Pregnancy and childbirth outcomes among adolescent mothers: a World Health Organization multicountry study

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Objective To investigate the risk of adverse pregnancy outcomes among adolescents in 29 countries.

Design Secondary analysis using facility-based cross-sectional data of the World Health Organization Multicountry Survey on Maternal and Newborn Health.

Setting Twenty-nine countries in Africa, Latin America, Asia and the Middle East.

Population Women admitted for delivery in 359 health facilities during 2–4 months between 2010 and 2011.

Methods Multilevel logistic regression models were used to estimate the association between young maternal age and adverse pregnancy outcomes.

Main outcome measures Risk of adverse pregnancy outcomes among adolescent mothers.

Results A total of 124 446 mothers aged ≤24 years and their infants were analysed. Compared with mothers aged 20–24 years, adolescent mothers aged 10–19 years had higher risks of eclampsia, puerperal endometritis, systemic infections, low birthweight, preterm delivery and severe neonatal conditions. The increased risk of intra-hospital early neonatal death among infants born to adolescent mothers was reduced and statistically insignificant after adjustment for gestational age and birthweight, in addition to maternal characteristics, mode of delivery and congenital malformation. The coverage of prophylactic uterotonics, prophylactic antibiotics for caesarean section and antenatal corticosteroids for preterm delivery at 26–34 weeks was significantly lower among adolescent mothers.

Conclusions Adolescent pregnancy was associated with higher risks of adverse pregnancy outcomes. Pregnancy prevention strategies and the improvement of healthcare interventions are crucial to reduce adverse pregnancy outcomes among adolescent women in low- and middle-income countries.

Keywords Adolescent pregnancy, adverse pregnancy outcomes, low birthweight, perinatal mortality, preterm birth.

Introduction

Adolescent pregnancy is defined as pregnancy in girls aged 10–19 years. It is estimated that about 11% of births worldwide are to adolescents aged 15–19 years, and more than 90% of these births occur in low- and middle-income countries.[1] Giving birth during adolescence is not only a risk factor for adverse pregnancy outcomes, but also has a negative

impact on the future well-being of the mother and infant.[2,3] Previous studies have reported an increased incidence of adverse maternal and perinatal outcomes, such as low birthweight,[4–7] preterm delivery,[4–7] perinatal death,[5,8] cephalo-pelvic disproportion[9,10] and maternal death.[6,11] However, there were conflicting findings from previous studies as to whether the adverse pregnancy outcomes among adolescent mothers were caused by their biological immaturity[4–6] or poor socio-environmental factors.[7,12,13] This may be explained by the heterogeneity between study settings, small sample size, especially for younger adolescents (i.e. ≤15 years), and the quality of medical services and women's social and cultural backgrounds. To evaluate pregnancy and childbirth outcomes among adolescent mothers, we used data from the World Health Organization (WHO) Multicountry Survey on Maternal and Newborn Health 2010–2011, which was conducted concurrently in 29 countries using a standard methodology. The aim of our study was to investigate whether adolescent mothers are at higher risk of adverse pregnancy outcomes compared with mothers aged 20–24 years after controlling for country and health facility effects and potential confounding factors.

Methods

Study design and data collection
The WHO Multicountry Survey on Maternal and Newborn Health was a multicountry, facility-based, cross-sectional study implemented from May 2010 to December 2011 across 29 countries in Africa, Asia, Latin America and the Middle East. A stratified multi-stage cluster sampling strategy was used to obtain samples from 359 health facilities from the capital city and two randomly selected provinces in each participating country. Methodological details of this survey have been published previously.[14,15] The study included all women who were admitted for delivery and with severe maternal outcomes (SMO) regardless of gestational age at the participating health facilities. Data were collected at individual and facility levels. At the individual level, data on demographic and reproductive characteristics, pregnancy and childbirth complications and their management, and maternal and newborn morbidity and mortality were collected before their discharge from hospital, or within 7 days after delivery, directly from medical records by trained medical staff. At the health facility level, data on the availability of obstetric and newborn services, laboratory tests and human resources were obtained.

Study population
The study population in this analysis was restricted to mothers aged 24 years or younger who gave birth to an infant of at least 22 weeks' gestation or with a birthweight of at least 500 g.

