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Teenage pregnancy and adverse birth outcomes: a large population based retrospective cohort study

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Background Whether the association between teenage pregnancy and adverse birth outcomes could be explained by deleterious social environment, inadequate prenatal care, or biological immaturity remains controversial. The objective of this study was to determine whether teenage pregnancy is associated with increased adverse birth outcomes independent of known confounding factors.

Methods We carried out a retrospective cohort study of 3 886 364 nulliparous pregnant women <25 years of age with a live singleton birth during 1995 and 2000 in the United States.

Results All teenage groups were associated with increased risks for pre-term delivery, low birth weight and neonatal mortality. Infants born to teenage mothers aged 17 or younger had a higher risk for low Apgar score at 5 min. Further adjustment for weight gain during pregnancy did not change the observed association. Restricting the analysis to white married mothers with age-appropriate education level, adequate prenatal care, without smoking and alcohol use during pregnancy yielded similar results.

Conclusions Teenage pregnancy increases the risk of adverse birth outcomes that is independent of important known confounders. This finding challenges the accepted opinion that adverse birth outcome associated with teenage pregnancy is attributable to low socioeconomic status, inadequate prenatal care and inadequate weight gain during pregnancy.

Keywords Teenage pregnancy, low birth weight, pre-term delivery, Apgar score, neonatal mortality

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Introduction

Some important factors have strongly influenced the teenage pregnancy rate in recent decades.[1] The first factor is the declining age at menarche. Historical data from the United States and several European countries show a clear secular trend, with age at menarche declining at a rate of 2–3 months per decade since the 19th century, resulting in overall declines of about 3 years.[2] The decline in the age of menarche is

attributed mostly to improved health and nutrition.[3] The second factor is that the first sexual activity is initiated at a much younger age. The youth risk behaviour study (YRBS) suggested that almost one-half of the United States high school students have had sexual intercourse in their lifetime, while ~7% initiated sexual intercourse before the age of 13 years.[4] The third factor is the low use rate of contraception. Although knowledge and use of contraception has been increasing globally, many teenagers have inadequate protection against pregnancy and contraception use among teenagers is still very low. For example, in 2005, only 51.8% teenagers consistently use contraception in Italy.[5] This may be related to less education awareness about contraception, and less access to contraceptives and emergency contraception. Approximately one million adolescents become pregnant in the United States every year, with ~500 000 births occurring to school age mothers with 11–19 years old.[6] Although recent USA data have shown a decrease in the proportion of teenage births over the last 10 years, teenage childbirth rate in the United States remained at least five times greater than that of other industrialized countries.[7] As a result, teenage pregnancy remains a significant social, economical and health care problem in the United States.[6–8]

Most studies from developed and developing countries have consistently reported that teenage pregnancy were at increased risk for pre-term delivery[8–12] and low birth weight (LBW),[8,10,11,13,14] although some studies failed to find such an association.[15–17] The relation between teenage pregnancy and small for gestational age (SGA) births in teenage mothers has been reported by some studies,[9,10,18,19] but not by others.[20,21] Some studies have found increased risk of neonatal mortality among infants born to teenage mothers,[8,20,21] whereas others found no increase.[14,18,19] Some adverse outcomes that might be associated with teenage pregnancy, such as low Apgar score and congenital malformations, should be further evaluated.

Young maternal age is probably a marker for one or more other maternal risk factors associated with adverse birth outcomes rather than only an indication of incomplete maternal growth.[22] Whether the observed association between teenage pregnancy and adverse birth outcomes simply reflects the deleterious sociodemographic environment that many pregnant teenagers confront or whether biological immaturity is also causally related remains controversial. Mahfouz *et al*.[23] thought that pregnant teenagers were not a high-risk group if good prenatal care was provided. Rogers and Yoder *et al*.[24,25] found that young maternal age was not an independent risk factor for adverse birth outcomes. The increased risk probably was attributable to other factors that were related to teenage pregnancy such as: black, unmarried, low socioeconomic status and inadequate prenatal care. Satin *et al*.[14] concluded that teenage pregnancies aged between 16 and 19 years had no risk for intrinsic maternal youth and the obstetric risk increased only in teenage <16 years of age, while Fraser *et al*.[9] suggested that young age conferred an increased risk of adverse pregnancy outcome, which was intrinsic to maternal youth.

