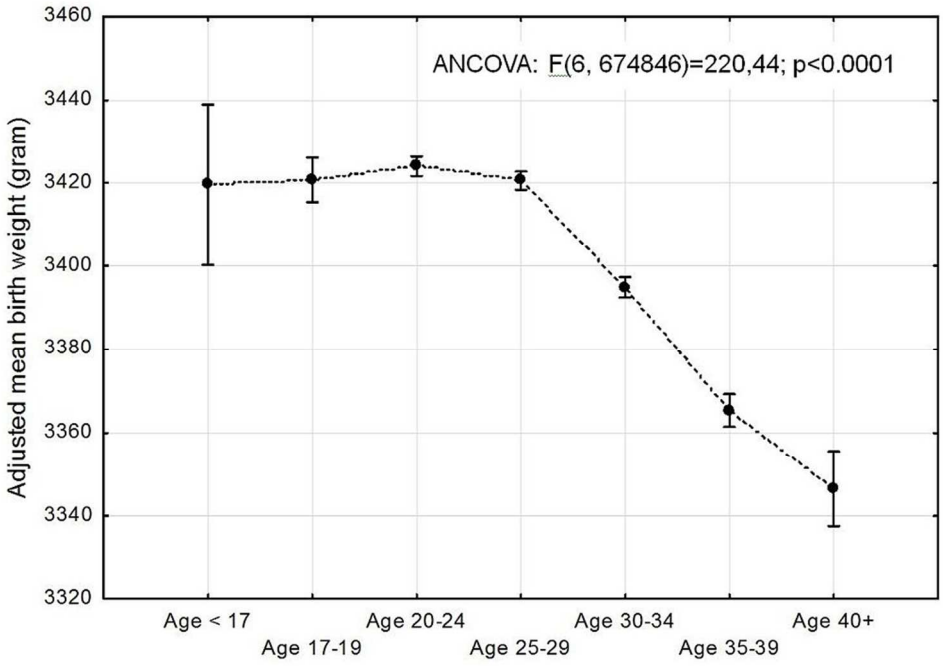
LEGENDS

Figure 1. Adjusted mean birth weight of neonates in singleton primiparous women in different maternal age groups. Birth weight adjusted for gestational age, maternal BMI and smoking habits, and year of delivery. Plots indicate means and bars 95% CI.



90x66mm (300 x 300 DPI)

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract.Done
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found Done
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported. Done
Objectives	3	State specific objectives, including any prespecified hypotheses. Done
Methods		
Study design	4	Present key elements of study design early in the paper.Done
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection. Done
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up. Done *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable. Done
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.Done
Bias	9	Describe any efforts to address potential sources of bias. Done
Study size	10	Explain how the study size was arrived at. All primiparous were included.
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why. Done
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding. Done
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed. Done
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed. Done *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses

Continued on next page

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. Done
		(b) Give reasons for non-participation at each stage
		(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. Tables.
		(b) Indicate number of participants with missing data for each variable of interest
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount). Done
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time. Done
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures
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. Done only Adjusted Ors are given.
		(*b*) Report category boundaries when continuous variables were categorized. Done
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period. Done.
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	18	Summarise key results with reference to study objectives. Done
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias. done
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence. Done
Generalisability	21	Discuss the generalisability (external validity) of the study results. Done
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. Done

*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.

BMJ Open

Impact of maternal age on obstetric and neonatal outcome with emphasis on primiparous adolescents and older women-a Swedish Medical Birth Register Study.

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Primary Subject Heading:	Obstetrics and gynaecology
Secondary Subject Heading:	Epidemiology
Keywords:	maternal age, obstetric outcome, neonatal outcome

Impact of maternal age on obstetric and neonatal outcome with emphasis on primiparous adolescents and older women-a Swedish Medical Birth Register Study.

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Keywords: maternal age, mode of delivery, neonatal outcome, obstetric outcome, adolescents

Word count: 3598 words

Abstract

Objectives: To evaluate the associations between maternal age and obstetric and neonatal outcomes in primiparous women with emphasis on teenagers and older women.

Design: A population-based cohort study.

Setting: The Swedish Medical Birth Register.

Participants: Primiparous women with singleton births from 1992 through 2010 (N=798,674) were divided into seven age groups: <17 years, 17-19 years, and additional five five-year classes. The reference group consisted of the women age 25-29 years.

Primary outcome: Obstetric and neonatal outcome.

Results: The teenager groups had significantly more vaginal births (aOR 2.04 (1.79-2.32) and 1.95 (1.88-2.02) for age <17 years and 17–19 years, respectively); fewer caesarean sections (aOR 0.57 (0.48-0.67) and 0.55 (0.53-0.58)), and instrumental vaginal births (aOR 0.43 (0.36-0.52) and 0.50 (0.48-0.53)) compared with the reference group. The opposite was found among older women reaching a 4-fold increased odds ratio for caesarean section. The teenagers showed no increased risk of adverse neonatal outcome but presented an increased risk of prematurity <32 weeks (aOR 1.66 (1.10-2.51) and 1.20 (1.04-1.38)). Women with advancing age (≥ 30 years) revealed significantly increased risk of prematurity, perineal lacerations, preeclampsia, abruption, placenta previa, postpartum haemorrhage and unfavourable neonatal outcomes compared with the reference group.

Conclusions: For clinicians counselling young women it is of importance to highlight the obstetrically positive consequences that fewer maternal complications and favourable neonatal outcomes are expected. The results imply that there is a need for individualizing the antenatal surveillance programs and obstetric care based on age grouping in order to attempt to improve the outcomes in the age groups with less favourable obstetric and neonatal outcomes. Such changes in surveillance programs and obstetric interventions need to be evaluated in further studies.

Article summary

Impact of maternal age on obstetric and neonatal outcome with emphasis on primiparous adolescents and older women-a Swedish Medical Birth Register Study.

Strengths and limitations of this study:

- A strength of the present study is that it includes primiparous women of an entire country where the antenatal care program is equally available to all pregnant women and is comprehensive.
- Another advantage is the large number of individuals available for evaluation, which makes it possible to divide the study population into subgroups with sufficient numbers in each stratum to provide high statistical power.
- A limitation is that the external validity is reduced to facilities with similar socio-economic and demographic characteristics and health care systems with comparable standards.
- The Swedish medical birth register contain a large body of information concerning the mother and the child but only the available data in the register could be used for outcome evaluation and adjustments for putative confounders.

INTRODUCTION

There are a large number of studies evaluating obstetric and neonatal outcome over the full range of reproductive maternal ages, but especially with a focus on the youngest and the oldest mothers. Young mothers have been shown to be exposed to an increased risk of anaemia, low birth weight, foetal death, eclampsia and preterm birth although they at the same time were more likely to have a spontaneous normal vaginal birth and the risk of preeclampsia and post-partum haemorrhage were significantly decreased.[1-6] These studies evaluated outcomes in low-income countries. Many studies performed in low-income countries presented in recent years on the topic of teenage pregnancies have found similar obstetric and neonatal outcomes.[7-11]

Complications during pregnancy and birth at advanced maternal age (either defined as 35 years and older or 40 years or older) have also been evaluated in high-income countries. Advanced maternal age at birth has been found to be associated with gestational diabetes, preeclampsia, placenta previa, caesarean section (CS), placental abruption, preterm delivery, low birth weight, intrauterine foetal death and an increased perinatal mortality.[12-20] The difference in obstetric and neonatal outcomes between teenagers and women at advanced age seemed to be lower risks for several unwanted and threatening outcomes in the teenage group; thus there were no obvious advantages concerning obstetric and neonatal outcomes at advanced maternal ages. The earlier published studies concerning the impact of maternal age on perinatal outcome differ in many aspects methodologically as well as in the socio-demographic characteristics of the populations and health care systems. All these factors make interpretation of comparisons between data sets difficult.

Sweden has during several decades actively developed strategies in social care, education and health care in order to improve antenatal care and parenthood. In a Swedish state-of-the-art conference held in 1990, the scientific basis of the routine antenatal program was critically evaluated. It was concluded that the scientific evidence to support the timing and contents of routine visits was unsatisfactory.[21] Consequently there is a constant need for evaluation both of single diagnostic procedures and

intervention and of outcomes. An analysis of perinatal outcomes in relation to maternal age in the Swedish population will provide important knowledge that may be used to further improve social, antenatal, obstetric and neonatal care and reveals risk groups that in particular may need more attention in the antenatal care.

The objective of the present study was to assess the impact of maternal age on obstetric and neonatal outcomes among singleton primiparous women in Sweden, with special emphasis on the adolescents and older mothers.

MATERIALS AND METHODS

This study analyses the obstetric and neonatal outcomes of all singleton primiparous women prospectively registered in the Swedish Medical Birth Register (MBR) who gave births from January 1, 1992 through December 31, 2010. MBR has collected information about births in Sweden since 1973. It is compulsory for every health care provider to report to the MBR. Medical and other data on almost all (99%) births in Sweden are listed in the register, which also includes stillbirths. Starting with the first antenatal visit, usually in gestational week 10-12, the information is collected prospectively in standardized medical record forms completed at the maternity health care centers at antenatal care visits, in the birth units, and at the paediatric examination of the newborn. The standardized medical records are identical throughout the country. A description and validation of the register content is available.[22-24]

The study population was grouped according to maternal age into seven subgroups: <17 years; 17-19 years; 20-24 years, 25-29 years, 30-34 years; 35-39 years and 40+ years. In the outcome analyses we selected the group of women age 25-29 years as reference group.

The list of available variables in MBR has been extended throughout the years that the register has been active. The obstetric and neonatal outcome data for the purpose of this study are those that have been available since 1992. From 1992 until June 2008 the MBR includes stillbirths after 28 weeks of gestation and from July 2008 until 2010 all stillbirths after 22 weeks of gestation are included. Each outcome studied was either marked in the MBR or registered according to the International Statistical Classification of Diseases and Related Health Problems (ICD). The obstetric outcome variables studied were gestational age, mode of delivery; normal vaginal birth (defined as neither instrumental vaginal delivery, nor CS), CS, instrumental vaginal delivery divided into forceps and vacuum extraction, mode of onset of labour, perineal laceration, preeclampsia, abruptio placentae, placenta previa, use of epidural analgesia and postpartum haemorrhage (PPH) exceeding 1000 ml. The foetal and neonatal outcomes evaluated were Apgar-score at 5 minutes, foetal distress (ICD code P20.0, P20.1 and P20.9),

aspiration of meconium (ICD code P24.0), shoulder dystocia (ICD code O66.0), and stillbirth. Small-for-gestational age (SGA) newborns were defined as those with birth weight more than 2 standard deviations (SD) below the mean birth weight for gestational age (sex and parity specific) according to a Swedish reference curve.[25] Large-for-gestational age (LGA) newborns were those with a birth weight above 2 SD. All descriptive and background data were extracted from the MBR. The register information on these variables was obtained from the antenatal care center records.

The study was approved by the Regional Ethical Review Board in Linköping, Sweden (Dnr 2011/479-31. Approved January 25; 2012).

Statistical analysis

Data are presented as counts and per cent or mean and one SD. Logistic regression analyses were used for comparison of groups for categorical data. Data on a continuous scale were compared using analysis of covariance (ANCOVA). Multivariate logistic regression models were used in order to adjust comparisons for the confounding factors. Consequently crude and adjusted odds ratios (OR and aOR) and 95% confidence intervals (CIs) are reported. Maternal weight and height (used for calculation of maternal Body Mass Index (BMI)) and smoking habits in early pregnancy (unknown, no smoking, smoking) and year of birth were included as confounders in the adjusted analyses. The simultaneous model of including independent variables in the multivariate logistic regression was used since we found it most appropriate for the relevance of the research goal of the study. Such a research strategy is appropriate when there is no logical or theoretical basis for considering any variable to be prior to any other, either in terms of a hypothetical causal structure of the data or in terms of its relevance to the research goals of focusing on prediction and explanation.

