Educational inequalities in adverse pregnancy outcomes in rural China, 2010-2018

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Abstract

Background:

Educational inequalities have been found in adverse pregnancy outcomes, but no previous study has investigated in China. This study examined the patterns of educational inequalities in the risk of adverse pregnancy outcomes in rural China and examined the mediations of birthweight and gestational age in the stillbirth and neonatal mortality.

Methods:

The study population consisted of 217,070 registered pregnancies in Yunnan Province during 2010–2018. Logistic regression models were performed on the association studies between education and adverse pregnancy outcomes including stillbirth, neonatal mortality, preterm birth (PTB), and low birth weight (LBW). The subgroup analysis by ethnicity was further carried out.

Results:

Compared to women with mid education, least educated women had a significantly increased risk of stillbirth (Adjusted OR (AOR) 1.36 [95%CI 1.19–1.56]), neonatal mortality (AOR 1.55 [1.29–1.87]), PTB (AOR 1.10 [1.04–1.16]), and LBW (AOR 1.30 [1.19–1.41]). Highly educated women showed a similar risk to least educated women in LBW. The magnitude of these associations differed among ethnic groups, among which education had a larger impact on neonatal mortality of Yi women and a smaller impact on stillbirth of Dai women. Low education level lead to stillbirth and neonatal mortality mainly by acting through birthweight.

Conclusions:

Education had the strongest link to neonatal mortality and the weakest link to PTB. Highly educated women also need concern on LBW. Improving education may reduce adverse pregnancy outcomes especially for Yi women in rural China.

Introduction

Adverse pregnancy outcomes, a major public health concern, refer to pregnancy outcomes other than normal live births, mainly including preterm birth (PTB), stillbirth, low birth weight (LBW), small for gestational age (SGA), abortions and infant death[1]. It seems to be more severe in China where the rates of stillbirth in 2015 ranked among the top five countries in the world according to statistics[2, 3]. Recognized risk factors for adverse pregnancy outcomes include maternal age, education, smoking, alcohol, pregnancy complications, etc[2, 4]. Among these, maternal education is increasingly recognized

for its crucial role in pregnancy outcomes[5–7]. Most studies reveal that maternal educational level is inversely associated with elevated risks of PTB[8–10], stillbirth[8, 9, 11, 12], SGA[8, 10], abortions[9], LBW[10, 13, 14], and infant death[8]. However, these studies mainly conducted in the United States, Canada, Australia, and other developed countries, which differ greatly from China in terms of population and education system[15, 16].

In China, 40.42% of Chinese total population lives in rural areas[17]. China's rural schooling levels have improved significantly in recent years, and rural education policies have also been reformed simultaneously, but there is still a large gap in educational attainment between China's urban and rural populations[18, 19]. Only half of junior high graduates can attend senior high school in poor rural areas, in contrast to well over 90% of students in large cities in China[20]. Hence, education inequality is relatively more obvious in rural areas. To date, little research has focused on the relationship between maternal education and adverse pregnancy outcomes in China. Furthermore, birthweight and gestational age are found to be associated with stillbirths and are major risk factors for infant death[21, 22]. What is not yet clear is how maternal education act through them to affect stillbirth and neonatal mortality.

The objective of this study was to examine the educational patterns in the risk of adverse pregnancy outcomes in rural China and explore whether and to what extent gestational age and birthweight mediate the association between maternal education and stillbirth and neonatal mortality.

Methods

Study population

This study was supported by the National Free Preconception Health Examination Project (NFPHEP), providing rural married couples who planning to conceive within 6 months with free preconception health examinations in 220 pilot counties in 30 provinces in China since 2010. In this study, we analyzed data registered in Yunnan province during 2010 to 2018, which recorded the general information of 217,070 pregnancies including parental characteristics, disease history, living habits before and during pregnancies, and final pregnancy outcomes. Compared with other provinces or regions of China, Yunnan province is less developed and has a very high level of ethnic diversity, which mostly leads to a relatively low education level.