Exposure and potential confounding factors
The main exposure of interest in this study was the young maternal age, defined as mothers <20 years of age. Adolescents younger than 16 years have been shown to be at an increased risk of adverse pregnancy outcomes and were categorised separately from older adolescents (16–19 years).[5,6] It has also been suggested that girls who conceive shortly after menarche (<2 years after menarche, defined as low gynaecological age) are at an increased risk of adverse outcomes.[16] As menarche tends to start later in girls with poor nutritional and environmental conditions,[3] it was assumed that many adolescent mothers aged 16–17 years would have a low gynaecological age, and therefore it may not be appropriate to categorise them with older adolescents aged 18–19 years. Therefore, the maternal age was categorised into four groups: ≤15, 16–17, 18–19 and 20–24 years. The last group served as the reference group in all analyses. Categorisations of the demographic and reproductive characteristics used for adjustment corresponded to those shown in Table 1. Medical conditions during pregnancy and childbirth included severe anaemia, defined as haemoglobin (Hb) < 7 mg/dl, malaria or dengue, and others, such as the presence of any disease or injury affecting the heart, lungs, kidneys (except pyelonephritis) and liver. A coincidental condition describes an acute injury caused by external factors, such as violence, accident, poisoning or self-harm. The facility capacity index score was defined as the total score of essential and additional services provided by the selected health facilities. This index has been used in previous studies and is detailed elsewhere.[17]

Main outcomes and definitions
We assessed the following adverse maternal outcomes: caesarean section, pre-eclampsia, eclampsia, postpartum haemorrhage, puerperal endometritis, SMO and intra-hospital maternal death. Women with SMO were defined as maternal death or maternal near-miss cases; the latter describes women who presented with a life-threatening condition and nearly died, but survived pregnancy, childbirth or a pregnancy termination, and who were identified by clinical, laboratory and management markers.[18] Intra-hospital maternal deaths were defined as deaths that occurred on or before the eighth day postpartum.

We evaluated the following perinatal outcomes: low birthweight (live infant weighing <2500 g at birth), preterm delivery (live infant delivered at <37 weeks' gestation), stillbirths (macerated and fresh stillbirths), severe neonatal conditions (neonates presenting with any of the following conditions: birthweight <1500 g, gestational age <32 weeks and Apgar score at 5 minutes <7)[19] and early neonatal death. Intra-hospital deaths that occurred within 7 days after birth were classified as early neonatal deaths.

Table 1. Maternal characteristics and medical conditions by age group

	Total, n (%)	Maternal age, n (%)				
		≤15 years	16–17 years	18–19 years	20–24 years	P
No. of deliveries	124446 (100)	2206 (1.8)	9025 (7.3)	20948 (16.8)	92267 (74.1)	
Marital status						
Single	19728 (16.1)	1079 (49.3)	3524 (10.0)	5022 (24.4)	10103 (11.1)	<0.001
Education (years)						
None	16301 (14.1)	201 (9.7)	845 (9.9)	2490 (12.9)	12765 (14.9)	<0.001
1–6	18141 (15.7)	723 (34.9)	1952 (23.1)	3326 (17.2)	12140 (14.1)	
7–9	31251 (26.9)	1148 (55.4)	3431 (40.6)	5969 (30.9)	20703 (24.1)	
10–12	39861 (34.4)	–	2229 (26.4)	7087 (36.6)	30545 (35.5)	
>12	10216 (8.9)	–	–	473 (2.4)	9763 (11.4)	
Parity						
0	81928 (65.8)	2125 (96.3)	8262 (91.6)	16982 (81.1)	54559 (59.1)	<0.001
1	38877 (31.2)	69 (3.1)	732 (8.1)	3822 (18.2)	34254 (37.1)	
≥2	3641 (2.9)	12 (0.6)	31 (0.3)	144 (0.7)	3454 (3.7)	
Multiple birth	1487 (1.2)	13 (0.6)	69 (0.8)	205 (1.0)	1200 (1.3)	<0.001
Mode of delivery						
Vaginal	95351 (76.8)	1582 (71.9)	6941 (77.1)	16394 (78.4)	70434 (76.5)	<0.01
Caesarean section	28885 (23.2)	617 (28.1)	2067 (23.0)	4513 (21.6)	21688 (23.5)	
Previous caesarean section	7739 (18.2)	21 (25.9)	132 (17.3)	717 (18.1)	6869 (18.2)	0.295
Medical conditions						
Anaemia	1847 (1.5)	61 (2.8)	203 (2.2)	325 (1.6)	1258 (1.4)	<0.05
Malaria/dengue	163 (0.1)	8 (0.4)	23 (0.3)	30 (0.1)	102 (0.1)	<0.001
Other conditions*	546 (0.4)	12 (0.5)	46 (0.5)	102 (0.5)	386 (0.4)	0.597
Coincidental conditions**	350 (0.3)	23 (1.0)	62 (0.7)	85 (0.4)	181 (0.2)	<0.001