Many previous studies in this area suffered from limited sample size and lack of information on confounders, and the study sample came from testing centers. Moreover, some studies were carried out during a long time period that might not reflect current health care practices. The objective of this large population based study was to determine whether teenage pregnancy was associated with increased risks of adverse birth outcomes independent of known confounders.

Materials and methods

The study data were derived from the 1995–2000 nationally linked birth/infant death data set of the United States, compiled by National Center for Health Statistics and Centers for Disease Control and Prevention. The live births and infant deaths were registered in the 50 states and the District of Columbia. The data were pre-coded according to uniform specifications, and passed through vigorous statistical quality checks by the National Center for Health Statistics.[26] Available information in this linked data set included maternal race, education, marital status, obstetric history, antenatal high-risk conditions, maternal life-style factors such as smoking and alcohol consumptions, onset time of prenatal care, total intensity of prenatal visits, labour and delivery complications, gestational age, birth weight and neonatal/infant diseases and death.[27]

Maternal age was defined as the age of mother in completed years at the time of delivery.[27] All nulliparous women aged 10–24 years who had singleton live births during the period between 1995 and 2000 in the United States were included in the present study. Maternal age was categorized into 4 groups: less than 16, 16 to 17, 18 to 19, and 20 to 24 years. Since mothers with 20–24 years old had the lowest risk of adverse outcomes, they served as the reference group in all analysis.

Because of the correlation between increasing age and number of grades completed for younger women, we categorize maternal education as appropriate or inappropriate for age. Mothers who were older than 19 years were considered to have an age-appropriate educational level if they had completed high school, whereas younger mothers had to have completed the minimal number of grades for their age.[9] Prenatal care was categorized as adequate, intermediate or inadequate according to the criteria of the Modified Kessner Index,[28,29] in which those cases with missing information on number of prenatal care visits, onset time of prenatal care or gestational age were coded as unknown in the linked data set and were excluded from the present study. Gestational age was calculated as the interval between the date of delivery and the date of last normal menstrual period. When the last normal menstrual period date was missing, a clinical estimate of gestational age was used instead (about 5% of the records).[30] These imputations and replacement of gestational age by clinical estimate were performed by the National Center for Health Statistics. The information on 5-minute Apgar score was not included in birth certificates in California (1995–2000) and Texas (1995–2000). Data on tobacco use were not reported from California (1995–2000), Indiana (1995–1998), South Dakota (1995–1999) and New York State (except New York City, 1995–1998). California (1995–2000) and South Dakota (1995–1999) did not include items on alcohol use in on their birth certificates. The birth certificates in California (1995–2000) had no information on weight gain during pregnancy. Birth defects were not included in New Mexico (1995–2000) birth certificate data set. Subjects with no

available information on maternal tobacco use, alcohol use or weight gain during pregnancy was set as an independent category in this study. In the analysis of Apgar score at 5 min, the subjects from California and Texas were not included. Those subjects with missing information on maternal education, prenatal care status, gestational age, birth weight or birth defects were excluded from this study.

Birth outcomes of interest in this study were very pre-term delivery (live infant delivered at less than 32 weeks' gestation), pre-term delivery (live infant delivered at <37 weeks' gestation), very LBW (live infant weighting <1500 g at birth), LBW (live infant weighting <2500 g at birth), SGA (live infants with birth weights below 10th percentile for gestational age and sex[31]), very low Apgar score at 5 min (<4), low Apgar score at 5 min (<7) and neonatal death (death of a live birth within 28 days).