In this study, analysis limited to all singleton births that delivered between 20 and 42 weeks' gestation. Of all 217,070 pregnancies, we sequentially excluded 13,359 pregnancies with missing fetus number and 1,103 multiple births, 1,912 births with gestational age at delivery < 20 and > 42 weeks' gestation, 2 births with missing gestational age. 2,972 pregnancies with missing maternal education information were further removed. After the above exclusions, 197,722 singleton births remained for analysis (Fig. 1). The possible selection bias resulted from missing would be identified by comparisons of characteristics between the included sample and excluded sample with missing information, which would be presented in the discussion section.

Main Variables

Maternal education was obtained by questionnaire, which was classified into illiteracy, primary school, junior middle school, senior middle school, undergraduate, and above, which corresponded to the Chinese current education system. For comparisons with convenience, education level was further categorized by the number of completed years of schooling, which were low education level (less than 6 years) corresponding to illiteracy and primary school, mid (6–9 years) corresponding to junior middle school and high (more than 9 years) corresponding to senior middle school and undergraduate and above.

Our outcomes of interest were presented as follows: stillbirth, neonatal mortality, PTB, and LBW. Stillbirth was defined as a fetal loss occurring at 20 weeks or longer. Neonatal mortality referred to deaths occurred in the first 4 weeks of life. PTB was defined as live births before 37 complete weeks of gestations. LBW was defined as live births with birthweight < 2,500 g.

Covariates included maternal ethnicity (Han, Yi, Dai, and other ethnic groups), parity (0, 1, > 1 previous deliveries), maternal age (< 30, >=30), work (farmers, non-farmers), BMI (< 24.9 kg/m^2, >=24.9 kg/m^2), economic stress (never, slightly, considerable), smoking status (smoke-free, passive smoking (only), smoker), folate using (unused, irregular used, regular used), IUD use, fetus sex, prior adverse outcomes and maternal diseases including hypertension, thyroid disease, syphilis and hepatitis B. For categorical factors whose missing value proportion were over 20%, we regarded missing value as a separate category rather than excluded cases with missing values. Also, two dichotomous variables, gestational age (< 37, >=37 weeks) and birthweight (< 2,500 g, >=2,500 g) were created for all pregnancies, which needs to be distinguished from the definitions of PTB and LBW that refer to the outcome of live births.

Statistical analysis

Comparisons concerning above characteristics between women with low, mid, and high educational levels were performed by chi-squared tests. The distribution of maternal characteristics among adverse pregnancy outcomes were also compared. Binary logistic regression analyses were modeled to estimate the effect of maternal education level, with and without control for covariates of maternal ethnicity, parity, maternal age, work, maternal BMI, economic stress, smoking in early pregnancy, folate using, IUD use, and prior adverse outcomes.

Gestational age and birthweight were known to be important mediators for stillbirth, which considered as causal confounders. In this study, we expected maternal education level to act primarily through the effect on the risk of gestational age and birthweight, then impacted the risks of stillbirth and neonatal mortality. To demonstrate this, we made a mediation analysis using difference method[23], observing whether any considerable difference occurred in the coefficients of education levels in the multivariable regressions without and with gestational age and birthweight variables. The percentage change in odds ratio (ORC) due to adding variables to the model was calculated to measure the mediation effect with the formula:

$([OR_{model} - OR_{model + mediator}] / [1 - OR_{model}] * 100)$,

on the promise that the adjusted model showed a significant association.

Additionally, consider the heterogeneity among the multi-ethnic population, the multivariable analysis above was run again in three main ethnic groups separately including Han, Yi, and Dai, which totally accounted for 83% of the study population. All statistical analyses were performed using R software 3.6.0. A P-value of < 0.05 was considered statistically significant in all analysis.

Results

We analyzed 197,722 singleton pregnancies from Yunnan during 2010–2018, of which stillbirth rate was 6.4 per 1,000 born, neonatal mortality rate was 3.1 per 1,000 born, PTB rate and LBW rate were 49.03 and 18.10 per 1,000 live born, respectively. The distribution of births with adverse outcomes among maternal characteristics were presented in Supplementary Table 1, Additional File. As seen, all adverse pregnancy outcomes shared some common characteristics, i.e. low education, advanced age, high parity, suffering from maternal diseases, and disusing folate. Particularly, with the multiethnic study population, ethnicity was found to be significantly associated with adverse outcomes, which Dai women had a higher risk of adverse outcomes than other ethnic groups.