The rationale for including year of birth as an independent variable was that there was variability in the occurrence of obstetric and neonatal diagnoses during the observation period. This may be due to true changes but may also be a result of changes in recording with expanding use of computerized medical records. Maternal BMI and smoking was included as covariates in the adjusted analyses based on their

well-known associations with maternal and foetal outcome and their unequal distribution over the maternal age strata.[26,27] BMI was included as a continuous variable as the distribution of maternal BMI was almost uniform over the maternal age strata and the association between BMI and maternal age was almost linear (presented as means and standard deviations in Table 1). For the purpose of this study gestational age was added to the confounders in the analyses of CS, preeclampsia and birth weight based on their clinically well-known associations.[25,28,29] The OR for instrumental vaginal delivery was calculated among women with vaginal births only in order to exclude women with an instrumental attempt to deliver followed by an emergency CS. The ORs of perineal lacerations were also estimated among women with vaginal births only. The information concerning use of epidural analgesia was also restricted to vaginal births only. Epidural is an analgesic method that has been widely used in the delivery wards for vaginal births during the entire time period. In contrast the use of epidural analgesia in CS has varied substantially over the time period and has almost exclusively been used in elective CS. Our purpose was to evaluate the odds ratio for epidural use over the maternal age strata and consequently we selected the mode of delivery that exhibited the least variation in the use of the analgesic method over the time period, i.e. vaginal births.

The software STATISTICA 64 version 10 (StatSoft Inc. 2300 East 14th St. Tulsa, OK 74104 USA) was used to carry out the statistical analyses.

RESULTS

In the period 1992 – 2010, 798,732 women were registered in the MBR as giving birth to their first child. The annual number of primiparous women giving birth varied between 34060 and 49417. Information on maternal age was missing in 58 cases leaving 798,674 women for the analyses. The average age of primiparous women increased substantially from 26.2 years in 1992 to 28.5 in 2004; hereafter it has stayed almost constant at that level. The demographic, obstetric and neonatal data subdivided into maternal age groups are presented in Table 1 and 2.

Table 1. Descriptive data of primiparous women with singleton births in the period 1992-2010.

Characteristics	< 17 years (n=2392)		17-19 years (n=29816)		20-24 years (n=185942)		25-29 years (n=300822)		30-34 years (n=205905)		35-39 years (n=63163)		40+ years (n=10634)	
BMI (kg/m²)	22.8	3.7	23.2	4.1	23.8	4.3	23.7	4.0	23.8	4.0	24.4	4.1	24.7	4.3
BMI† class														
<18.5 kg/m²	135	5.6%	1815	6.1%	7650	4.1%	7509	2.5%	3847	1.9%	918	1.5%	133	1.3%
18.5-24.9 kg/m²	1352	56.5%	16823	56.4%	104600	56.3%	180163	59.9%	122571	59.5%	34439	54.5%	5381	50.1%
25.0-29.9 kg/m²	315	13.2%	4687	15.7%	33961	18.3%	53896	17.9%	37234	18.1%	13310	21.1%	2442	23.0%
30.0-34-9 kg/m²	81	3.4%	1327	4.5%	10550	5.7%	14401	4.8%	9389	4.6%	3575	5.7%	683	6.4%
35.0-39.9 kg/m²	11	0.5%	337	1.1%	3013	1.6%	4070	1.4%	2724	1.3%	1024	1.6%	188	1.8%
≥ 40.0 kg/m²	4	0.2%	87	0.3%	904	0.5%	1312	0.4%	944	0.5%	342	0.5%	68	0.6%
Missing data	494	20.7%	4740	15.9%	25264	13.6%	39471	13.1%	29196	14.2%	9555	15.1%	1739	16.4%
Smoking†														
Yes	666	27.8%	9012	30.2%	31675	17.0%	24676	8.2%	13971	6.8%	5287	8.4%	958	9.0%
No	1542	64.5%	19154	64.3%	145695	78.4%	261348	86.9%	178792	86.8%	53416	84.6%	8883	83.5%
Missing data	184	7.7%	1650	5.5%	8572	4.6%	14798	4.9%	13142	6.4%	4460	7.0%	793	7.5%
Gestational age														
Information available	2368	99.0%	29715	99.7%	185700	99.9%	300603	99.9%	205719	99.9%	63098	99.9%	10620	99.9%
Missing data	24	1.0%	101	0.3%	242	0.1%	219	0.1%	186	0.1%	65	0.1%	14	0.1%

Figures denote mean and standard deviation or counts and proportions.
BMI = body mass index.
† Reported height, weight and smoking habits at first antenatal visit.

Table 2. Obstetric and neonatal outcome characteristics of primiparous women with singleton births in the period 1992-2010.

	Age groups													
Characteristics	< 17 years (n=2392)		17-19 years (n=29816)		20-24 years (n=185942)		25-29 years (n=300822)		30-34 years (n=205905)		35-39 years (n=63163)		40+ years (n=10634)	
Labour:														
Spontaneous onset labour	2055	85.9%	25853	86.7%	158879	85.4%	251340	83.6%	163876	79.6%	45330	71.2%	6261	58.9%
Induced labour	184	7.7%	2528	8.5%	17433	9.4%	30873	10.3%	25474	12.4%	10065	15.9%	2111	19.9%
Mode of delivery:														
Normal vaginal birth	2030	84.9%	25096	84.2%	147082	79.1%	219993	73.1%	135099	65.6%	35112	55.6%	4724	44.4%
Forceps	7	0.3%	126	0.4%	1143	0.6%	2166	0.7%	1515	0.7%	575	0.9%	84	0.8%
Vacuum extraction	143	6.0%	2090	7.0%	18011	9.7%	36696	12.2%	29811	14.5%	10119	16.0%	1599	15.0%
CS¥	213	8.9%	2500	8.4%	19747	10.6%	42044	14.0%	39534	19.2%	17355	27.5%	4226	39.7%
CS elective 1999-2010 ‡	53	2.2%	373	1.3%	2828	1.5%	6973	2.3%	7656	3.7%	3853	6.1%	1132	10.6%
CS acute 1999-2010 ‡	73	3.1%	882	3.0%	7092	3.8%	16651	5.5%	17953	8.7%	7826	12.4%	1798	16.9%
Gestational age:														
GA < 28 weeks	20	0.8%	107	0.4%	464	0.2%	743	0.2%	640	0.3%	292	0.5%	73	0.7%
GA < 32 weeks	40	1.7%	308	1.0%	1436	0.8%	2415	0.8%	2048	1.0%	900	1.4%	206	1.9%
GA < 37 weeks	213	8.9%	1937	6.5%	11030	5.9%	18005	5.6%	12727	6.2%	4586	7.3%	877	8.2%
GA 37 – 41 weeks	1990	83.2%	25811	86.6%	161043	86.6%	257320	85.5%	172621	83.8%	51494	81.5%	8786	82.6%
GA ≥ 42 weeks	165	6.9%	1967	6.6%	13627	7.3%	25278	8.4%	20371	9.9%	7018	11.1%	957	9.0%
Maternal complications and use of epidural analgesia:														
Perineal laceration gr 1-2*	311	14.3%	3982	14.6%	32602	19.6%	70452	27.3%	55163	33.2%	15477	33.9%	2116	33.1%
Perineal laceration gr 3-4*	23	1.1%	272	1.0%	3030	1.8%	8202	3.2%	6846	4.1%	1856	4.1%	222	3.5%
Preeclampsia	43	1.8%	576	1.9%	4317	2.3%	6520	2.2%	4265	2.1%	1610	2.5%	365	3.4%
Abruptio placentae	16	0.7%	135	0.5%	643	0.3%	1171	0.4%	955	0.5%	390	0.6%	87	0.8%
Placenta previa	2	0.1%	16	0.1%	159	0.1%	505	0.2%	612	0.3%	375	0.6%	89	0.8%
PPH > 1000 ml (VB)	65	3.0%	667	2.4%	5078	3.1%	10931	4.2%	9720	5.9%	3173	6.9%	485	7.6%
PPH > 1000 ml (CS)	2	0.9%	28	1.1%	252	1.3%	541	1.3%	578	1.5%	237	1.4%	80	1.9%
Epidural analgesia*	903	41.4%	11569	42.4%	68332	41.1%	105266	40.7%	70691	42.5%	20151	44.0%	2743	42.9%

Table 2 continued. Obstetric and neonatal outcome characteristics of primiparous women with singleton births in the period 1992-2010.

	Age groups													
Characteristics	< 17 years (n=2392)		17-19 years (n=29816)		20-24 years (n=185942)		25-29 years (n=300822)		30-34 years (n=205905)		35-39 years (n=63163)		40+ years (n=10634)	
Neonatal														
Foetal distress	8	0.3%	122	0.4%	932	0.5%	1621	0.5%	1070	0.5%	388	0.6%	56	0.5%
Aspiration of meconium	0	0%	30	0.1%	363	0.2%	649	0.2%	563	0.3%	193	0.3%	42	0.4%
Shoulder dystocia	6	0.3%	78	0.3%	793	0.4%	1580	0.5%	1382	0.7%	489	0.8%	79	0.7%
Stillbirth	7	0.3%	102	0.3%	571	0.3%	893	0.3%	768	0.4%	347	0.5%	87	0.8%
SGA	91	3.8%	1136	3.8%	6016	3.2%	8831	2.9%	7216	3.5%	2962	4.7%	617	5.8%
LGA	47	2.0%	539	1.8%	3838	2.1%	5943	2.0%	3846	1.9%	1279	2.0%	224	2.1%
Apgar score < 7 at 5	43	1.8%	381	1.3%	2409	1.3%	4158	1.4%	3354	1.6%	1274	2.0%	240	2.3%
Birth weight (gram)	3348	592	3403	565	3453	554	3470	555	3452	572	3415	612	3360	640

Figures denote counts and proportions or mean and one standard deviation.

BMI = body mass index; CS = caesarean section; GA = gestational age at birth; LGA = large for gestational age; PPH = postpartum haemorrhage; SGA = small for gestational age; VB = vaginal birth

[¥]All CS independent of status of performance – acute or elective. [†]Caesarean section was subdivided into elective and acute CS from 1999.

*Epidural analgesia and perineal lacerations in vaginal births only.

The crude odds rates and the results of the multivariate analyses models of obstetric and neonatal outcomes are shown in Table 3 and 4, respectively.

Table 3. Obstetric outcome data in singleton primiparous women in the period 1992-2010 in relation to maternal age group.