We first described the distribution of demographic characteristics, tobacco and alcohol use during pregnancy, prenatal care utilization and weight gain during pregnancy by maternal age groups. Rates of adverse birth outcomes were calculated for each maternal age group. The adjusted relative risks (RRs) along with their 95% confidence intervals (CIs) associated for teenage pregnancies, with reference to the 20–24 years olds were derived through unconditional multivariate logistic regression models with adjustment for potential confounders.[32] Potential confounding variables considered for adjustment in the regression models included State of birth, maternal race, age-appropriate educational level, marital status, prenatal care utilization, maternal tobacco and alcohol use during pregnancy. Interaction between maternal age and tobacco or alcohol use was controlled in the model, when it was significant. To explore the mechanism by which teenage pregnancy make impacts on neonatal mortality, we also evaluated the association between teenage pregnancy and neonatal death with further adjustment of gestational age (every 1 week) and birth weight (every 500 g). In order to understand the independent roles of biological vs social factors in the association between teenage pregnancy and adverse birth outcomes, we also evaluated the associations with further adjustment of weight gain during pregnancy. Weight gain (per week) during pregnancy were categorized as low, when it was <0.16 kg/week.[33] To further reduce residual confounding, the effects of teenage pregnancies on birth outcomes were evaluated in mothers who were white, married, had age-appropriate education, received adequate prenatal care and did not smoke tobacco or drink alcohol during pregnancy. All data were analysed using Statistical Analysis System, Version 9.1 (SAS Institute Inc., Cary, NC, USA).

Results

There were 23 654 785 live births in the linked 1995–2000 birth and infant death data set. Among them, 9.24% infants were born to mothers aged 20–24 years and 8.75% to women <20 years. There were about 0.85% infants born to younger teenage mothers aged 10–15 years old, 3.02% to women aged 16–17 years and 4.89% to women with 18–19 years old. In total, there were 4 254 751 first-born singleton infants whose mothers were <25 years of age. Subjects with no available information on gestational age (43 351), birth weight (1443), birth defects (108 776), maternal education (64 464), and prenatal care status (217 742) were excluded, leaving 3 886 364 subjects for final analysis.

Table 1 Characteristics of subjects in different maternal age groups (%)

	Maternal age (years old)				
Variables	10–15	16–17	18–19	10–19 (All teenagers)	20–24
No. of live birth	175 019	646 594	1 058 101	1 879 714	2 006 650
Maternal race					
White	58.22	70.43	76.09	72.48	81.45
Other than black and white	3.41	3.28	3.22	3.26	4.50
Black	38.37	26.29	20.68	24.26	14.05
Education					
Age-appropriate	93.36	83.07	72.77	78.23	83.34
Age-inappropriate	6.64	16.93	27.23	21.77	16.66
Marital status					
Married	6.87	14.25	26.76	20.60	54.54
Unmarried	93.13	85.75	73.24	79.40	45.64
Tobacco use during pregnancy					
No	75.21	70.30	68.82	69.92	72.25
Yes	8.64	13.08	14.40	13.41	9.76
Not reported[a]	16.15	16.62	16.78	16.67	17.99
Alcohol use during pregnancy					
No	85.80	85.77	85.62	85.69	84.50
Yes	0.61	0.63	0.64	0.63	0.62
Not reported[b]	13.59	13.60	13.74	13.68	14.88
Prenatal care (Modified Kessner index)					
Adequate	46.62	58.84	66.69	62.12	75.76
Intermediate	37.81	31.66	26.46	29.31	19.49
Inadequate	15.57	9.49	6.85	8.57	4.75
Weight gain during pregnancy (kg/week)					
<0.16	8.32	8.39	8.55	8.48	6.98
0.16–	65.42	67.83	68.40	67.93	68.91
⩾0.60	5.40	4.66	4.60	4.69	4.76
Not reported[c]	20.86	19.12	18.45	18.90	19.35

[a] Information on tobacco use was not available for California, Indiana, South Dakota and New York State (except for New York City).
[b] California and South Dakota did not report alcohol use in their birth certificates.
[c] The births in California have no information on weight gain during pregnancy.