Educational inequalities among maternal characteristics

The maternal education level distribution was 21.13% for the low education group, 54.89% for mid education group and 23.97% for the high education group. Maternal characteristics for each educational group were compared in Table 1. All characteristics showed statistical differences among these three education levels. Large disparities between low and high education were found in work, IUD use, prior adverse outcomes, and ethnicity. Specifically, the high education group had 31% more Han women, 20% more non-farmers, 23% fewer women with IUD, and 25% more missing of prior adverse outcomes history than the low education group.

Table 1
Maternal education according to maternal characteristic and infant characteristic

	Low (N = 41,788)	Mid (N = 108,539)	High (N = 47,395)	Total (N = 197,722)	P value
Maternal ethnicity					< 0.001
Han	17,698 (42.4)	69,648 (64.2)	34,670 (73.2)	122,016 (61.7)	
Yi	9,258 (22.2)	18,391 (16.9)	6,364 (13.4)	34,013 (17.2)	
Dai	2,767 (6.6)	4,636 (4.3)	1,310 (2.8)	8,713 (4.4)	
Others	12,065 (28.9)	15,864 (14.6)	5,051 (10.7)	32,980 (16.7)	
Parity (times)					< 0.001
N-Miss	111	333	148	592	
0	10,461 (25.1)	40,237 (37.2)	26,647 (56.4)	77,345 (39.2)	
1	19,118 (45.9)	44,986 (41.6)	13,524 (28.6)	77,628 (39.4)	
> 1	12,098 (29.0)	22,983 (21.2)	7,076 (15.0)	42,157 (21.4)	
Maternal age					< 0.001
N-Miss	153	110	13	276	
<30	30,025 (72.1)	88,590 (81.7)	37,574 (79.3)	156,189 (79.1)	
>=30	11,610 (27.9)	19,839 (18.3)	9,808 (20.7)	41,257 (20.9)	
Work					< 0.001
N-Miss	318	749	322	1389	
Farmers	41,196 (99.3)	105,765 (98.1)	35,453 (75.3)	182,414 (92.9)	
Non-farmers	274 (0.7)	2,025 (1.9)	11,620 (24.7)	13,919 (7.1)	
BMI (kg/m^2)					< 0.001
N-Miss	55	190	76	321	
< 24.9	36,834 (88.3)	97,012 (89.5)	42,872 (90.6)	176,718 (89.5)	
>=24.9	4,899 (11.7)	11,337 (10.5)	4,447 (9.4)	20,683 (10.5)	

Note. N-miss refer to the number of missing data

* Maternal disease including hypertension, thyroid disease, syphilis and hepatitis B

	Low (N = 41,788)	Mid (N = 108,539)	High (N = 47,395)	Total (N = 197,722)	P value
Economic Stress					< 0.001
N-Miss	240	632	253	1,125	
Never	28,595 (68.8)	79,587 (73.8)	36,649 (77.7)	144,831 (73.7)	
Slightly	7,268 (17.5)	17,049 (15.8)	6,005 (12.7)	30,322 (15.4)	
Considerable	5,685 (13.7)	11,271 (10.4)	4,488 (9.5)	21,444 (10.9)	
Smoking status					< 0.001
N-Miss	351	829	357	1,537	
Smoke-free	36,009 (86.9)	93,467 (86.8)	37,984 (80.8)	167,460 (85.4)	
Passive smoking (only)	5,275 (12.7)	13,866 (12.9)	8,854 (18.8)	27,995 (14.3)	
Smoker	153 (0.4)	377 (0.4)	200 (0.4)	730 (0.4)	
Folate using					< 0.001
N-Miss	239	683	291	1,213	
Unused	2,596 (6.2)	4,849 (4.5)	2,016 (4.3)	9,461 (4.8)	
Irregular Used	19,220 (46.3)	46,877 (43.5)	19,760 (41.9)	85,857 (43.7)	
Regular Used	19,733 (47.5)	56,130 (52.0)	25,328 (53.8)	101,191 (51.5)	
IUD use					< 0.001
N-Miss	259	709	300	1,268	
Ever	13,725 (33.0)	25,348 (23.5)	4,619 (9.8)	43,692 (22.2)	
Fetus sex					< 0.001
N-Miss	147 (0.4)	206 (0.2)	66 (0.1)	419 (0.2)	
Female	19,843 (47.5)	51,953 (47.9)	22,550 (47.6)	94,346 (47.7)	
Male	21,619 (51.7)	55,913 (51.5)	24,634 (52.0)	102,166 (51.7)	