Characteristics	Crude OR (95%CI)	aOR (95%CI)†	Crude OR (95%CI)	aOR (95%CI)†	Crude OR (95%CI)	aOR (95%CI)†
Labour	< 17 years		17-19 years		20-24 years	
Spontaneous onset labour	1.20 (1.07-1.35)	1.20 (1.05-1.37)	1.28 (1.24-1.33)	1.26 (1.21-1.31)	1.16 (1.14-1.17)	1.16 (1.14-1.18)
Induced labour	0.73 (0.63-0.85)	0.78 (0.66-0.93)	0.81 (0.78-0.85)	0.86 (0.82-0.90)	0.90 (0.89-0.92)	0.91 (0.90-0.93)
	30 - 34 years		35 - 39 years		40+ years	
Spontaneous onset labour	0.77 (0.76-0.78)	0.78 (0.77-0.79)	0.50 (0.49-0.51)	0.52 (0.51-0.54)	0.29 (0.26-0.30)	0.30 (0.28-0.31)
Induced labour	1.23 (1.21-1.26)	1.19 (1.17-1.21)	1.66 (1.62-1.70)	1.54 (1.50-1.58)	2.17 (2.06-2.27)	1.97 (1.87-2.08)
Mode of delivery	< 17 years		17-19 years		20-24 years	
Normal vaginal birth	2.05 (1.84-2.30)	2.04 (1.79-2.32)	1.95 (1.89-2.02)	1.95 (1.88-2.02)	1.39 (1.37-1.41)	1.39 (1.37-1.41)
Forceps¥	0.38 (0.18-0.81)	0.41 (0.18-0.92)	0.55 (0.46-0.64)	0.48 (0.39-0.59)	0.82 (0.76-0.88)	0.77 (0.71-0.84)
Vacuum extraction¥	0.42 (0.36-0.51)	0.43 (0.36-0.52)	0.50 (0.48-0.53)	0.50 (0.48-0.53)	0.74 (0.72-0.75)	0.74 (0.72-0.75)
CS. all	0.60 (0.52-0.69)	0.57 (0.48-0.67)	0.56 (0.54-0.69)	0.55 (0.53-0.58)	0.73 (0.72-0.74)	0.72 (0.71-0.74)
CS elective 1999-2010 ‡	0.95 (0.73-1.25)	0.83 (0.60-1.14)	0.53 (0.48-0.59)	0.53 (0.47-0.60)	0.65 (0.62-0.68)	0.68 (0.65-0.71)
CS acute 1999-2010 ‡	0.54 (0.43-0.68)	0.53 (0.40-0.69)	0.52 (0.49-0.56)	0.56 (0.52-0.61)	0.68 (0.66-0.70)	0.71 (0.69-0.73)
	30 - 34 years		35 - 39 years		40+ years	
Normal vaginal delivery	0.70 (0.69-0.71)	0.72 (0.71-0.73)	0.46 (0.45-0.47)	0.48 (0.47-0.49)	0.29 (0.28-0.31)	0.31 (0.30-0.32)
Forceps¥	1.08 (1.01-1.15)	1.20 (1.12-1.29)	1.48 (1.35-1.63)	1.66 (1.49-1.84)	1.58 (1.27-1.98)	1.75 (1.37-2.24)
Vacuum extraction¥	1.32 (1.30-1.34)	1.29 (1.27-1.32)	1.72 (1.67-1.76)	1.67 (1.63-1.72)	2.01 (1.90-2.13)	1.92 (1.80-2.04)
CS. all	1.46 (1.44-1.49)	1.44 (1.42-1.47)	2.34 (2.29-2.38)	2.21 (2.16-2.26)	4.07 (3.91-4.23)	3.78 (3.61-3.96)
CS elective 1999-2010 ‡	1.63 (1.57-1.68)	1.44 (1.39-1.49)	2.74 (2.63-2.85)	2.25 (2.15-2.35)	5.03 (4.70-5.36)	3.89 (3.61-4.20)
CS acute 1999-2010 ‡	1.63 (1.59-1.67)	1.44 (1.40-1.47)	2.41 (2.35-2.48)	1.94 (1.88-2.00)	3.47 (3.29-3.66)	2.68 (2.52-2.85)
Gestational age	< 17 years		17-19 years		20-24 years	
GA < 28 weeks	3,44 (2.20-5.37)	2.84 (1.59-5.06)	1.46 (1.19-1.79)	1.25 (0.97-1.62)	1.01 (0.90-1.14)	0.89 (0.77-1.02)
GA < 32 weeks	2.12 (1.55-2.91)	1.66 (1.10-2.51)	1.29 (1.15-1.46)	1.20 (1.04-1.38)	0.96 (0.90-1.03)	0.92 (0.85-0.99)
GA < 37 weeks	1.55 (1.34-1.79)	1.46 (1.24-1.72)	1.09 (1.04-1.15)	1.03 (0.98-1.09)	0.99 (0.97-1.02)	0.97 (0.95-1.00)
GA 37 – 41 weeks	0.89 (0.79-0.99)	0.88 (0.77-0.99)	1.11 (1.07-1.15)	1.14 (1.09-1.18)	1.10 (2.08-1.12)	1.12 (1.10-1.14)
GA ≥ 42 weeks	0.82 (0.70-0.96)	0.89 (0.75-1.06)	0.77 (0.74-0.81)	0.79 (0.74-0.83)	0.86 (0.84-0.88)	0.85 (0.83-0.87)
	30 - 34 years		35 - 39 years		40+ years	
GA < 28 weeks	1.26 (1.13-1.40)	1.17 (1.04-1.33)	1.88 (1.64-2.15)	1.61 (1.40-1.90)	2.79 (2.19-3.56)	2.48 (1.86-3.29)
GA < 32 weeks	1.24 (1-17-1.32)	1.24 (1.16-1.33)	1.79 (1.65-1.93)	1.68 (1.53-1.84)	2.44 (2.12-2.82)	2.25 (1.90-2.66)
GA < 37 weeks	1.04 (1.01-1.06)	1.02 (0.99-1.05)	1.23 (1-19-1.27)	1.19 (1.15-1.24)	1.41 (1.32-1.52)	1.37 (1.26-1.48)
GA 37 – 41 weeks	0.88 (0.86-0.89)	0.89 (0.86-0.89)	0.75 (0.73-0.76)	0.76 (0.74-0.78)	0.81 (0.77-0.85)	0.83 (0.79-0.88)
GA ≥ 42 weeks	1.20 (1.17-1.22)	1.20 (1.18-1.23)	1.36 (1.33-1.40)	1.35 (1.31-1.39)	1.08 (1.01-1.15)	1.06 (0.98-1.14)

Table 3 continued. Obstetric outcome data in singleton primiparous women in the period 1992-2010 in relation to maternal age group.

Characteristics	Crude OR (95%CI)	aOR (95%CI)†	Crude OR (95%CI)	aOR (95%CI)†	Crude OR (95%CI)	aOR (95%CI)†
Maternal complications and use of epidural analgesia:	< 17 years		17-19 years		20-24 years	
Perineal laceration grade 1-2¥	0.44 (0.39-0.50)	0.44 (0.38-0.50)	0.46 (0.44-0.47)	0.47 (0.45-0.49)	0.65 (0.64-0.66)	0.68 (0.67-0.69)
Perineal laceration grade 3-4¥	0.33 (0.22-0.49)	0.39 (0.25-0.60)	0.31 (0.25-0.37)	0.37 (0.32-0.42)	0.57 (0.54-0.59)	0.61 (0.58-0.64)
Preeclampsia	0.83 (0.61-1.12)	0.89 (0.62-1.27)	0.89 (0.82-0.97)	0.93 (0.84-1.02)	1.07 (1.03-1.12)	1.01 (0.96-1.05)
Abruptio placentae	1.72 (1.05-2.83)	1.76 (1.03-3.00)	1.16 (0.97-1.39)	1.02 (0.83-1.26)	0.89 (0.81-0.98)	0.83 (0.74-0.92)
Placenta praevia	0.50 (0.12-2.00)	0.57 (0.14-2.30)	0.32 (0.19-0.53)	0.28 (0.16-0.50)	0.52 (0.43-0.61)	0.52 (0.43-0.63)
PPH > 1000 ml (VB)	0.70 (0.54-0.89)	0.65 (0.48-0.88)	0.57 (0.53-0.61)	0.64 (0.59-0.70)	0.71 (0.69-0.74)	0.78 (0.75-0.81)
PPH > 1000 ml (CS)	0.73 (0.18-2.93)	0.52 (0.07-3.74)	0.87 (0.59-1.27)	1.16 (0.77-1.93)	0.99 (0.92-1.07)	1.09 (0.93-1.28)
Epidural analgesia¥	1.03 (0.95-1.12)	1.03 (0.93-1.13)	1.07 (1.06-1.08)	1.07 (1.04-1.10)	1.02 (1.01-1.03)	1.03 (1.01-1.04)
	30 - 34 years		35 - 39 years		40+ years	
Perineal laceration grade 1-2¥	1.33 (1.31-1.34)	1.11 (1.10-1.13)	1.37 (1-34-1.40)	1.08 (1.05-1.10)	1.32 (1.25-1.39)	1.00 (0.94-1.07)
Perineal laceration grade 3-4¥	1.31 (1.27-1.36)	1.16 (1.12-1.20)	1.29 (1.23-1.36)	1.12 (1.05-1.18)	1.10 (0.96-1.26)	0.88 (0.75-1.02)
Preeclampsia	0.95 (0.92-0.99)	1.07 (1.03-1.12)	1.18 (1.12-1.25)	1.30 (1.22-1.39)	1.60 (1.44-1.79)	1.83 (1.62-2.06)
Abruptio placentae	1.19 (1.09-1.30)	1.27 (1.16-1.40)	1.59 (1.42-1.78)	1.71 (1.50-1.94)	2.11 (1-70-2.63)	2.09 (1.62-2.71)
Placenta praevia	1.77 (1.58-1.99)	1.74 (1.53-2.00)	3.55 (3.11-4.06)	3.47 (2.99-4.03)	5.02 (4.00-6.29)	5.23 (4.08-6.70)
PPH > 1000 ml (VB)	1.41 (1.37-1.45)	1.27 (1.23-1.31)	1.69 (1.62-1.76)	1.47 (1.40-1.53)	1.86 (1.69-2.05)	1.48 (1.26-1.52)
PPH > 1000 ml (CS)	1.14 (1.01-1.28)	1.04 (0.91-1.18)	1.06 (0.91-1.24)	0.95 (0.81-1.12)	1.48 (1.17-1.88)	1.35 (1.05-1.73)
Epidural analgesia¥	1.08 (1.06-1.09)	1.03 (1.02-1.05)	1.14 (1.12-1.17)	1.06 (1.04-1.09)	1.10 (1.04-1.15)	0.98 (0.93-1.03)

Reference group: Maternal age 25-29 years.

CI = confidence intervals; CS = Caesarean section; GA = gestational age at delivery; N/A = not applicable; aOR = adjusted odds ratio; PPH = postpartum haemorrhage; VD = vaginal birth.

† Adjusted for maternal BMI and smoking habits at first antenatal care visit and year of birth. CS and preeclampsia also adjusted for gestational age. ‡ Caesarean section was subdivided into elective and acute CS from 1999. ¥ Forceps, vacuum extraction, epidural analgesia and perineal lacerations among vaginally delivered women.

Table 4. Neonatal outcome data in singleton primiparous women in the period 1992-2010 in relation to maternal age group.

Characteristics	Crude OR (95%CI)	aOR (95%CI)†	Crude OR (95%CI)	aOR (95%CI)†	Crude OR (95%CI)	aOR (95%CI)†
	< 17 years		17-19 years		20-24 years	
Foetal distress	0.62 (0.31-1.24)	0.52 (0.22-1.26)	0.76 (0.63-0.91)	0.63 (0.51-0.79)	0.93 (0.86-1.01)	0.79 (0.72-0.91)
Aspiration of meconium	N/A	N/A	0.47 (0.32-0.67)	0.46 (0.31-0.70)	0.90 (0.80-1.03)	0.93 (0.81-1.07)
Shoulder dystocia¥	0.45 (0.11-1.82)	0.32(0.05-2.29)	0.74 (0.58-0.90)	0.74 (0.52-1.07)	1.01 (0.88-1.16)	1.00 (0.86-1.16)
Stillbirth	0.99 (0.47-2.08)	0.58 (0.19-1.80)	1.15 (0.94-1.42)	0.97 (0.75-1.25)	1.03 (0.93-1.15)	0.98 (0.87-1.11)
SGA	1.32 (1.07-1.63)	1.00 (0.78-1.28)	1.31 (1.23-1.40)	1.01 (0.94-1.09)	1.11 (1.07-1.14)	1.00 (0.96-1.04)
LGA	1.01 (0.75-1.34)	1.08 (0.76-1.53)	0.92 (0.84-1.00)	1.03 (0.94-1.14)	1.05 (1.00-1.09)	1.05 (1.00-1.10)
Apgar score < 7 at 5 minutes	1.31 (0.96-1.77)	1.30 (0.91-1.86)	0.92 (0.83-1.03)	0.92 (0.81-1.11)	0.93 (0.89-0.99)	0.93 (0.88-0.98)
	30 - 34 years		35 - 39 years		40+ years	
Foetal distress	0.96 (0.89-1.04)	1.23 (1.13-1.35)	1.14 (1.02-1.27)	1.51 (1.33-1.72)	0.98 (0.75-1.28)	1.60 (1.20-2.13)
Aspiration of meconium	1.27 (1.13-1.42)	1.36 (1.20-1.54)	1.42 (1.21-1.67)	1.48 (1.24-1.77)	1.83 (1.34-2.51)	1.82 (1.28-2.58)
Shoulder dystocia¥	1.18 (1.04-1.35)	1.13 (0.90-1.41)	1.13 (0.91-1.39)	1.13 (0.91-1.41)	1.47 (0.93-2.33)	1.27 (0.76-2.12)
Stillbirth	1.26 (1.14-1.38)	1.25 (1.12-1.39)	1.85 (1.64-2.10)	1.72 (1.49-1.99)	2.77 (2.22-3.46)	2.34 (1.80-3.03)
SGA	1.20 (1.16-1.24)	1.24 (1.20-1.28)	1.63 (1.56-1.70)	1.65 (1.58-1.73)	2.04 (1.87-2.22)	2.06 (1.87-2.26)
LGA	0.94 (0.91-0.98)	0.94 (0.90-0.98)	1.03 (0.97-1.09)	0.97 (0.91-1.04)	1.07 (0.93-1.22)	0.94 (0.81-1.09)
Apgar score < 7 at 5 minutes	1.18 (1.13-1.24)	1.18 (1.12-1.24)	1.47 (1.38-1.56)	1.39 (1.29-1.49)	1.65 (1.44-1.88)	1.51 (1.30-1.75)

Reference group: Maternal age 25-29 years.