Compared with women aged 20–24 years, teenage mothers were more likely to be black, unmarried, to have smoked cigarette during pregnancy, to have had inadequate prenatal care and have gained less weight during pregnancy (Table 1).

The rates of very pre-term delivery, pre-term delivery, very LBW, LBW, SGA, very low Apgar score, low Apgar score and neonatal mortality were higher in teenage pregnancies. They were consistently increased with decreasing maternal age and were always highest among infants born to mothers aged 15 years or younger (Table 2).

Adjusted RRs and 95% CIs for adverse birth outcomes associated with maternal age are presented in Table 3. Risks

Table 2 Frequency of adverse birth outcome in different maternal age groups

	Maternal age (years old)				
Variables	10–15	16–17	18–19	10–19	20–24
				(All teenagers)	
No. of live births	175 019	646 594	1 058 101	1 879 714	2 006 650
Gestational age (weeks)	38.44 ± 3.27	38.86 ± 2.86	39.07 ± 2.66	38.94 ± 2.80	39.18 ± 2.48
Gestational age < 32 weeks	4.06	2.48	1.84	2.26	1.41
Gestational age < 37 weeks	18.10	13.26	10.85	12.36	9.15
Birth weight (grams)	3124 ± 591	3193 ± 566	3293 ± 560	3212 ± 566	3303 ± 557
Birth weight < 1500 g	2.17	1.49	1.23	1.41	1.04
Birth weight < 2500 g	10.81	8.69	7.61	8.28	6.26
Birth weight < 10th percentile for gestational age and sex	14.56	13.87	13.13	13.52	11.13
Apgar score < 4[a]	0.71	0.49	0.40	0.46	0.36
Apgar score < 7[a]	2.31	1.77	1.59	1.72	1.48
Birth defects	1.03	1.08	1.10	1.09	1.03
Neonatal death (<28 days)	0.70	0.48	0.40	0.45	0.33

[a] Subjects in California and Texas were not included.

Table 3 RR of adverse birth outcome in different maternal age groups among all subjects

	Maternal age (years old)			
Variables	10–15	16–17	18–19	10–19
				(All teenagers)
No. of live birth	175 019	646 594	1 058 101	1 879 714
	Relative risk and 95% confidence interval[a,b]			
Gestational age < 32 weeks	1.91 (1.85, 1.96)	1.34 (1.31, 1.37)	1.11 (1.08, 1.13)	1.26 (1.24, 1.28)
Gestational age < 37 weeks	1.65 (1.62, 1.67)	1.27 (1.26, 1.28)	1.09 (1.08, 1.10)	1.20 (1.19, 1.20)
Birth weight < 1500 g	1.46 (1.40, 1.51)	1.14 (1.11, 1.17)	1.03 (1.01, 1.05)	1.11 (1.09, 1.13)
Birth weight < 2500 g	1.33 (1.31, 1.36)	1.17 (1.16, 1.19)	1.08 (1.07, 1.09)	1.14 (1.13, 1.14)
Birth weight < 10th percentile for gestational age and sex	1.10 (1.08, 1.12)	1.09 (1.08, 1.10)	1.06 (1.05, 1.07)	1.07(1.07, 1.08)
Apgar score < 4	1.29 (1.20, 1.39)	1.06 (1.01, 1.12)	0.95 (0.91, 1.00)	1.02 (0.98, 1.06)
Apgar score < 7	1.24 (1.19, 1.29)	1.04 (1.02, 1.07)	0.98 (0.96, 1.01)	1.02 (1.01, 1.04)
Neonatal death 1 (<28 days)	1.55 (1.45, 1.65)	1.19 (1.13, 1.24)	1.06 (1.02, 1.11)	1.15 (1.11, 1.19)
Neonatal death 2 (<28 days)[c]	1.07 (0.93, 1.22)	0.99 (0.91, 1.09)	1.04 (0.96, 1.12)	1.04 (0.96, 1.10)