Note. N-miss refer to the number of missing data

* Maternal disease including hypertension, thyroid disease, syphilis and hepatitis B

	Low (N = 41,788)	Mid (N = 108,539)	High (N = 47,395)	Total (N = 197,722)	P value
Unknown	179 (0.4)	467 (0.4)	145 (0.3)	791 (0.4)	
Prior adverse outcomes					< 0.001
N-Miss	10,553 (25.3)	35,086 (32.3)	24,076 (50.8)	69,715 (35.3)	
Yes	12,462 (29.8)	29,095 (26.8)	12,333 (26.0)	53,890 (27.3)	
Maternal Diseases *					0.005
N-Miss	391	1,118	445	1954	
Yes	304 (0.7)	717 (0.7)	384 (0.8)	1,405 (0.7)	
Note. N-miss refer to the number of missing data					
* Maternal disease including hypertension, thyroid disease, syphilis and hepatitis B					

Educational inequalities among pregnant outcomes

For all included deliveries, least educated women had the highest rates of all adverse pregnancy outcomes (Fig. 2). The adjusted odds ratio (AOR (95% CI)) showed low education had a stronger association with the elevated risk of neonatal mortality (1.55 (1.29–1.87)) while smaller association with that of PTB (1.10 (1.04–1.16)). Strikingly, the high education group was found to have a higher risk of LBW compared to the mid education group. The comparisons among education groups of three main subpopulations by maternal ethnicity were also displayed in Fig. 2. The results of the Han, Yi, and Dai showed a similar pattern of associations between education and outcome of neonatal mortality and LBW. Stillbirth in the Dai group was found to be little affected by education, which differed from other groups. Yi women were more likely to be affected by education with higher AORs for stillbirth and neonatal mortality.

Mediating effects of gestational age and birthweight

We investigated the associations between education and the outcome of stillbirth and neonatal mortality when further controlling gestational age, birthweight, and both them, respectively (Fig. 3). For stillbirth of low education group, we found the ORC unadjusted for birthweight (Fig. 3A1, model 2) was significantly less than that unadjusted for gestational age (Fig. 3A1, model 3) (16.7% vs 47.2%). When they were both controlled together (Fig. 3A1, model 4), the ORC of education was less than the model unadjusted for gestational age (25.0% vs 47.2%). Similar patterns but to lesser extent also were found to neonatal mortality. As shown, low education lead to adverse outcomes mainly by acting through birthweight. On this point, there was little difference found in three subpopulations (See Supplementary Figs. 1, 2, 3, Additional File).

Discussion

Main findings

We found all pregnancy outcomes were associated with education but not in the same way. Education had the strongest link to the elevated risk of neonatal mortality and the weakest link to PTB. For LBW, the high education group had a similar higher risk to the low education group. Moreover, the magnitude of these associations may differ among ethnic groups that education exerts a larger influence on neonatal mortality of Yi women but relatively small or little influence on stillbirth of Dai women. Additionally, we found low education level was more likely to affect stillbirth and neonatal mortality by affecting birthweight.

Comparison with the existing literature

In this study, the finding of inverse assocaitons of education level with adverse pregnancy outcomes except LBW were consistent with prior studies[8–10]. For the outcome of LBW, the high education group revealed a similar risk to the low education group, which was inconsistent with the finding in other studies[10, 14]. Consider a different study population and education environment, there may exist some risk factors of LBW that were more prevalent but uncollected in women with high education. Additionally, we found birthweight can mediate a considerable proportion of the difference between education groups, which were in concordance with literature[22, 24].