CI = confidence interval; LGA = large for gestational age; N/A = not applicable; aOR = adjusted odds ratio; SGA = small for gestational age

† Adjusted for maternal BMI and smoking habits at first antenatal care visit and year of birth

¥ Shoulder dystocia among vaginal delivered women.

Mode of delivery, obstetric and neonatal outcome of adolescents

Compared with the reference group the teenagers had a significantly higher likelihood of having spontaneous onset of labour and of having a normal vaginal delivery. Teenagers also demonstrated a significantly higher risk of giving birth prematurely. However, only the group of teenagers younger than 17 years of age had an increased risk of giving birth very prematurely i.e. before 28 weeks of gestational age, and the same group revealed a significantly higher risk of placental abruption. In contrast with these observations the teenagers were delivered instrumentally and by CS significantly less often, and the vaginal births caused significantly fewer perineal lacerations (only evaluated among women who delivered vaginally) and PPH > 1000 ml. Likewise the occurrence of placenta previa was seen less often among teenagers whereas the occurrence of preeclampsia was equal to that seen in the reference group.

Concerning the foetal and neonatal outcomes for adolescents the newborns were less likely to show foetal distress and meconium aspiration in spite of a similar occurrence of Apgar score < 7 at 5 minutes. The newborns of the adolescents were not more prone to being stillborn or being SGA than the newborns of women in the reference group. The adjusted mean birth weight of newborns of adolescents did not differ significantly from that of women up to 29 years of age (Figure 1).

Mode of delivery, obstetric and neonatal outcome of women 20-24 years of age

The young women, 20 – 24 years of age, differed in some aspects from the reference group as well as from the adolescents. They were less likely to be delivered prematurely and had a lower frequency of placental abruption. Otherwise the obstetric and neonatal outcomes were similarly favourable as those observed for the adolescents in comparison with the reference group.

Mode of delivery, obstetric and neonatal outcome of women older than 29 years of age

As shown in Table 3 compared with the reference group almost all obstetric outcome variables demonstrated a continuously progressive deterioration with increasing age. The likelihood of normal

vaginal births decreased; induced labour, instrumental deliveries and CS increased as well as prematurity including very premature deliveries. The risk of perineal laceration increased moderately whereas the risk of PPH > 1000 ml in vaginal births was more pronounced. The likelihood of the pregnancy complications preeclampsia, abruptio placenta and placenta previa was also higher in the older age groups and progressed substantially with increasing age. Similarly, the foetal and neonatal outcome was adversely progressively influenced by increasing maternal age. With increasing maternal age over 30 years significantly more neonates were SGA, showed foetal distress, had Apgar score < 7 at 5 minutes or meconium aspiration, or were stillborn. The mean birth weight of the neonates also decreased significantly with increasing maternal age after the age of 30 (Figure 1).

DISCUSSION

This Swedish nation-wide population-based study with prospectively collected data concerning singleton primiparous women showed that the mode of delivery differed over the maternal age strata. Significantly more normal vaginal deliveries and fewer CS and instrumental vaginal deliveries were seen among the teenagers and among women aged 20-24 compared with the reference group of women aged 25-29. The opposite was found among older women reaching a 4-fold increased risk for CS compared with women aged 20-24. The teenagers as well as women aged 20-24 were less prone to perineal lacerations and PPH exceeding 1000 ml. Prematurity (< 28 weeks of GA) was associated with very low maternal age (<17 years) among the adolescents although the increased risk was at the same level as among women aged 40 years and above, indicating a u-shaped risk curve. Adolescents were not afflicted more by preeclampsia than the reference women whereas the risk of preeclampsia increased significantly with advancing maternal age. The risk of placentae praevia increased dramatically with maternal age, actually a 500% increased risk was found after the age of 40 compared with the reference group. There was a significantly increased risk of stillbirth, SGA and low Apgar score only in women aged 30 years and over.

The most prominent difference between the findings in the present study and earlier studies is that no increased risk for SGA was found among the adolescents and young mothers 20-24 years of age compared with the reference women.[8-9] It must be kept in mind that the definition of SGA may differ between countries. In the United States and Latin America SGA is usually defined as birth weight below the 10th percentile compared with two SD in the Nordic countries.[3, 9] Adjusted risks for SGA among teenagers, recently presented from Finland, one of the Nordic countries, showed no increased risk among the youngest mothers.[6] In that study the control group was defined in the same way as in the present study but the Finnish study did not adjust for smoking habits. We found that smoking in early pregnancy was a significant independent risk factor for SGA in all age groups but it was only in the young women below 25 years of age that the adjustment of smoking turned the statistically

significant crude ORs into non-significant adjusted OR values. The contrary was found for the older women where the already significant crude ORs for SGA even became increased. This observation may support a biological explanation for SGA in the older women. Differences concerning the risk for SGA could also be attributable to differences in socio-economic status. Chen et al. restricted their analysis to white married mothers with age-appropriate education level, adequate prenatal care, without smoking and alcohol use during pregnancy but found the increased risk for SGA to persist.[3] Several studies have shown low infant birth weight for adolescents as well as for mothers with advancing age.[18, 14, 30, 31] We failed to find such association among the adolescents, but in women with advancing age the difference in birth weight was statistically significant although the difference lacked clinical significance.

The finding of a preferable birth outcome with lower CS rates and lower rates of instrumental delivery among teenagers compared with older women has been pinpointed to a lesser extent than observed adverse outcomes. Earlier studies have shown relatively consistent results concerning a decreased rate of CS in the adolescent group and a higher rate in women with advancing age.[6, 8, 9, 12-18] We were able to evaluate elective and emergency CS separately and the risks among the teenagers and mothers age 20-24 years were decreased for both types. This might indicate that the different risks concerning CS among young and older mothers could not exclusively be explained by more CS on maternal request among older mothers but may even be caused by biological factors. A low rate of instrumental deliveries and CS among adolescents and a high rate among older women have almost unanimously been shown in several reports from high-income as well as low-income countries.[5, 7, 12-18, 30-33] Whether this phenomenon depends on differences in handling the delivery, inherent or cultural behavioural, domestic or social attitudes among the obstetric staff or biological factors has not been investigated. Advancing age is associated with impaired uterine contractility as well as endothelial dysfunction which theoretically may lead to impaired uterine and utero-placental function.[34, 35] The fact that adolescents in our study had a lower risk of induction of labour, perineal laceration, PPH,

abruption (except for the very young women) and placenta previa and women with advancing age had higher risks of all these outcomes including preeclampsia could support a biological explanation. Concerning prematurity the age related risk curve was U shaped. This may also support a biological aetiology; immaturity of the uterus in the very young women that obstruct development of a term pregnancy and uterine dysfunction caused by ageing processes in women with advancing age and consequently deliver prematurely in both situations. The neonatal outcomes followed almost the same pattern; foetal distress, meconium aspiration, stillbirth, SGA and low Apgar score were exclusively attributed to women older than 29.

The strength of this study is that it deals with the outcomes in the population of an entire country where the antenatal care program is equally available to all pregnant women and is comprehensive. In Sweden pregnant women have completely cost free access to antenatal and obstetric facilities; poverty and malnutrition are practically non-existent and the vast majority of women attends the antenatal care program (99%) independent of socio-economic status and is delivered in obstetric units.[21] This context is valid for the whole study period. Another advantage is the large number of individuals available for evaluation, which makes it possible to divide the study population into subgroups with sufficient numbers in each stratum to provide high statistical power. A sufficient number of study subjects made it possible to evaluate three subgroups of young maternal age. Only primiparous women were included in order to avoid the confounding effects of factors associated with subsequent deliveries. There are limitations that should be considered. The external validity is reduced to facilities with similar socio-economic and demographic characteristics and health care systems with comparable standards. The drawback is obvious given the large size of the study and the numbers of health care units involved that the criteria for diagnosis (ICD codes) to define outcomes may not be uniform across the study population but the variation is most likely not related to maternal age. The MBR contain a large body of information concerning the mother and the child which made it possible to adjust the results for confounding factors. At the same time this is a limitation as only the data available in the

register could be used for adjustments. The register lacks information on ethnicity and socio-economic status. Our effort was to evaluate obstetric and neonatal outcome in different maternal age groups compared with women aged 25-29 overall. The only stratifications made were for year of birth, maternal BMI and smoking in early pregnancy. The data on year of birth showed that there is variability in the existence of obstetric and neonatal diagnoses during the observation period. This may be due to true changes but may also be a result of changes in recording, including the expanding use of computerized medical records. It was therefore necessary to adjust for year of birth. Maternal BMI, maternal smoking and gestational age (for some relevant outcomes) were included in the adjusted analyses based on their well known association with maternal and foetal outcome.[26,27] Putative confounders and intermediaries were not identified with statistical analysis. To demonstrate causality between the different outcomes evaluated in the analyses and maternal age a great number of putative intermediaries could have been considered such as the use of fertility treatment, foetal size, gestational weight gain etc., but that was not the purpose of the study. There may be other variables (which are not intermediaries) but we have not been able to identify them. The proportion of missing data concerning the included confounders could have affected the results. The youngest age group had the highest frequency of missing data on BMI (20.7%) and smoking (7.7%) compared with the reference group (13.1% and 4.9%, respectively). The distribution of BMI in the youngest age group was almost equal to the other maternal age groups. One explanation for a higher proportion of missing data in the youngest age group could be a later detection of their pregnancies and attendance to the antenatal care and questions concerning exposure in early pregnancy were not raised. Gestational age could be calculated for more than 99% of the study subjects in this study with just minimal variations between maternal age groups.

Our approach of analysing the data may be a benefit for clinicians interpreting the results when dealing with young and aged mothers.

In conclusion, in a country with a highly developed social and antenatal maternity health care security system giving cost free maternity and obstetric care to all pregnant women adolescents had a decreased risk for adverse obstetric and neonatal outcome compared with the reference group. In the same social context childbirth at advanced maternal age was associated with a number of serious complications for both the woman and the child. For clinicians counselling young mothers it is of great importance to highlight the positive consequences that less obstetric complications and favourable neonatal outcomes are expected. The results imply that there is a need for individualizing the antenatal surveillance programs and obstetric care based on age grouping in order to attempt to improve the outcomes in the age groups with less favourable obstetric and neonatal outcomes. Such changes in surveillance programs and obstetric interventions need to be evaluated in further studies.

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Checklist: The manuscript conforms to the STROBE requirement.

Data sharing statement: Technical appendix, statistical code, and dataset available from the corresponding author at Dryad repository, who will provide a permanent, citable and open access home for the dataset.

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LEGENDS

Figure 1. Adjusted mean birth weight of neonates in singleton primiparous women in different maternal age groups. Birth weight adjusted for gestational age, maternal BMI and smoking habits, and year of delivery. Plots indicate means and bars 95% CI.