*Presence of any disease or injury affecting the heart, lungs, kidneys (except pneumonia and pyelonephritis) and liver.

**An acute injury caused by external factors, such as violence, accident, poisoning or self-harm.

We also assessed the coverage of health interventions by country group. Countries were stratified by country-level maternal mortality ratios (MMR), i.e. maternal deaths per 100 000 live births, into four groups: low (MMR < 20), moderate (MMR = 20–99), high (MMR = 100–299) and very high (MMR > 300) MMR countries.[20] Health intervention coverage was determined as the proportion of women who received essential interventions.

Statistical analysis

We performed the chi-squared test to assess the association between each of the maternal and neonatal characteristics and adolescent age, accounting for the clustering effect of the survey design, in which women were nested within facilities, and facilities within countries. We also undertook frequency comparisons between adolescent and adult mothers for demographic and reproductive characteristics, potentially life-threatening conditions per 1000 live births (i.e. maternal near-miss ratio, severe outcome ratio, intra-hospital maternal and neonatal mortality ratio) and intervention coverage.

To estimate the effect of young maternal age on pregnancy outcomes, we constructed multilevel logistic regression models with random effects for facilities and countries. The analysis was also adjusted for potential confounding factors, including maternal and health facility characteristics and country groups. The significance of the random effects was tested with a likelihood ratio test by comparing models nested within models with additional levels. Crude and adjusted odds ratios (AORs) with their 95% confidence intervals (CIs) were used to present the effects among mothers of <20 years of age compared with mothers aged 20–24 years. Statistical analysis was conducted using Stata/MP version 12.0 (Stata Corp LP, College Station, TX, USA), and P < 0.05 was considered to be statistically significant.

Results

The data of 314 623 women in total were collected from 359 health facilities in 29 countries by the WHO Multi-country Survey on Maternal and Newborn Health. We excluded deliveries with missing maternal age (935), missing birthweight and missing gestational age at birth (891) and pregnancies with an offspring birthweight of <500 g. If the birthweight was missing, we excluded pregnancies at

<22 weeks of gestational age (500). This left a total of 312 297 deliveries retained in the analysis. Of these, a total of 32 179 (10.3%) deliveries occurred among adolescents aged 10–19 years, with a mean age of 17.7 years [standard deviation (SD), 1.3 years]. Figure 1 shows the number of adolescent births per 1000 deliveries in the participating countries of the WHO survey. Among the study population, the overall number of adolescent (i.e. ≤19 years) births was 103 per 1000 deliveries, and the highest occurrences of adolescent birth were in Nicaragua (288.2), Ecuador (233.8) and Angola (213.0), whereas the lowest were found in Japan (7.4), Qatar (19.4), India (29.3) and Vietnam (29.2). With further restrictions applied to mothers of ≤24 years of age, the sample size was 124 446, which consisted of 2206 (1.8%), 9025 (7.3%), 20 948 (16.8%) and 92 268 (74.1%) mothers aged ≤15, 16–17, 18–19 and 20–24 years, respectively.

Table 1 shows the maternal characteristics and medical conditions during pregnancy by age group. Compared with mothers aged 20–24 years, adolescents were more likely to be single, less educated and nulliparous. The proportion of mothers with severe anaemia (Hb < 7 mg/dl) and coincidental conditions was significantly higher among all adolescents, whereas malaria and dengue were higher among younger adolescents aged ≤17 years.