Interpretations

The causal mechanisms that underlie the observed associations between education and adverse outcomes remained elusive and likely to be multifactorial. We controlled possible confounders or mediators including smoking, age, parity, work, economic stress, folate using, IUD use, previous adverse outcomes, BMI, and ethnicity, which explained partly associations between education and adverse outcomes. Certainly, higher educational attainment indicated greater social support and better life circumstances which would be associated with healthier pregnancies through health-protective behaviors, such as good nutrition and physical activity[25, 26]. These factors are also important mediators for associations between education and pregnancy outcomes, which may account for remained educational inequalities in adverse pregnancy outcomes.

As birthweight is a function of both gestational age and fetal growth rate, low birth weight can result from either shortened gestation, growth retardation or both. In our study, disparities in ORC among three models (Fig. 3) may reveal that gestational age had small or little effect on the causal pathway between education and stillbirth and neonatal mortality. It may be explained by protective or risk factors likely to be associated with education, such as health habits during pregnancy, mainly acting through impacting the fetal growth rather than gestation age. The possible causal mechanisms can be explained by Fig. 4. As seen, the counterintuitive nature of ORC of model 4 smaller than model 3 may be explained by collider bias by some unmeasured confounders between gestational age and stillbirth. In other words, the path between education and unmeasured factors which confounding gestation age and the outcome was

opened when birthweight and gestation age were controlled simultaneously, where unmeasured factors in turn confounded the association between education and the outcome.

The disparities found in the magnitude of associations between education and different adverse pregnancy outcomes implied a complicated mechanism. Factors associated with education can act on different outcomes at different magnitude or even in different directions. For example, obvious inverse educational gradient in neonatal mortality indicated a better nurse environment closely associated with educational level. It was somewhat surprising that U-shape relationship between education and risk of LBW was observed in both overall populationa and three subpopulations. It was possible that some unmeasured risk factors were more prevalent in high educated women of Yunnan like more intensive work or more anxiety to pregnancy outcomes. This finding may imply us to emphasize potential risk factors associated LBW in high educated women.

Notably, we also found the ethnic disparities in the effect of education on adverse outcomes. Yi women were more likely to be affected by education to a greater extent especially for the outcome of neonatal mortality. It can be explained the Yi women of whom a certain amount were living in rural mountains which would lead to fewer antenatal visits and worse health services[27]. Little association between education and stillbirth found in Dai women may be explained by their unique midwife culture from elderly women of parturient woman's family and relatives, which may impact more on the intrauterine environment than school education[28].

Strengths and limitations

Our study was the first study of China to evaluate education as a main effect on adverse pregnancy outcomes, based on a large cohort comprising 217,070 registered pregnancies in Yunnan rural areas during 2010–2018. It systematically reflected maternal education level and prevalence of adverse pregnancy outcomes in rural China. Importantly, it provided further demonstration that low education in rural areas can increase prevalence of adverse pregnancy outcomes. Moreover, our study challenged prior findings and showed high educated women also need concern on LBW. Better yet, the study population was also a multi-ethnic population with minorities over 30%. It offered a valuable policy reference that improving the education level can reduce adverse pregnancy outcomes for minorities especially for Yi women.

Our study failed to capture more information associated with women’s family which might play an important role in confounding or mediating the associations found. The major confounders including factors associated with paternal education and factors associated with the family-of-origin of women. For example, husbands with high education level can offset the high risk of women with low education[29]. Women born with low birthweight or grown with insufficient nutrient intake in childhood are more likely to be small adult women, who have a higher risk of adverse pregnancy outcomes[30]. Additionally, the possible selection bias resulted from missing information may affect the associations between education and pregnancy outcomes. As Supplementary Table 2, Additional File showed, compared to the included sample, the excluded sample had about 3% more of the proportion of the low

education group. Moreover, the excluded sample was more likely to be a higher risk population, with a higher proportion in the characteristics of high parity, advanced age, high BMI, more previous adverse outcomes, and low rate of folate use. Though the excluded sample only accounted for about 6% of the total sample, the possible sample selection bias was also considered.

Conclusions

In conclusion, education had the strongest link to neonatal mortality and the weakest link to PTB. Least educated women need more attention, support, and observation during pregnancy and labor, especially for Yi women. Highly educated women also need concern on LBW. These findings reinforce the importance of improving the education level in reducing the prevalence of adverse pregnancy outcomes in rural China.