Impact of maternal age on obstetric and neonatal outcome with emphasis on primiparous adolescents and older women-a Swedish Medical Birth Register Study.

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Abstract

Objectives: To evaluate the associations between maternal age and obstetric and neonatal outcomes in primiparous women with emphasis on teenagers and older women.

Design: A population-based cohort study.

Setting: The Swedish Medical Birth Register.

Participants: Primiparous women with singleton births from 1992 through 2010 (N=798,674) were divided into seven age groups: <17 years, 17-19 years, and additional five five-year classes. The reference group consisted of the women age 25-29 years.

Primary outcome: Obstetric and neonatal outcome.

Results: The teenager groups had significantly more vaginal births (aOR 2.04 (1.79-2.32) and 1.95 (1.88-2.02) for age <17 years and 17–19 years, respectively); fewer caesarean sections (aOR 0.57 (0.48-0.67) and 0.55 (0.53-0.58)), and instrumental vaginal births (aOR 0.43 (0.36-0.52) and 0.50 (0.48-0.53)) compared with the reference group. The opposite was found among older women reaching a 4-fold increased odds ratio for caesarean section. The teenagers showed no increased risk of adverse neonatal outcome but presented an increased risk of prematurity <32 weeks (aOR 1.66 (1.10-2.51) and 1.20 (1.04-1.38)). Women with advancing age (≥ 30 years) revealed significantly increased risk of prematurity, perineal lacerations, preeclampsia, abruption, placenta previa, postpartum haemorrhage and unfavourable neonatal outcomes compared with the reference group.

Conclusions: For clinicians counselling young women it is of importance to highlight the obstetrically positive consequences that fewer maternal complications and favourable neonatal outcomes are expected. The results imply that there is a need for individualizing the antenatal surveillance programs and obstetric care based on age grouping in order to attempt to improve the outcomes in the age groups with less favourable obstetric and neonatal outcomes. Such changes in surveillance programs and obstetric interventions need to be evaluated in further studies.

Article summary

Impact of maternal age on obstetric and neonatal outcome with emphasis on primiparous adolescents and older women-a Swedish Medical Birth Register Study.

Strengths and limitations of this study:

- A strength of the present study is that it includes primiparous women of an entire country where the antenatal care program is equally available to all pregnant women and is comprehensive.
- Another advantage is the large number of individuals available for evaluation, which makes it possible to divide the study population into subgroups with sufficient numbers in each stratum to provide high statistical power.
- A limitation is that the external validity is reduced to facilities with similar socio-economic and demographic characteristics and health care systems with comparable standards.
- The Swedish medical birth register contain a large body of information concerning the mother and the child but only the available data in the register could be used for outcome evaluation and adjustments for putative confounders.

INTRODUCTION

There are a large number of studies evaluating obstetric and neonatal outcome over the full range of reproductive maternal ages, but especially with a focus on the youngest and the oldest mothers. Young mothers have been shown to be exposed to an increased risk of anaemia, low birth weight, foetal death, eclampsia and preterm birth although they at the same time were more likely to have a spontaneous normal vaginal birth and the risk of preeclampsia and post-partum haemorrhage were significantly decreased.[1-6] These studies evaluated outcomes in low-income countries. Many studies performed in low-income countries presented in recent years on the topic of teenage pregnancies have found similar obstetric and neonatal outcomes.[7-11]

Complications during pregnancy and birth at advanced maternal age (either defined as 35 years and older or 40 years or older) have also been evaluated in high-income countries. Advanced maternal age at birth has been found to be associated with gestational diabetes, preeclampsia, placenta previa, caesarean section (CS), placental abruption, preterm delivery, low birth weight, intrauterine foetal death and an increased perinatal mortality.[12-20] The difference in obstetric and neonatal outcomes between teenagers and women at advanced age seemed to be lower risks for several unwanted and threatening outcomes in the teenage group; thus there were no obvious advantages concerning obstetric and neonatal outcomes at advanced maternal ages. The earlier published studies concerning the impact of maternal age on perinatal outcome differ in many aspects methodologically as well as in the socio-demographic characteristics of the populations and health care systems. All these factors make interpretation of comparisons between data sets difficult.

Sweden has during several decades actively developed strategies in social care, education and health care in order to improve antenatal care and parenthood. In a Swedish state-of-the-art conference held in 1990, the scientific basis of the routine antenatal program was critically evaluated. It was concluded that the scientific evidence to support the timing and contents of routine visits was unsatisfactory.[21] Consequently there is a constant need for evaluation both of single diagnostic procedures and

intervention and of outcomes. An analysis of perinatal outcomes in relation to maternal age in the Swedish population will provide important knowledge that may be used to further improve social, antenatal, obstetric and neonatal care and reveals risk groups that in particular may need more attention in the antenatal care.

The objective of the present study was to assess the impact of maternal age on obstetric and neonatal outcomes among singleton primiparous women in Sweden, with special emphasis on the adolescents and older mothers.

MATERIALS AND METHODS

This study analyses the obstetric and neonatal outcomes of all singleton primiparous women prospectively registered in the Swedish Medical Birth Register (MBR) who gave births from January 1, 1992 through December 31, 2010. MBR has collected information about births in Sweden since 1973. It is compulsory for every health care provider to report to the MBR. Medical and other data on almost all (99%) births in Sweden are listed in the register, which also includes stillbirths. Starting with the first antenatal visit, usually in gestational week 10-12, the information is collected prospectively in standardized medical record forms completed at the maternity health care centers at antenatal care visits, in the birth units, and at the paediatric examination of the newborn. The standardized medical records are identical throughout the country. A description and validation of the register content is available.[22-24]

The study population was grouped according to maternal age into seven subgroups: <17 years; 17-19 years; 20-24 years, 25-29 years, 30-34 years; 35-39 years and 40+ years. In the outcome analyses we selected the group of women age 25-29 years as reference group.

The list of available variables in MBR has been extended throughout the years that the register has been active. The obstetric and neonatal outcome data for the purpose of this study are those that have been available since 1992. From 1992 until June 2008 the MBR includes stillbirths after 28 weeks of gestation and from July 2008 until 2010 all stillbirths after 22 weeks of gestation are included. Each outcome studied was either marked in the MBR or registered according to the International Statistical Classification of Diseases and Related Health Problems (ICD). The obstetric outcome variables studied were gestational age, mode of delivery; normal vaginal birth (defined as neither instrumental vaginal delivery, nor CS), CS, instrumental vaginal delivery divided into forceps and vacuum extraction, mode of onset of labour, perineal laceration, preeclampsia, abruptio placentae, placenta previa, use of epidural analgesia and postpartum haemorrhage (PPH) exceeding 1000 ml. The foetal and neonatal outcomes evaluated were Apgar-score at 5 minutes, foetal distress (ICD code P20.0, P20.1 and P20.9),

aspiration of meconium (ICD code P24.0), shoulder dystocia (ICD code O66.0), and stillbirth. Small-for-gestational age (SGA) newborns were defined as those with birth weight more than 2 standard deviations (SD) below the mean birth weight for gestational age (sex and parity specific) according to a Swedish reference curve.[25] Large-for-gestational age (LGA) newborns were those with a birth weight above 2 SD. All descriptive and background data were extracted from the MBR. The register information on these variables was obtained from the antenatal care center records.

The study was approved by the Regional Ethical Review Board in Linköping, Sweden (Dnr 2011/479-31. Approved January 25; 2012).

Statistical analysis

Data are presented as counts and per cent or mean and one SD. Logistic regression analyses were used for comparison of groups for categorical data. Data on a continuous scale were compared using analysis of covariance (ANCOVA). Multivariate logistic regression models were used in order to adjust comparisons for the confounding factors. Consequently crude and adjusted odds ratios (OR and aOR) and 95% confidence intervals (CIs) are reported. Maternal weight and height (used for calculation of maternal Body Mass Index (BMI)) and smoking habits in early pregnancy (unknown, no smoking, smoking) and year of birth were included as confounders in the adjusted analyses. The simultaneous model of including independent variables in the multivariate logistic regression was used since we found it most appropriate for the relevance of the research goal of the study. Such a research strategy is appropriate when there is no logical or theoretical basis for considering any variable to be prior to any other, either in terms of a hypothetical causal structure of the data or in terms of its relevance to the research goals of focusing on prediction and explanation.

The rationale for including year of birth as an independent variable was that there was variability in the occurrence of obstetric and neonatal diagnoses during the observation period. This may be due to true changes but may also be a result of changes in recording with expanding use of computerized medical records. Maternal BMI and smoking was included as covariates in the adjusted analyses based on their

well-known associations with maternal and foetal outcome and their unequal distribution over the maternal age strata.[26,27] BMI was included as a continuous variable as the distribution of maternal BMI was almost uniform over the maternal age strata and the association between BMI and maternal age was almost linear (presented as means and standard deviations in Table 1). For the purpose of this study gestational age was added to the confounders in the analyses of CS, preeclampsia and birth weight based on their clinically well-known associations.[25,28,29] The OR for instrumental vaginal delivery was calculated among women with vaginal births only in order to exclude women with an instrumental attempt to deliver followed by an emergency CS. The ORs of perineal lacerations were also estimated among women with vaginal births only. The information concerning use of epidural analgesia was also restricted to vaginal births only. Epidural is an analgesic method that has been widely used in the delivery wards for vaginal births during the entire time period. In contrast the use of epidural analgesia in CS has varied substantially over the time period and has almost exclusively been used in elective CS. Our purpose was to evaluate the odds ratio for epidural use over the maternal age strata and consequently we selected the mode of delivery that exhibited the least variation in the use of the analgesic method over the time period, i.e. vaginal births.

The software STATISTICA 64 version 10 (StatSoft Inc. 2300 East 14th St. Tulsa, OK 74104 USA) was used to carry out the statistical analyses.

RESULTS

In the period 1992 – 2010, 798,732 women were registered in the MBR as giving birth to their first child. The annual number of primiparous women giving birth varied between 34060 and 49417. Information on maternal age was missing in 58 cases leaving 798,674 women for the analyses. The average age of primiparous women increased substantially from 26.2 years in 1992 to 28.5 in 2004; hereafter it has stayed almost constant at that level. The demographic, obstetric and neonatal data subdivided into maternal age groups are presented in Table 1 and 2.

Table 1. Descriptive data of primiparous women with singleton births in the period 1992-2010.

Characteristics	< 17 years (n=2392)		17-19 years (n=29816)		20-24 years (n=185942)		25-29 years (n=300822)		30-34 years (n=205905)		35-39 years (n=63163)		40+ years (n=10634)	
BMI (kg/m²)	22.8	3.7	23.2	4.1	23.8	4.3	23.7	4.0	23.8	4.0	24.4	4.1	24.7	4.3
BMI† class														
<18.5 kg/m²	135	5.6%	1815	6.1%	7650	4.1%	7509	2.5%	3847	1.9%	918	1.5%	133	1.3%
18.5-24.9 kg/m²	1352	56.5%	16823	56.4%	104600	56.3%	180163	59.9%	122571	59.5%	34439	54.5%	5381	50.1%
25.0-29.9 kg/m²	315	13.2%	4687	15.7%	33961	18.3%	53896	17.9%	37234	18.1%	13310	21.1%	2442	23.0%
30.0-34-9 kg/m²	81	3.4%	1327	4.5%	10550	5.7%	14401	4.8%	9389	4.6%	3575	5.7%	683	6.4%
35.0-39.9 kg/m²	11	0.5%	337	1.1%	3013	1.6%	4070	1.4%	2724	1.3%	1024	1.6%	188	1.8%
≥ 40.0 kg/m²	4	0.2%	87	0.3%	904	0.5%	1312	0.4%	944	0.5%	342	0.5%	68	0.6%
Missing data	494	20.7%	4740	15.9%	25264	13.6%	39471	13.1%	29196	14.2%	9555	15.1%	1739	16.4%
Smoking†														
Yes	666	27.8%	9012	30.2%	31675	17.0%	24676	8.2%	13971	6.8%	5287	8.4%	958	9.0%
No	1542	64.5%	19154	64.3%	145695	78.4%	261348	86.9%	178792	86.8%	53416	84.6%	8883	83.5%
Missing data	184	7.7%	1650	5.5%	8572	4.6%	14798	4.9%	13142	6.4%	4460	7.0%	793	7.5%
Gestational age														
Information available	2368	99.0%	29715	99.7%	185700	99.9%	300603	99.9%	205719	99.9%	63098	99.9%	10620	99.9%
Missing data	24	1.0%	101	0.3%	242	0.1%	219	0.1%	186	0.1%	65	0.1%	14	0.1%

Figures denote mean and standard deviation or counts and proportions.
BMI = body mass index.
† Reported height, weight and smoking habits at first antenatal visit.