The prevalence of adverse pregnancy outcomes varied by country among adolescents versus adult mothers aged 20–24 years (Tables S1 and S2). Table 2 shows the overall prevalence of adverse pregnancy outcomes among adolescents in participating countries. Pre-eclampsia, eclampsia, puerperal endometritis and systematic infections were significantly higher among adolescents than among adult mothers, whereas caesarean section was higher among younger adolescent mothers (≤15 years) than among adult mothers (27.9% versus 23.5%, respectively). The number of SMO cases per 1000 deliveries was insignificantly higher among all adolescent mothers relative to adult mothers.

Among all mothers with SMO, the most frequent complications were eclampsia (75.0%, 47.8%, 41.1% and 33.8% among mothers aged ≤15, 16–17, 18–19 and 20–24 years, respectively; $P = 0.006$). The prevalence of other complications was varied among mothers with SMO.

For perinatal outcomes, a significant increase in the prevalence of preterm delivery and severe neonatal conditions with decreasing maternal age, compared with adult mothers aged 20–24 years, was observed. The increased prevalence of other perinatal outcomes was not significant and is presented in Table 2.

Table 3 shows the coverage of essential interventions among the study population. The total coverage of prophylactic antibiotics for caesarean section, parenteral antibiotics for systemic infections and therapeutic uterotonics was 86.2%, 77.9% and 93.1%, respectively, with no significant differences among maternal age groups. However, despite the higher coverage of prophylactic uterotonics, all adolescent mothers had significantly lower coverage than adult mothers aged 20–24 years (91.4%, 92.7% and 94.4% among mothers aged ≤15, 16–17 and 18–19 years, respectively, versus 95.4% for adult mothers). The coverage of antenatal corticosteroids for preterm births at 26–34 weeks was noticeably lower and the overall coverage was 48.1%, ranging from 28.4% to 52.3% across the maternal age groups, with significantly lower coverage among the youngest age group. Similar trends were observed for prophylactic uterotonics and antenatal corticosteroids for preterm births at 26–34 weeks among moderate to high MMR country groups, but not in the very high MMR country group (Table S3).

Table 4 presents the results of multilevel logistic models of adverse outcomes among adolescent mothers. After adjustment for country- and facility-level effects and covariates, AOR for caesarean sections among mothers aged <20 years was significantly lower than among mothers aged 20–24 years. Although adolescent mothers had a lower risk of pre-eclampsia, the risk of eclampsia was 1.85, 1.88 and 1.55
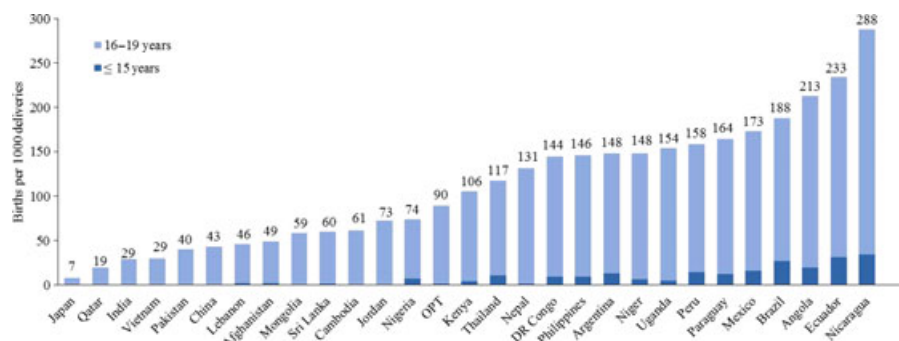

Figure 1. Number of adolescent births per 1000 deliveries in participating countries in the World Health Organization (WHO) 2010–2011 Multicountry Survey. DR Congo, Democratic Republic of Congo; OPT, Occupied Palestinian Territory.