Abbreviations

AOR	Adjusted odds ratio
BMI	Body Mass Index
CI	Confidence interval
IUD	Intrauterine device
LBW	Low birth weight
NFPHEP	National Free Preconception Health Examination Project
OR	Odds ratio
ORC	Percentage change in odds ratio
PTB	Preterm birth
SGA	Small for gestational age

Declarations

Ethics approval and consent to participate

Ethics approval for the study was granted by the Medical Ethics Committee of Yunnan Provincial Population and Family Planning Science and Technology (reference number 2017101702). Informed consent was implied through submission of the survey.

Consent for publication

Not applicable.

Availability of data and materials

The datasets generated and/or analysed during the current study are not publicly available due to the privacy of the participants, but are available from the corresponding author on reasonable request.

Conflict of Interests

The authors declare that they have no conflict of interest.

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Authors' contributions

YW(Yanpeng Wu), LL, PC, YW(Ying Wu) and DY were involved in study conception. RL and DY were involved in data curation. RL, MT, YW(Ying Wu) and DY obtained funding. YW(Yanpeng Wu), LL, YW(Yanfei Wu) and ZL were involved in investigation and methodology design. YW(Yanpeng Wu) completed statistical analysis. MT, YZ, PC, YW(Ying Wu) and DY were involved in project administration. YW(Yanpeng Wu), LL and YW(Ying Wu) were responsible for manuscript preparation and revision. All authors provided critical feedback on manuscript drafts and approved the final manuscript to be published.

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Figures

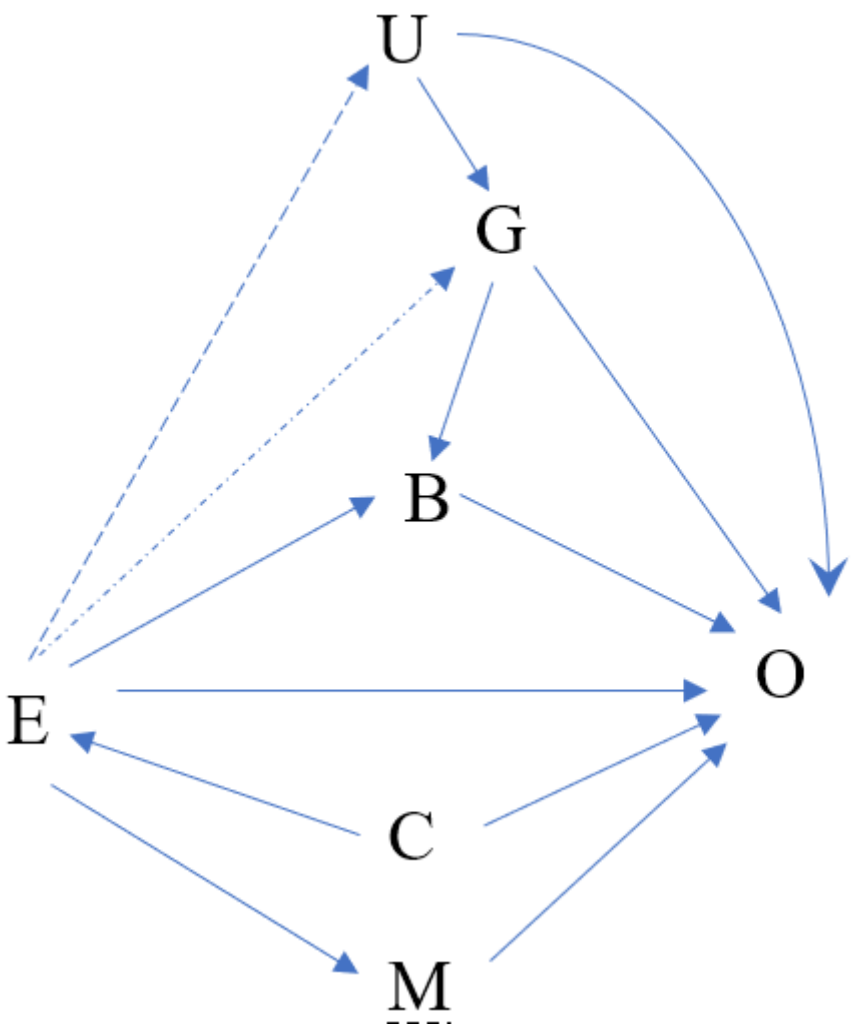

Figure 1

Path diagrams of causal models developed. E, education; B, birthweight; G, gestation age; U, unmeasured factors; C, confounders; M, mediators; O, outcomes