Table 2. Obstetric and neonatal outcome characteristics of primiparous women with singleton births in the period 1992-2010.

	Age groups													
Characteristics	< 17 years (n=2392)		17-19 years (n=29816)		20-24 years (n=185942)		25-29 years (n=300822)		30-34 years (n=205905)		35-39 years (n=63163)		40+ years (n=10634)	
Labour:														
Spontaneous onset labour	2055	85.9%	25853	86.7%	158879	85.4%	251340	83.6%	163876	79.6%	45330	71.2%	6261	58.9%
Induced labour	184	7.7%	2528	8.5%	17433	9.4%	30873	10.3%	25474	12.4%	10065	15.9%	2111	19.9%
Mode of delivery:														
Normal vaginal birth	2030	84.9%	25096	84.2%	147082	79.1%	219993	73.1%	135099	65.6%	35112	55.6%	4724	44.4%
Forceps	7	0.3%	126	0.4%	1143	0.6%	2166	0.7%	1515	0.7%	575	0.9%	84	0.8%
Vacuum extraction	143	6.0%	2090	7.0%	18011	9.7%	36696	12.2%	29811	14.5%	10119	16.0%	1599	15.0%
CS¥	213	8.9%	2500	8.4%	19747	10.6%	42044	14.0%	39534	19.2%	17355	27.5%	4226	39.7%
CS elective 1999-2010 ‡	53	2.2%	373	1.3%	2828	1.5%	6973	2.3%	7656	3.7%	3853	6.1%	1132	10.6%
CS acute 1999-2010 ‡	73	3.1%	882	3.0%	7092	3.8%	16651	5.5%	17953	8.7%	7826	12.4%	1798	16.9%
Gestational age:														
GA < 28 weeks	20	0.8%	107	0.4%	464	0.2%	743	0.2%	640	0.3%	292	0.5%	73	0.7%
GA < 32 weeks	40	1.7%	308	1.0%	1436	0.8%	2415	0.8%	2048	1.0%	900	1.4%	206	1.9%
GA < 37 weeks	213	8.9%	1937	6.5%	11030	5.9%	18005	5.6%	12727	6.2%	4586	7.3%	877	8.2%
GA 37 – 41 weeks	1990	83.2%	25811	86.6%	161043	86.6%	257320	85.5%	172621	83.8%	51494	81.5%	8786	82.6%
GA ≥ 42 weeks	165	6.9%	1967	6.6%	13627	7.3%	25278	8.4%	20371	9.9%	7018	11.1%	957	9.0%
Maternal complications and use of epidural analgesia:														
Perineal laceration gr 1-2*	311	14.3%	3982	14.6%	32602	19.6%	70452	27.3%	55163	33.2%	15477	33.9%	2116	33.1%
Perineal laceration gr 3-4*	23	1.1%	272	1.0%	3030	1.8%	8202	3.2%	6846	4.1%	1856	4.1%	222	3.5%
Preeclampsia	43	1.8%	576	1.9%	4317	2.3%	6520	2.2%	4265	2.1%	1610	2.5%	365	3.4%
Abruptio placentae	16	0.7%	135	0.5%	643	0.3%	1171	0.4%	955	0.5%	390	0.6%	87	0.8%
Placenta previa	2	0.1%	16	0.1%	159	0.1%	505	0.2%	612	0.3%	375	0.6%	89	0.8%
PPH > 1000 ml (VB)	65	3.0%	667	2.4%	5078	3.1%	10931	4.2%	9720	5.9%	3173	6.9%	485	7.6%
PPH > 1000 ml (CS)	2	0.9%	28	1.1%	252	1.3%	541	1.3%	578	1.5%	237	1.4%	80	1.9%
Epidural analgesia*	903	41.4%	11569	42.4%	68332	41.1%	105266	40.7%	70691	42.5%	20151	44.0%	2743	42.9%

Table 2 continued. Obstetric and neonatal outcome characteristics of primiparous women with singleton births in the period 1992-2010.

	Age groups													
Characteristics	< 17 years (n=2392)		17-19 years (n=29816)		20-24 years (n=185942)		25-29 years (n=300822)		30-34 years (n=205905)		35-39 years (n=63163)		40+ years (n=10634)	
Neonatal														
Foetal distress	8	0.3%	122	0.4%	932	0.5%	1621	0.5%	1070	0.5%	388	0.6%	56	0.5%
Aspiration of meconium	0	0%	30	0.1%	363	0.2%	649	0.2%	563	0.3%	193	0.3%	42	0.4%
Shoulder dystocia	6	0.3%	78	0.3%	793	0.4%	1580	0.5%	1382	0.7%	489	0.8%	79	0.7%
Stillbirth	7	0.3%	102	0.3%	571	0.3%	893	0.3%	768	0.4%	347	0.5%	87	0.8%
SGA	91	3.8%	1136	3.8%	6016	3.2%	8831	2.9%	7216	3.5%	2962	4.7%	617	5.8%
LGA	47	2.0%	539	1.8%	3838	2.1%	5943	2.0%	3846	1.9%	1279	2.0%	224	2.1%
Apgar score < 7 at 5	43	1.8%	381	1.3%	2409	1.3%	4158	1.4%	3354	1.6%	1274	2.0%	240	2.3%
Birth weight (gram)	3348	592	3403	565	3453	554	3470	555	3452	572	3415	612	3360	640

Figures denote counts and proportions or mean and one standard deviation.

BMI = body mass index; CS = caesarean section; GA = gestational age at birth; LGA = large for gestational age; PPH = postpartum haemorrhage; SGA = small for gestational age; VB = vaginal birth

[¥]All CS independent of status of performance – acute or elective. [†]Caesarean section was subdivided into elective and acute CS from 1999.

*Epidural analgesia and perineal lacerations in vaginal births only.

The crude odds rates and the results of the multivariate analyses models of obstetric and neonatal outcomes are shown in Table 3 and 4, respectively.

Table 3. Obstetric outcome data in singleton primiparous women in the period 1992-2010 in relation to maternal age group.

Characteristics	Crude OR (95%CI)	aOR (95%CI)†	Crude OR (95%CI)	aOR (95%CI)†	Crude OR (95%CI)	aOR (95%CI)†
Labour	< 17 years		17-19 years		20-24 years	
Spontaneous onset labour	1.20 (1.07-1.35)	1.20 (1.05-1.37)	1.28 (1.24-1.33)	1.26 (1.21-1.31)	1.16 (1.14-1.17)	1.16 (1.14-1.18)
Induced labour	0.73 (0.63-0.85)	0.78 (0.66-0.93)	0.81 (0.78-0.85)	0.86 (0.82-0.90)	0.90 (0.89-0.92)	0.91 (0.90-0.93)
	30 - 34 years		35 - 39 years		40+ years	
Spontaneous onset labour	0.77 (0.76-0.78)	0.78 (0.77-0.79)	0.50 (0.49-0.51)	0.52 (0.51-0.54)	0.29 (0.26-0.30)	0.30 (0.28-0.31)
Induced labour	1.23 (1.21-1.26)	1.19 (1.17-1.21)	1.66 (1.62-1.70)	1.54 (1.50-1.58)	2.17 (2.06-2.27)	1.97 (1.87-2.08)
Mode of delivery	< 17 years		17-19 years		20-24 years	
Normal vaginal birth	2.05 (1.84-2.30)	2.04 (1.79-2.32)	1.95 (1.89-2.02)	1.95 (1.88-2.02)	1.39 (1.37-1.41)	1.39 (1.37-1.41)
Forceps¥	0.38 (0.18-0.81)	0.41 (0.18-0.92)	0.55 (0.46-0.64)	0.48 (0.39-0.59)	0.82 (0.76-0.88)	0.77 (0.71-0.84)
Vacuum extraction¥	0.42 (0.36-0.51)	0.43 (0.36-0.52)	0.50 (0.48-0.53)	0.50 (0.48-0.53)	0.74 (0.72-0.75)	0.74 (0.72-0.75)
CS. all	0.60 (0.52-0.69)	0.57 (0.48-0.67)	0.56 (0.54-0.69)	0.55 (0.53-0.58)	0.73 (0.72-0.74)	0.72 (0.71-0.74)
CS elective 1999-2010 ‡	0.95 (0.73-1.25)	0.83 (0.60-1.14)	0.53 (0.48-0.59)	0.53 (0.47-0.60)	0.65 (0.62-0.68)	0.68 (0.65-0.71)
CS acute 1999-2010 ‡	0.54 (0.43-0.68)	0.53 (0.40-0.69)	0.52 (0.49-0.56)	0.56 (0.52-0.61)	0.68 (0.66-0.70)	0.71 (0.69-0.73)
	30 - 34 years		35 - 39 years		40+ years	
Normal vaginal delivery	0.70 (0.69-0.71)	0.72 (0.71-0.73)	0.46 (0.45-0.47)	0.48 (0.47-0.49)	0.29 (0.28-0.31)	0.31 (0.30-0.32)
Forceps¥	1.08 (1.01-1.15)	1.20 (1.12-1.29)	1.48 (1.35-1.63)	1.66 (1.49-1.84)	1.58 (1.27-1.98)	1.75 (1.37-2.24)
Vacuum extraction¥	1.32 (1.30-1.34)	1.29 (1.27-1.32)	1.72 (1.67-1.76)	1.67 (1.63-1.72)	2.01 (1.90-2.13)	1.92 (1.80-2.04)
CS. all	1.46 (1.44-1.49)	1.44 (1.42-1.47)	2.34 (2.29-2.38)	2.21 (2.16-2.26)	4.07 (3.91-4.23)	3.78 (3.61-3.96)
CS elective 1999-2010 ‡	1.63 (1.57-1.68)	1.44 (1.39-1.49)	2.74 (2.63-2.85)	2.25 (2.15-2.35)	5.03 (4.70-5.36)	3.89 (3.61-4.20)
CS acute 1999-2010 ‡	1.63 (1.59-1.67)	1.44 (1.40-1.47)	2.41 (2.35-2.48)	1.94 (1.88-2.00)	3.47 (3.29-3.66)	2.68 (2.52-2.85)
Gestational age	< 17 years		17-19 years		20-24 years	
GA < 28 weeks	3,44 (2.20-5.37)	2.84 (1.59-5.06)	1.46 (1.19-1.79)	1.25 (0.97-1.62)	1.01 (0.90-1.14)	0.89 (0.77-1.02)
GA < 32 weeks	2.12 (1.55-2.91)	1.66 (1.10-2.51)	1.29 (1.15-1.46)	1.20 (1.04-1.38)	0.96 (0.90-1.03)	0.92 (0.85-0.99)
GA < 37 weeks	1.55 (1.34-1.79)	1.46 (1.24-1.72)	1.09 (1.04-1.15)	1.03 (0.98-1.09)	0.99 (0.97-1.02)	0.97 (0.95-1.00)
GA 37 – 41 weeks	0.89 (0.79-0.99)	0.88 (0.77-0.99)	1.11 (1.07-1.15)	1.14 (1.09-1.18)	1.10 (2.08-1.12)	1.12 (1.10-1.14)
GA ≥ 42 weeks	0.82 (0.70-0.96)	0.89 (0.75-1.06)	0.77 (0.74-0.81)	0.79 (0.74-0.83)	0.86 (0.84-0.88)	0.85 (0.83-0.87)
	30 - 34 years		35 - 39 years		40+ years	
GA < 28 weeks	1.26 (1.13-1.40)	1.17 (1.04-1.33)	1.88 (1.64-2.15)	1.61 (1.40-1.90)	2.79 (2.19-3.56)	2.48 (1.86-3.29)
GA < 32 weeks	1.24 (1-17-1.32)	1.24 (1.16-1.33)	1.79 (1.65-1.93)	1.68 (1.53-1.84)	2.44 (2.12-2.82)	2.25 (1.90-2.66)
GA < 37 weeks	1.04 (1.01-1.06)	1.02 (0.99-1.05)	1.23 (1-19-1.27)	1.19 (1.15-1.24)	1.41 (1.32-1.52)	1.37 (1.26-1.48)
GA 37 – 41 weeks	0.88 (0.86-0.89)	0.89 (0.86-0.89)	0.75 (0.73-0.76)	0.76 (0.74-0.78)	0.81 (0.77-0.85)	0.83 (0.79-0.88)
GA ≥ 42 weeks	1.20 (1.17-1.22)	1.20 (1.18-1.23)	1.36 (1.33-1.40)	1.35 (1.31-1.39)	1.08 (1.01-1.15)	1.06 (0.98-1.14)

Table 3 continued. Obstetric outcome data in singleton primiparous women in the period 1992-2010 in relation to maternal age group.