Table 2. Prevalence of adverse pregnancy outcomes by maternal age

Outcome	Total, *n* (%)	Maternal age, *n* (%)				
		≤15 years	16–17 years	18–19 years	20–24 years	*P*
Number of deliveries	124446 (100)	2206 (1.8)	9025 (7.3)	20948 (16.8)	92267 (74.1)	
Maternal outcomes						
Caesarean section	28885 (23.2)	617 (27.9)	2067 (22.9)	4513 (21.5)	21688 (23.5)	0.004
Pre-eclampsia	2398 (1.9)	84 (3.8)	221 (2.5)	419 (2.0)	1674 (1.8)	<0.001
Eclampsia	547 (0.4)	23 (1.0)	81 (0.9)	139 (0.7)	304 (0.3)	<0.001
Postpartum haemorrhage	1438 (1.2)	18 (0.8)	127 (1.4)	232 (1.1)	1061 (1.2)	0.134
Puerperal endometritis	151 (0.1)	10 (0.5)	22 (0.2)	43 (0.2)	76 (0.1)	<0.001
Systemic infections*	503 (0.4)	14 (0.6)	69 (0.8)	111 (0.5)	309 (0.3)	<0.001
Severe maternal outcomes** (ratio)	582 (4.6)	12 (5.4)	46 (5.1)	107 (5.1)	417 (4.5)	0.648
Eclampsia	216 (37.1)	9 (75.0)	22 (47.8)	44 (41.1)	141 (33.8)	0.006
Haemorrhage	254 (43.6)	1 (8.3)	20 (43.5)	37 (34.6)	196 (47.0)	0.009
Systemic infections	66 (11.3)	NR	11 (23.9)	11 (10.3)	44 (10.6)	0.027
Others	83 (14.3)	3 (25.0)	7 (15.2)	11 (10.3)	62 (14.9)	0.444
Maternal severity score***	2.5 (±2.7)	1.5 (±0.9)	2.7 (±3.1)	2.1 (±2.3)	2.6 (±2.7)	0.530
Maternal severity index****	8.8% (±21.7)	0.1% (±0.2)	11.1% (±23.6)	5.7% (±18.3)	9.6% (±22.5)	0.455
Maternal near miss***** (ratio)	479 (3.8)	12 (5.4)	36 (4.0)	89 (4.2)	342 (3.7)	0.501
IHMM****** (ratio)	103 (0.8)	NR	10 (1.1)	18 (0.9)	75 (0.8)	0.554
Perinatal outcomes						
Low birthweight (<2500 g)	14594 (12.3)	308 (14.6)	1071 (12.4)	2441 (12.2)	10774 (12.3)	0.357
Preterm delivery (<37 weeks)	8610 (7.3)	235 (11.2)	743 (8.6)	1524 (7.7)	6108 (7.0)	<0.001
Neonatal severe conditions*******	2536 (2.1)	72 (3.6)	239 (2.7)	467 (2.3)	1758 (1.9)	<0.001
Stillbirths	2375 (1.9)	50 (2.3)	202 (2.2)	382 (1.8)	1741 (1.9)	0.108
IHENM********	1171 (1.0)	31 (1.4)	84 (1.0)	223 (1.1)	833 (0.9)	0.053

Numbers and rates are shown for severe maternal outcomes (SMO), maternal near miss (MNM) and intra-hospital maternal mortality (IHMM); for other entries, numbers and percentages are shown. NR, not reported.
*Systemic infections includes pneumonia, peritonitis and post-operative abdominal infections.
**SMO includes MNM and IHMM.
***The maternal severity score is calculated as the number of markers of organ dysfunction.
****The maternal severity index is defined as the probability of maternal death among women with severe maternal outcomes.
*****Maternal near miss is an event in which a woman survives a life-threatening complication during pregnancy, childbirth or termination of pregnancy.
******IHMM refers to the intra-hospital death of a liveborn baby during the first 8 days after delivery.
*******Neonatal severe conditions refer to a liveborn baby with one of the following conditions: birthweight < 1500 g, <32 gestational weeks at birth or a 5-minute Apgar score of <7.
********Intra-hospital early neonatal mortality (IHENM) refers to the death of a liveborn baby during the first 7 days after delivery.

times higher among adolescent mothers aged ≤15, 16–17 and 18–19 years, respectively, compared with adult mothers. Higher risks of puerperal endometritis and systemic infections were observed among all adolescent age groups, with no significant differences among mothers aged 16–17 years for puerperal endometritis and ≤15 years for systemic infections. The risk of SMO was not significant among adolescent mothers aged ≤15, 16–17 and 18–19 years: 1.13 (95% CI, 0.59–2.18), 1.03 (95% CI, 0.72–2.18) and 1.10 (95% CI, 0.86–1.41), respectively. Additional adjustment for medical conditions during pregnancy, e.g. chronic and acute diseases, severe anaemia, malaria and coincidental conditions and stratified analysis for parity, did not alter the risks of adverse maternal outcomes among adolescents (data not shown).