[a] Relative risk is expressed as compared with 2 006 650 infants born to mothers aged 20–24 years.
[b] With adjustment of State of birth, maternal race, marital status, tobacco smoking and alcohol drinking during pregnancy, prenatal care status
[c] With further adjustment of gestational age (every 1 week) and birth weight (every 500 g).

of very pre-term delivery, pre-term delivery, very LBW, LBW, SGA and neonatal mortality increased with decreasing maternal age. The risks of very low Apgar score and low Apgar score were significantly higher in infants born to mothers ⩽17 years old than infants born to mothers of 20–24 years old. The association between teenage pregnancy and neonatal mortality became non-significant when it was further adjusted for birth weight and gestational age.

Further adjustment of weight gain during pregnancy did not change the results (data available upon request). Restricting the analysis to white married women with age-appropriate education level, adequate prenatal care, and without smoking and alcohol use during pregnancy yielded similar results (Table 4). The association between teenage pregnancy and low Apgar score and neonatal death was not significant in the youngest mothers aged 10–15 due to the limited sample size in this age group.

Discussion

Our large population based study indicated that teenage pregnancy was associated with increased risks of very pre-term delivery, pre-term delivery, very LBW, LBW, SGA and neonatal mortality, with a general tendency of poorer outcomes in younger teenagers. Younger teenage (<18) was associated with very low/low Apgar score at 5 min. Further adjustment of weight gain during pregnancy did not change the observed association. Restricting analysis to white married mothers with age-appropriate education, adequate prenatal care and without smoking and alcohol during pregnancy did not change the results either, suggesting teenage pregnancy was associated with an increased risk of adverse perinatal outcomes independent of known confounders of teenage pregnancy.[9]

Table 4 RR of adverse birth outcome in different age groups among mothers who were white, married, had age-appropriate education, received adequate prenatal care, had no smoking and alcohol during pregnancy

	Maternal age (years old)			
Variables	10–15	16–17	18–19	10–19
No. of live birth	3515	28 587	98 737	550 805
	Relative risk and 95% confidence interval[a,b]			
Gestational age < 32 weeks	1.88 (1.45, 2.44)	1.69 (1.53, 1.87)	1.20 (1.12, 1.28)	1.32 (1.32, 1.40)
Gestational age < 37 weeks	1.56 (1.40, 1.73)	1.32 (1.27, 1.38)	1.11 (1.09, 1.14)	1.17 (1.14, 1.20)
Birth weight < 1500 g	1.65 (1.20, 2.26)	1.58 (1.41, 1.78)	1.14 (1.06, 1.23)	1.25 (1.17, 1.33)
Birth weight < 2500 g	1.61 (1.41, 1.84)	1.42 (1.35, 1.50)	1.17 (1.13, 1.21)	1.24 (1.20, 1.27)
Birth weight < 10th percentile for gestational age and sex	1.56 (1.40, 1.73)	1.37 (1.32, 1.43)	1.19 (1.16, 1.21)	1.23 (1.21, 1.26)
Apgar score < 4	1.24 (0.55, 2.77)	1.44 (1.13, 1.83)	1.18 (1.02, 1.36)	1.23 (1.09, 1.40)
Apgar score < 7	1.37 (0.97, 1.95)	1.30 (1.16, 1.46)	1.11 (1.04, 1.18)	1.15 (1.09, 1.22)
Neonatal death 1 (<28 days)	1.18 (0.61, 2.27)	1.74 (1.43, 2.11)	1.21 (1.07, 1.38)	1.32 (1.18, 1.48)

[a] Relative risk is expressed as compared with 235 617 infants born to mothers aged 20–24 years.
[b] With adjustment of State of birth.