Characteristics	Crude OR (95%CI)	aOR (95%CI)†	Crude OR (95%CI)	aOR (95%CI)†	Crude OR (95%CI)	aOR (95%CI)†
Maternal complications and use of epidural analgesia:	< 17 years		17-19 years		20-24 years	
Perineal laceration grade 1-2¥	0.44 (0.39-0.50)	0.44 (0.38-0.50)	0.46 (0.44-0.47)	0.47 (0.45-0.49)	0.65 (0.64-0.66)	0.68 (0.67-0.69)
Perineal laceration grade 3-4¥	0.33 (0.22-0.49)	0.39 (0.25-0.60)	0.31 (0.25-0.37)	0.37 (0.32-0.42)	0.57 (0.54-0.59)	0.61 (0.58-0.64)
Preeclampsia	0.83 (0.61-1.12)	0.89 (0.62-1.27)	0.89 (0.82-0.97)	0.93 (0.84-1.02)	1.07 (1.03-1.12)	1.01 (0.96-1.05)
Abruptio placentae	1.72 (1.05-2.83)	1.76 (1.03-3.00)	1.16 (0.97-1.39)	1.02 (0.83-1.26)	0.89 (0.81-0.98)	0.83 (0.74-0.92)
Placenta praevia	0.50 (0.12-2.00)	0.57 (0.14-2.30)	0.32 (0.19-0.53)	0.28 (0.16-0.50)	0.52 (0.43-0.61)	0.52 (0.43-0.63)
PPH > 1000 ml (VB)	0.70 (0.54-0.89)	0.65 (0.48-0.88)	0.57 (0.53-0.61)	0.64 (0.59-0.70)	0.71 (0.69-0.74)	0.78 (0.75-0.81)
PPH > 1000 ml (CS)	0.73 (0.18-2.93)	0.52 (0.07-3.74)	0.87 (0.59-1.27)	1.16 (0.77-1.93)	0.99 (0.92-1.07)	1.09 (0.93-1.28)
Epidural analgesia¥	1.03 (0.95-1.12)	1.03 (0.93-1.13)	1.07 (1.06-1.08)	1.07 (1.04-1.10)	1.02 (1.01-1.03)	1.03 (1.01-1.04)
	30 - 34 years		35 - 39 years		40+ years	
Perineal laceration grade 1-2¥	1.33 (1.31-1.34)	1.11 (1.10-1.13)	1.37 (1-34-1.40)	1.08 (1.05-1.10)	1.32 (1.25-1.39)	1.00 (0.94-1.07)
Perineal laceration grade 3-4¥	1.31 (1.27-1.36)	1.16 (1.12-1.20)	1.29 (1.23-1.36)	1.12 (1.05-1.18)	1.10 (0.96-1.26)	0.88 (0.75-1.02)
Preeclampsia	0.95 (0.92-0.99)	1.07 (1.03-1.12)	1.18 (1.12-1.25)	1.30 (1.22-1.39)	1.60 (1.44-1.79)	1.83 (1.62-2.06)
Abruptio placentae	1.19 (1.09-1.30)	1.27 (1.16-1.40)	1.59 (1.42-1.78)	1.71 (1.50-1.94)	2.11 (1-70-2.63)	2.09 (1.62-2.71)
Placenta praevia	1.77 (1.58-1.99)	1.74 (1.53-2.00)	3.55 (3.11-4.06)	3.47 (2.99-4.03)	5.02 (4.00-6.29)	5.23 (4.08-6.70)
PPH > 1000 ml (VB)	1.41 (1.37-1.45)	1.27 (1.23-1.31)	1.69 (1.62-1.76)	1.47 (1.40-1.53)	1.86 (1.69-2.05)	1.48 (1.26-1.52)
PPH > 1000 ml (CS)	1.14 (1.01-1.28)	1.04 (0.91-1.18)	1.06 (0.91-1.24)	0.95 (0.81-1.12)	1.48 (1.17-1.88)	1.35 (1.05-1.73)
Epidural analgesia¥	1.08 (1.06-1.09)	1.03 (1.02-1.05)	1.14 (1.12-1.17)	1.06 (1.04-1.09)	1.10 (1.04-1.15)	0.98 (0.93-1.03)

Reference group: Maternal age 25-29 years.

CI = confidence intervals; CS = Caesarean section; GA = gestational age at delivery; N/A = not applicable; aOR = adjusted odds ratio; PPH = postpartum haemorrhage; VD = vaginal birth.

† Adjusted for maternal BMI and smoking habits at first antenatal care visit and year of birth. CS and preeclampsia also adjusted for gestational age. ‡ Caesarean section was subdivided into elective and acute CS from 1999. ¥ Forceps, vacuum extraction, epidural analgesia and perineal lacerations among vaginally delivered women.

Table 4. Neonatal outcome data in singleton primiparous women in the period 1992-2010 in relation to maternal age group.

Characteristics	Crude OR (95%CI)	aOR (95%CI)†	Crude OR (95%CI)	aOR (95%CI)†	Crude OR (95%CI)	aOR (95%CI)†
	< 17 years		17-19 years		20-24 years	
Foetal distress	0.62 (0.31-1.24)	0.52 (0.22-1.26)	0.76 (0.63-0.91)	0.63 (0.51-0.79)	0.93 (0.86-1.01)	0.79 (0.72-0.91)
Aspiration of meconium	N/A	N/A	0.47 (0.32-0.67)	0.46 (0.31-0.70)	0.90 (0.80-1.03)	0.93 (0.81-1.07)
Shoulder dystocia¥	0.45 (0.11-1.82)	0.32(0.05-2.29)	0.74 (0.58-0.90)	0.74 (0.52-1.07)	1.01 (0.88-1.16)	1.00 (0.86-1.16)
Stillbirth	0.99 (0.47-2.08)	0.58 (0.19-1.80)	1.15 (0.94-1.42)	0.97 (0.75-1.25)	1.03 (0.93-1.15)	0.98 (0.87-1.11)
SGA	1.32 (1.07-1.63)	1.00 (0.78-1.28)	1.31 (1.23-1.40)	1.01 (0.94-1.09)	1.11 (1.07-1.14)	1.00 (0.96-1.04)
LGA	1.01 (0.75-1.34)	1.08 (0.76-1.53)	0.92 (0.84-1.00)	1.03 (0.94-1.14)	1.05 (1.00-1.09)	1.05 (1.00-1.10)
Apgar score < 7 at 5 minutes	1.31 (0.96-1.77)	1.30 (0.91-1.86)	0.92 (0.83-1.03)	0.92 (0.81-1.11)	0.93 (0.89-0.99)	0.93 (0.88-0.98)
	30 - 34 years		35 - 39 years		40+ years	
Foetal distress	0.96 (0.89-1.04)	1.23 (1.13-1.35)	1.14 (1.02-1.27)	1.51 (1.33-1.72)	0.98 (0.75-1.28)	1.60 (1.20-2.13)
Aspiration of meconium	1.27 (1.13-1.42)	1.36 (1.20-1.54)	1.42 (1.21-1.67)	1.48 (1.24-1.77)	1.83 (1.34-2.51)	1.82 (1.28-2.58)
Shoulder dystocia¥	1.18 (1.04-1.35)	1.13 (0.90-1.41)	1.13 (0.91-1.39)	1.13 (0.91-1.41)	1.47 (0.93-2.33)	1.27 (0.76-2.12)
Stillbirth	1.26 (1.14-1.38)	1.25 (1.12-1.39)	1.85 (1.64-2.10)	1.72 (1.49-1.99)	2.77 (2.22-3.46)	2.34 (1.80-3.03)
SGA	1.20 (1.16-1.24)	1.24 (1.20-1.28)	1.63 (1.56-1.70)	1.65 (1.58-1.73)	2.04 (1.87-2.22)	2.06 (1.87-2.26)
LGA	0.94 (0.91-0.98)	0.94 (0.90-0.98)	1.03 (0.97-1.09)	0.97 (0.91-1.04)	1.07 (0.93-1.22)	0.94 (0.81-1.09)
Apgar score < 7 at 5 minutes	1.18 (1.13-1.24)	1.18 (1.12-1.24)	1.47 (1.38-1.56)	1.39 (1.29-1.49)	1.65 (1.44-1.88)	1.51 (1.30-1.75)

Reference group: Maternal age 25-29 years.

CI = confidence interval; LGA = large for gestational age; N/A = not applicable; aOR = adjusted odds ratio; SGA = small for gestational age

† Adjusted for maternal BMI and smoking habits at first antenatal care visit and year of birth

¥ Shoulder dystocia among vaginal delivered women.

Mode of delivery, obstetric and neonatal outcome of adolescents

Compared with the reference group the teenagers had a significantly higher likelihood of having spontaneous onset of labour and of having a normal vaginal delivery. Teenagers also demonstrated a significantly higher risk of giving birth prematurely. However, only the group of teenagers younger than 17 years of age had an increased risk of giving birth very prematurely i.e. before 28 weeks of gestational age, and the same group revealed a significantly higher risk of placental abruption. In contrast with these observations the teenagers were delivered instrumentally and by CS significantly less often, and the vaginal births caused significantly fewer perineal lacerations (only evaluated among women who delivered vaginally) and PPH > 1000 ml. Likewise the occurrence of placenta previa was seen less often among teenagers whereas the occurrence of preeclampsia was equal to that seen in the reference group.

Concerning the foetal and neonatal outcomes for adolescents the newborns were less likely to show foetal distress and meconium aspiration in spite of a similar occurrence of Apgar score < 7 at 5 minutes. The newborns of the adolescents were not more prone to being stillborn or being SGA than the newborns of women in the reference group. The adjusted mean birth weight of newborns of adolescents did not differ significantly from that of women up to 29 years of age (Figure 1).

Mode of delivery, obstetric and neonatal outcome of women 20-24 years of age

The young women, 20 – 24 years of age, differed in some aspects from the reference group as well as from the adolescents. They were less likely to be delivered prematurely and had a lower frequency of placental abruption. Otherwise the obstetric and neonatal outcomes were similarly favourable as those observed for the adolescents in comparison with the reference group.

Mode of delivery, obstetric and neonatal outcome of women older than 29 years of age

As shown in Table 3 compared with the reference group almost all obstetric outcome variables demonstrated a continuously progressive deterioration with increasing age. The likelihood of normal

vaginal births decreased; induced labour, instrumental deliveries and CS increased as well as prematurity including very premature deliveries. The risk of perineal laceration increased moderately whereas the risk of PPH > 1000 ml in vaginal births was more pronounced. The likelihood of the pregnancy complications preeclampsia, abruptio placenta and placenta previa was also higher in the older age groups and progressed substantially with increasing age. Similarly, the foetal and neonatal outcome was adversely progressively influenced by increasing maternal age. With increasing maternal age over 30 years significantly more neonates were SGA, showed foetal distress, had Apgar score < 7 at 5 minutes or meconium aspiration, or were stillborn. The mean birth weight of the neonates also decreased significantly with increasing maternal age after the age of 30 (Figure 1).