After adjusting for country- and facility-level effects and covariates, risks of preterm delivery (<37 weeks of gestational age), low birthweight infants (<2500 g) and severe neonatal conditions were significantly higher among all adolescent age groups, with the highest risk observed among the youngest age group (low birthweight: AOR = 1.17; 95% CI, 1.01–1.37; preterm delivery: AOR = 1.60; 95% CI, 1.37–1.87; severe neonatal conditions: AOR = 1.56; 95% CI, 1.20–1.70). A high risk of stillbirth was found among all adolescent age groups, but the risk was significant only among adolescent mothers aged 16–17 years (AOR = 1.32; 95% CI, 1.11–1.57). The risk of intra-hospital early neonatal mortality was significantly higher among all adolescent mothers compared with adult mothers (data not

Table 3. Intervention coverage by maternal age

Medical interventions	Total, n (%)	Maternal age, n (%)				P
		≤15 years	16–17 years	18–19 years	20–24 years	
Prophylactic uterotonic	117989 (95.0)	2011 (91.4)	8343 (92.7)	19727 (94.4)	87908 (95.4)	0.0007
Therapeutic uterotonic	1339 (93.1)	18 (100)	123 (96.9)	212 (91.4)	986 (92.9)	0.120
Prophylactic antibiotics for caesarean section	24907 (86.2)	534 (86.5)	1757 (85.0)	3847 (85.2)	18769 (86.5)	0.427
Parenteral antibiotic for systemic infections	392 (77.9)	10 (71.4)	53 (76.8)	86 (77.5)	243 (78.6)	0.919
Magnesium sulfate for eclampsia	493 (90.1)	19 (82.6)	78 (96.3)	128 (92.1)	268 (88.2)	0.077
Antenatal corticosteroids for preterm birth (26–34 weeks)	1655 (48.1)	27 (28.4)	117 (39.4)	236 (38.6)	1275 (52.3)	<0.001

Intervention coverage was determined as the proportion of women who received the essential intervention divided by all women who were eligible for that intervention.

shown). After further adjustment for birthweight and gestational age at birth, the risk decreased and became statistically insignificant. The results of adverse perinatal outcomes were not altered after additional adjustment for eclampsia (data not shown).

Discussion

Main findings

By using a large multicountry dataset, we have described the pregnancy outcomes among adolescent mothers in 29 countries. Controlling for country- and facility-level effects, and co-variates at the individual level, such as marital status, educational attainment, parity and multiple births, as well as for the capacity of the health facility and the maternal mortality rate by country, we found higher risks of eclampsia, puerperal endometritis and systemic infections and lower risks of caesarean section and pre-eclampsia among adolescent mothers compared with mothers aged 20–24 years. The risk of SMO was higher among adolescents than non-adolescent mothers; however, the differences were not significant. We observed higher risks of adverse perinatal outcomes with decreasing maternal age, but not for adverse maternal outcomes. Our results showed that adolescent pregnancy was independently associated with increased risks of low birthweight, preterm delivery and severe neonatal conditions, and an increased risk of intra-hospital early neonatal death was partially explained by the preterm delivery among infants born to adolescent mothers. Coverage of antenatal corticosteroids for preterm births at 26–34 weeks was significantly lower among adolescent mothers, despite the fact that they are at an increased risk of preterm delivery.

Strengths and limitations

To our knowledge, this is the most recent and largest multicountry study undertaken to assess pregnancy outcomes among adolescent mothers. There has been controversy regarding the association between young age and adverse pregnancy outcomes. Reasons for this could include the inconsistent definition of adolescents across the field, age-related reference groups, the small sample size and failure to adjust for known confounders. As our study included a large sample size, we categorised adolescent mothers into three age groups (≤15, 16–17 and 18–19 years), and obtained a sufficient number of adverse outcomes in each age group to estimate the risk of young maternal age. In our analysis, we selected mothers aged 20–24 years as the reference group, consistent with previous studies,[5,6,21] and have taken into account contextual factors, such as country and health facility, socio-demographic characteristics and medical conditions during pregnancy, to describe the biological effect on adverse outcomes.