Our study demonstrated that an increased risk of SGA among infants born to teenage mothers, with the youngest group running the highest risks, which was consistent with previous studies.[9,10,18,19] However, two previous studies[10,17] found that the risk of SGA was not associated with teenage pregnancy. In both studies, the adequacy of prenatal care was not controlled in the multivariate model, which was considered as an important confounder in the association between teenage pregnancy and SGA.

Consistent with previous studies,[20,21] we found that teenage pregnancy was associated with increased risk of neonatal mortality. However, a hospital based study found that the neonatal mortality was not increased in infants born to teenage mothers compared with infants born to mothers aged 20–22, after adjustment of maternal race, prenatal care status and major malformations.[14] A large hospital-based retrospective study in Latin American reported that the risk of early neonatal death was increased in teenage mothers <16 years of age as compared with mothers who were 20–24 years of age, not in those of 16–19 years old age with control of demographic characteristics, birth weight and gestational age.[18] Our large population based study suggested that the risk of neonatal mortality was increased in infants born to teenage mothers, even after adjustment for of potential confounders. The effect of teenage pregnancy on neonatal mortality disappeared after further adjustment for birth weight and gestational age, suggesting the increased risk of neonatal mortality in teenage pregnancy could largely be explained by the higher rates of pre-term delivery and LBW in teenage mothers, which was consistent with previous study.[18]

Our study found an increased risk of low Apgar score at 5 min in teenage pregnancy, which was different from two hospital based studies.[12,18] This might be explained by the selection bias and small sample of the hospital studies. With regard to very LBW, LBW, very pre-term delivery and pre-term delivery, our research finding was consistent with most previous studies.[8,9,11,13]

Limitations of our study should not be overlooked. In this study, gestational age was estimated based on self-reported last menstrual period. Last menstrual period was more likely to be uncertain among teenagers than among older women.[34] Our findings could have been affected by the fact that we were unable to evaluate the effect of some of psychological attributes that were believed to increase the risk of adverse pregnancy outcomes of pregnancy, such as emotional stress and lack of family support.[35] Similarly, we could not control the use of illicit drugs such as cocaine, which were known to influence reproductive outcomes.[36] In this data set, tobacco smoking and alcohol drinking data were collected respectively after delivery; it could lead to under-report and recall bias. Moreover, this study was based on birth certification data, which lacked detailed clinical information and socioeconomic status, and was subject to a certain degree of coding error.

The sociodemographic risk factors known to be more prevalent in teenage gravidas were poverty, low education level, inadequate prenatal care and unmarried status.[10,15] Some investigators believed that the adverse outcomes observed in teenage pregnancies might have been attributable to these sociodemographic factors.[15] Some researchers considered that pregnant teenagers were not a high-risk group if good prenatal care was provided.[23] Our findings in white married women with age-appropriate education level, adequate prenatal care and without smoking and alcohol during pregnancy suggested that the increased risk of adverse birth outcomes was less likely to be secondary to socioeconomic factors and prenatal care, and more likely intrinsic to maternal youth.[9]

Previous studies suggested that a young gynaecological age[37] (conception within 2 years after menarche) and the effect of a teenager's becoming pregnant before her own growth has ceased[38–40] might be associated with the increased risk of adverse outcomes in teenage pregnancy. Immaturity of the uterine or cervical blood supply in teenage pregnancy could increase the risk of subclinical infection and prostaglandin production, and lead to increased risk of pre-term delivery. Teenage mothers who themselves continued to grow during pregnancy could compete with the developing fetus for nutrients, which has been supported by some studies that weight gain during pregnancy might be more critical for teenage mothers than for older mothers.[38,39] In our study, the association between teenage pregnancy and adverse birth outcomes were similar in models

with and without adjustment of weight gain during pregnancy, which hinted that the increased risk of adverse outcomes for teenage pregnancy in the United States was less likely to be attributable to inadequate weight gain during pregnancy. Future studies are needed to further examine the mechanisms on how younger maternal age increases the risk of adverse birth outcomes.

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