DISCUSSION

This Swedish nation-wide population-based study with prospectively collected data concerning singleton primiparous women showed that the mode of delivery differed over the maternal age strata. Significantly more normal vaginal deliveries and fewer CS and instrumental vaginal deliveries were seen among the teenagers and among women aged 20-24 compared with the reference group of women aged 25-29. The opposite was found among older women reaching a 4-fold increased risk for CS compared with women aged 20-24. The teenagers as well as women aged 20-24 were less prone to perineal lacerations and PPH exceeding 1000 ml. Prematurity (< 28 weeks of GA) was associated with very low maternal age (<17 years) among the adolescents although the increased risk was at the same level as among women aged 40 years and above, indicating a u-shaped risk curve. Adolescents were not afflicted more by preeclampsia than the reference women whereas the risk of preeclampsia increased significantly with advancing maternal age. The risk of placentae praevia increased dramatically with maternal age, actually a 500% increased risk was found after the age of 40 compared with the reference group. There was a significantly increased risk of stillbirth, SGA and low Apgar score only in women aged 30 years and over.

The most prominent difference between the findings in the present study and earlier studies is that no increased risk for SGA was found among the adolescents and young mothers 20-24 years of age compared with the reference women.[8-9] It must be kept in mind that the definition of SGA may differ between countries. In the United States and Latin America SGA is usually defined as birth weight below the 10th percentile compared with two SD in the Nordic countries.[3, 9] Adjusted risks for SGA among teenagers, recently presented from Finland, one of the Nordic countries, showed no increased risk among the youngest mothers.[6] In that study the control group was defined in the same way as in the present study but the Finnish study did not adjust for smoking habits. We found that smoking in early pregnancy was a significant independent risk factor for SGA in all age groups but it was only in the young women below 25 years of age that the adjustment of smoking turned the statistically

significant crude ORs into non-significant adjusted OR values. The contrary was found for the older women where the already significant crude ORs for SGA even became increased. This observation may support a biological explanation for SGA in the older women. Differences concerning the risk for SGA could also be attributable to differences in socio-economic status. Chen et al. restricted their analysis to white married mothers with age-appropriate education level, adequate prenatal care, without smoking and alcohol use during pregnancy but found the increased risk for SGA to persist.[3] Several studies have shown low infant birth weight for adolescents as well as for mothers with advancing age.[18, 14, ~~28~~30, ~~29~~31] We failed to find such association among the adolescents, but in women with advancing age the difference in birth weight was statistically significant although the difference lacked clinical significance.

The finding of a preferable birth outcome with lower CS rates and lower rates of instrumental delivery among teenagers compared with older women has been pinpointed to a lesser extent than observed adverse outcomes. Earlier studies have shown relatively consistent results concerning a decreased rate of CS in the adolescent group and a higher rate in women with advancing age.[6, 8, 9, 12-18] We were able to evaluate elective and emergency CS separately and the risks among the teenagers and mothers age 20-24 years were decreased for both types. This might indicate that the different risks concerning CS among young and older mothers could not exclusively be explained by more CS on maternal request among older mothers but may even be caused by biological factors. A low rate of instrumental deliveries and CS among adolescents and a high rate among older women have almost unanimously been shown in several reports from high-income as well as low-income countries.[5, 7, 12-18, 30-33~~28-31~~] Whether this phenomenon depends on differences in handling the delivery, inherent or cultural behavioural, domestic or social attitudes among the obstetric staff or biological factors has not been investigated. Advancing age is associated with impaired uterine contractility as well as endothelial dysfunction which theoretically may lead to impaired uterine and utero-placental function.[~~32~~34, ~~33~~35] The fact that adolescents in our study had a lower risk of induction of labour, perineal laceration, PPH,

abruption (except for the very young women) and placenta previa and women with advancing age had higher risks of all these outcomes including preeclampsia could support a biological explanation. Concerning prematurity the age related risk curve was U shaped. This may also support a biological aetiology; immaturity of the uterus in the very young women that obstruct development of a term pregnancy and uterine dysfunction caused by ageing processes in women with advancing age and consequently deliver prematurely in both situations. The neonatal outcomes followed almost the same pattern; foetal distress, meconium aspiration, stillbirth, SGA and low Apgar score were exclusively attributed to women older than 29.

The strength of this study is that it deals with the outcomes in the population of an entire country where the antenatal care program is equally available to all pregnant women and is comprehensive. In Sweden pregnant women have completely cost free access to antenatal and obstetric facilities; poverty and malnutrition are practically non-existent and the vast majority of women attends the antenatal care program (99%) independent of socio-economic status and is delivered in obstetric units.[21] This context is valid for the whole study period. Another advantage is the large number of individuals available for evaluation, which makes it possible to divide the study population into subgroups with sufficient numbers in each stratum to provide high statistical power. A sufficient number of study subjects made it possible to evaluate three subgroups of young maternal age. Only primiparous women were included in order to avoid the confounding effects of factors associated with subsequent deliveries. There are limitations that should be considered. The external validity is reduced to facilities with similar socio-economic and demographic characteristics and health care systems with comparable standards. The drawback is obvious given the large size of the study and the numbers of health care units involved that the criteria for diagnosis (ICD codes) to define outcomes may not be uniform across the study population but the variation is most likely not related to maternal age. The MBR contain a large body of information concerning the mother and the child which made it possible to adjust the results for confounding factors. At the same time this is a limitation as only the data available in the

register could be used for adjustments. The register lacks information on ethnicity and socio-economic status. Our effort was to evaluate obstetric and neonatal outcome in different maternal age groups compared with women aged 25-29 overall. The only stratifications made were for year of birth, maternal BMI and smoking in early pregnancy. The data on year of birth showed that there is variability in the existence of obstetric and neonatal diagnoses during the observation period. This may be due to true changes but may also be a result of changes in recording, including the expanding use of computerized medical records. It was therefore necessary to adjust for year of birth. Maternal BMI, maternal smoking and gestational age (for some relevant outcomes) were included in the adjusted analyses based on their well known association with maternal and foetal outcome.[26,27] Putative confounders and intermediaries were not identified with statistical analysis. To demonstrate causality between the different outcomes evaluated in the analyses and maternal age a great number of putative intermediaries could have been considered such as the use of fertility treatment, foetal size, gestational weight gain etc., but that was not the purpose of the study. ~~A true confounder affects both the exposure and the outcome.~~ There may be other variables (which are not intermediaries) but we have not been able to identify them. ~~If we take for instance maternal hypertension as an example, it could be of interest. But as the higher risk of hypertension is a consequence of maternal age, it is not a true confounder but an intermediary, a way in which high maternal age can affect obstetric and neonatal pathology.~~ The proportion of missing data concerning the included confounders could have affected the results. The youngest age group had the highest frequency of missing data on BMI (20.7%) and smoking (7.7%) compared with the reference group (13.1% and 4.9%, respectively). The distribution of BMI in the youngest age group was almost equal to the other maternal age groups. One explanation for a higher proportion of missing data in the youngest age group could be a later detection of their pregnancies and attendance to the antenatal care and questions concerning exposure in early pregnancy were not raised. Gestational age could be calculated for more than 99% of the study subjects in this study with just minimal variations between maternal age groups.

Our approach of analysing the data may be a benefit for clinicians interpreting the results when dealing with young and aged mothers.

In conclusion, in a country with a highly developed social and antenatal maternity health care security system giving cost free maternity and obstetric care to all pregnant women adolescents had a decreased risk for adverse obstetric and neonatal outcome compared with the reference group. In the same social context childbirth at advanced maternal age was associated with a number of serious complications for both the woman and the child. For clinicians counselling young mothers it is of great importance to highlight the positive consequences that less obstetric complications and favourable neonatal outcomes are expected. The results imply that there is a need for individualizing the antenatal surveillance programs and obstetric care based on age grouping in order to attempt to improve the outcomes in the age groups with less favourable obstetric and neonatal outcomes. Such changes in surveillance programs and obstetric interventions need to be evaluated in further studies.

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Contribution of authorship: The study was planned and conducted by PK, MB and RBT, Data was analysed by all three. All authors contributed to the interpretation of the results, the elaboration of the manuscript and approval of the final version.

Checklist: The manuscript conforms to the STROBE requirement.

Data sharing statement: Technical appendix, statistical code, and dataset available from the corresponding author at Dryad repository, who will provide a permanent, citable and open access home for the dataset.

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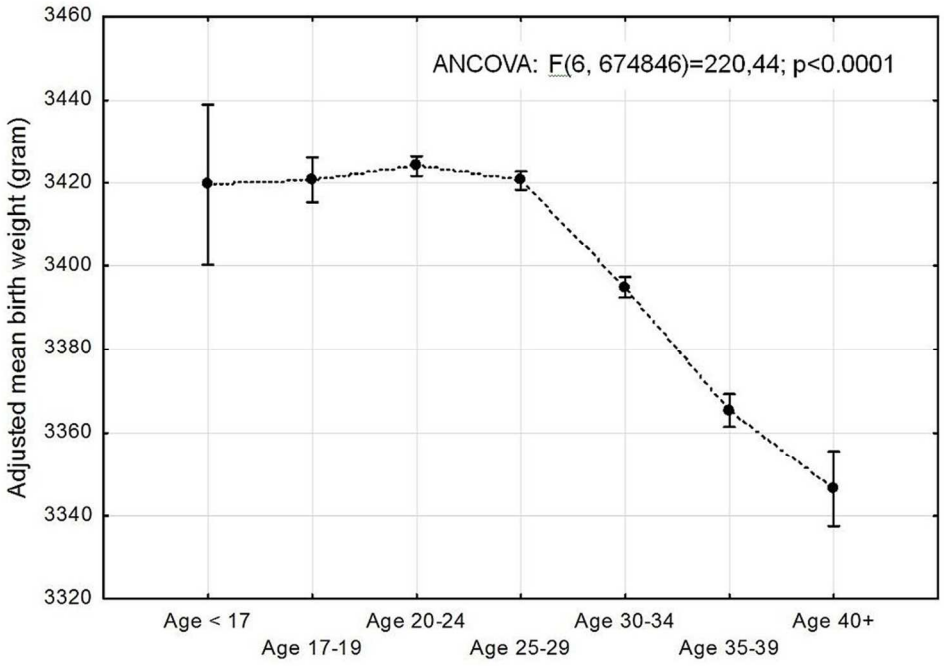
LEGENDS

Figure 1. Adjusted mean birth weight of neonates in singleton primiparous women in different maternal age groups. Birth weight adjusted for gestational age, maternal BMI and smoking habits, and year of delivery. Plots indicate means and bars 95% CI.



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STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract.Done
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found Done
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported. Done
Objectives	3	State specific objectives, including any prespecified hypotheses. Done
Methods		
Study design	4	Present key elements of study design early in the paper.Done
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection. Done
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up. Done *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable. Done
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.Done
Bias	9	Describe any efforts to address potential sources of bias. Done
Study size	10	Explain how the study size was arrived at. All primiparous were included.
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why. Done
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding. Done
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed. Done
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed. Done *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses

Continued on next page

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. Done
		(b) Give reasons for non-participation at each stage
		(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. Tables.
		(b) Indicate number of participants with missing data for each variable of interest
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount). Done
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time. Done
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures
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. Done only Adjusted Ors are given.
		(*b*) Report category boundaries when continuous variables were categorized. Done
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period. Done.
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	18	Summarise key results with reference to study objectives. Done
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias. done
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence. Done
Generalisability	21	Discuss the generalisability (external validity) of the study results. Done
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. Done

*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.