This study has several limitations. First, the estimation of adverse risks could be biased as this study was implemented in large health facilities, mainly located in urban settings, which had the capacity to perform caesarean sections. An overestimation of risks may exist when high-risk adolescent mothers are referred to these facilities; however, the majority of low- and middle-income countries are known to have low institutional delivery rates and a higher proportion of adolescent pregnancies in rural areas. In addition, adolescent mothers are more likely to seek out smaller hospitals, or have deliveries outside of hospitals.[3] Therefore, an underestimation of adverse risks is more likely to exist, which may limit the generalisability of the results. Second, it is likely that residual confounding exists in our analyses. We attempted adjustment for the socio-demographic and reproductive factors available in this survey; however, we did not have any information on key risk factors for adverse outcomes, including antenatal care[13] and smoking,[22] which may dilute risk estimates, as adolescent mothers tend to have inadequate antenatal care and a higher smoking rate than adult mothers. We tried to

Table 4. Risks of adverse birth outcomes among adolescent mothers compared with mothers aged 20–24 years

Outcome	Maternal age at delivery								
	≤15 years			16–17 years			18–19 years		
	OR	AOR	95% CI	OR	AOR	95% CI	OR	AOR	95% CI
Adverse maternal outcomes									
Caesarean section delivery	1.26**	0.79	0.65–0.89***	0.97	0.69	0.65–0.73***	0.89**	0.77	0.74–0.80***
Pre-eclampsia	2.14***	0.92	0.69–1.22	1.35***	0.73	0.61–0.86***	1.10	0.81	0.71–0.92**
Eclampsia	3.18***	1.85	1.14–2.98*	2.74***	1.88	1.41–2.50***	2.02	1.55	1.25–1.95***
Postpartum haemorrhage	0.70	0.67	0.40–1.09	1.22	1.07	0.86–1.32	0.96	0.91	0.77–1.07
Puerperal endometritis	5.52***	2.73	1.29–5.78*	2.96***	1.35	0.79–2.31	2.49***	1.66	1.10–2.50*
Systemic infections	1.90**	1.22	0.71–1.17	2.29***	1.69	1.26–2.27***	1.58***	1.35	1.07–1.71*
Severe maternal outcomes****	1.20	1.13	0.59–2.18	1.12	1.03	0.72–2.18	1.13	1.10	0.86–1.41
Adverse perinatal outcomes									
Low birthweight(<2500 g)	1.21	1.17	1.01–1.37*	1.01	1.15	1.05–1.25**	0.99	1.10	1.04–1.17**
Preterm delivery (<37 weeks)	1.67***	1.60	1.37–1.87***	1.26***	1.34	1.23–1.47***	1.11*	1.18	1.11–1.27***
Neonatal severe conditions*****	1.75***	1.56	1.20–2.01**	1.41***	1.27	1.09–1.48**	1.17*	1.16	1.04–1.30**
IHENM******	1.57*	1.36	0.86–2.15	1.04	1.05	0.79–1.39	1.18	1.18	0.98–1.41
Stillbirth	1.21	1.23	0.89–1.70	1.19	1.32	1.11–1.57*	0.96	1.03	0.91–1.17

Three-level structure random effects regression models were used to obtain adjusted odds ratios (AORs): individual (level 1), facility (level 2) and country (level 3).

At the individual level, adverse maternal outcomes were adjusted for marital status, education, parity and multiple births. For the analyses, additional adjustments were made for congenital malformation in stillbirths and preterm births, gestational age for low birthweight, and gestational age and birthweight for intra-hospital early neonatal mortality (IHENM).

All analyses were adjusted for facility capacity score at the facility level.

*P < 0.05.

**P < 0.01.

***P < 0.001.

****Severe maternal outcomes include maternal near miss and intra-hospital maternal mortality.

*****Neonatal severe conditions refer to a liveborn baby with one of the following conditions: birthweight <1500 g, <32 gestational weeks at birth or a 5-minute Apgar score of <7.

******Intra-hospital early neonatal mortality (IHENM) refers to the death of a liveborn baby during the first 7 days after delivery.

use appropriate and inappropriate education for age, as maternal education is closely related to maternal age. However, in our data, adult mothers had more inappropriate education than adolescents, possibly because, in recent years, school enrollment and attendance have increased among younger mothers in many countries.[23] We considered the interaction between age and parity, and, after performing an analysis stratified by parity, we found that the results were no different.

Interpretation

In this study, we found that adolescent mothers had a lower risk of pre-eclampsia and a higher risk of eclampsia, with eclampsia being the leading cause of SMO. A recent study in the USA has suggested that the risk of pre-eclampsia among adolescents is increased by maternal obesity and excessive gestational weight gain.[24] The majority of our study population were from low- and middle-income countries, where malnourishment is prevalent among adolescents[25]; therefore, the risk of pre-eclampsia may be lower

than in adults, as observed in a similar secondary analysis of adolescent pregnancy outcomes using the WHO Global Survey.[10] Limited access to antenatal care and a lack of prevention and treatment interventions for pre-eclampsia and infections during pregnancy among adolescents could be possible explanations for the higher risk of eclampsia, puerperal endometritis and systematic infections. However, a conclusion could not be drawn from our study in this regard because of an absence of data on antenatal care and interventions administered during pregnancy.

We also observed a significant low coverage of prophylactic interventions for postpartum haemorrhage, prophylactic antibiotics for caesarean section and antenatal corticosteroids for preterm delivery in countries with high and very high maternal mortality rates, which suggests the existence of inequality in effective interventions and may place adolescents at greater risk of adverse outcomes. Previous studies have shown that adequate antenatal care reduces the risks of pregnancy complications among adolescent mothers and their infants,[12,13,26] and the risk of

maternal mortality was not significantly higher than in mothers aged 20–24 years.[27]

In this study, all adolescent mothers were more likely to have a vaginal delivery and had a lower risk of caesarean section, which was consistent with previous studies.[7,28] However, this result should be interpreted carefully. It has been suggested that adolescents are at an increased risk of obstructed labour and caesarean section indicated for cephalo-pelvic disproportion because of the immaturity of their pelvic bone. However, it is important to note that practitioner policy or maternal request, as well as limited access or availability of caesarean section among adolescents, may influence the mode of delivery.[9,10] Although adolescent mothers had a lower risk of caesarean section after adjusting for confounding factors, higher caesarean section rates (21.6–28.1%) may increase the risk of adverse birth outcomes for the next pregnancy and require special care (repeat caesarean section or vaginal birth after caesarean section).[29]

Consistent with previous studies,[6,8,30–33] we found significantly higher risks of low birthweight and preterm delivery, with the magnitude of risk decreasing as age increased. Previous studies have also suggested that these risks among adolescent mothers are associated with biological immaturity independent of poor socio-economic status, smoking and inadequate antenatal care.[6,32,34] Feto–maternal competition for nutrients is a common explanation for the higher risk of delivering low birthweight infants in adolescent mothers.[16] Gynaecological immaturity (i.e. short cervix [≤25 mm] and small uterine volume) and susceptibility to subclinical infections increase the risk of preterm delivery among adolescent mothers.[35]

Our study suggested that the higher risk of early neonatal death was partly explained by the poor socio-demographic factors and prematurity of infants born to adolescent mothers, which was consistent with previous studies.[7,21]

Our study found higher risks of adverse birth outcomes among adolescent mothers, suggesting that adolescent pregnancy prevention is crucial. As early marriage (<18 years) and sexual debut have been reported to be determinants of adolescent pregnancy, government policies to control marital age, and early education on sex and contraception, are fundamental to prevent adolescent pregnancies.[1]

Conclusions

In this study, we identified increased risks of maternal and perinatal adverse outcomes among adolescent mothers after adjustment for country- and facility-level effects and potential confounding factors. Coverage of essential interventions was significantly lower among adolescent mothers. These findings underline the importance of the further implementation of pregnancy prevention strategies and the improvement of healthcare interventions to reduce adverse birth outcomes among adolescent women in low- and middle-income countries.

Supporting Information

Additional Supporting Information may be found in the online version of this article:

Table S1. Distribution of adverse maternal outcomes by maternal age and regions defined by the maternal mortality rate (MMR).

Table S2. Proportion of adolescent deliveries and adverse maternal outcomes by country.

Table S3. Intervention coverage by maternal age and country group. ■

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