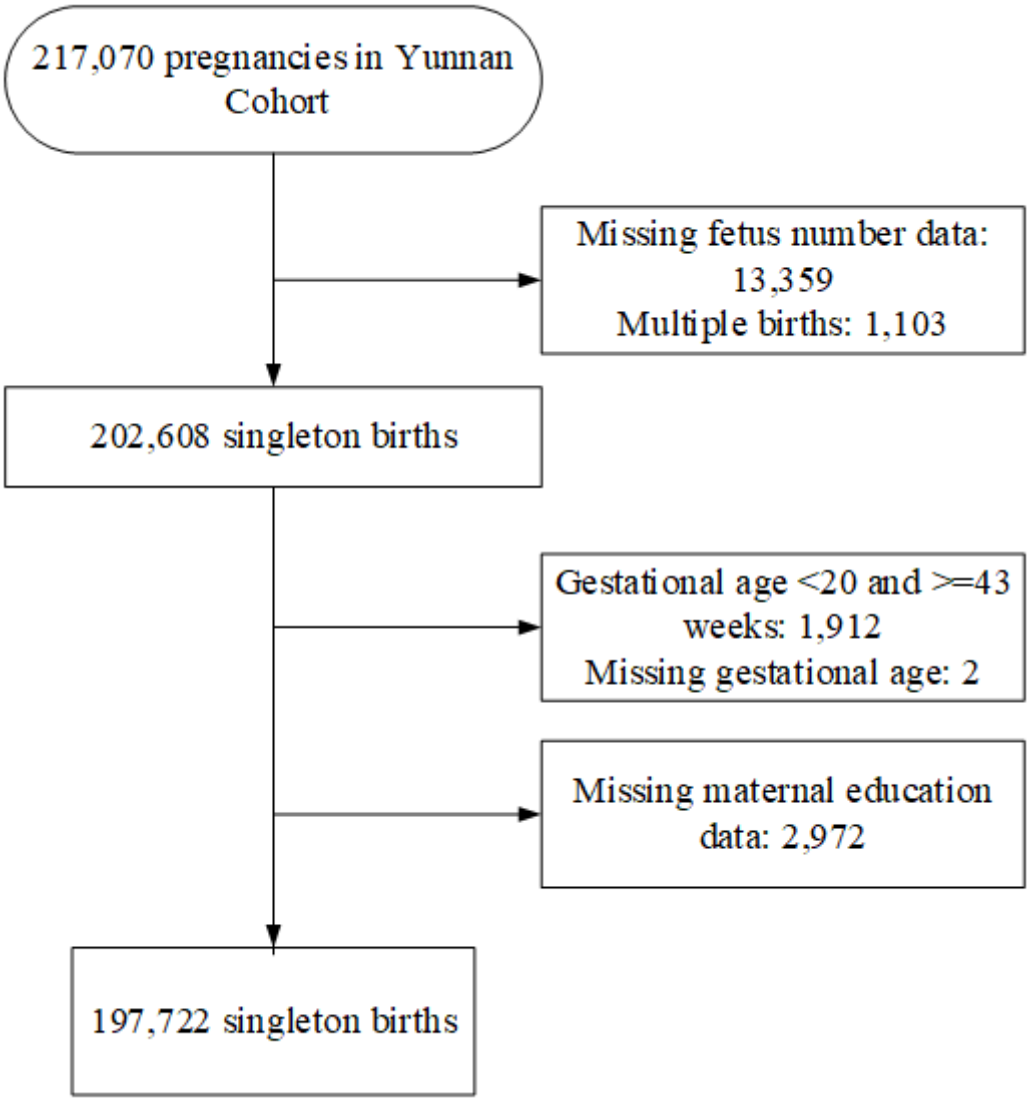

Figure 2

Flow diagram of the study protocol

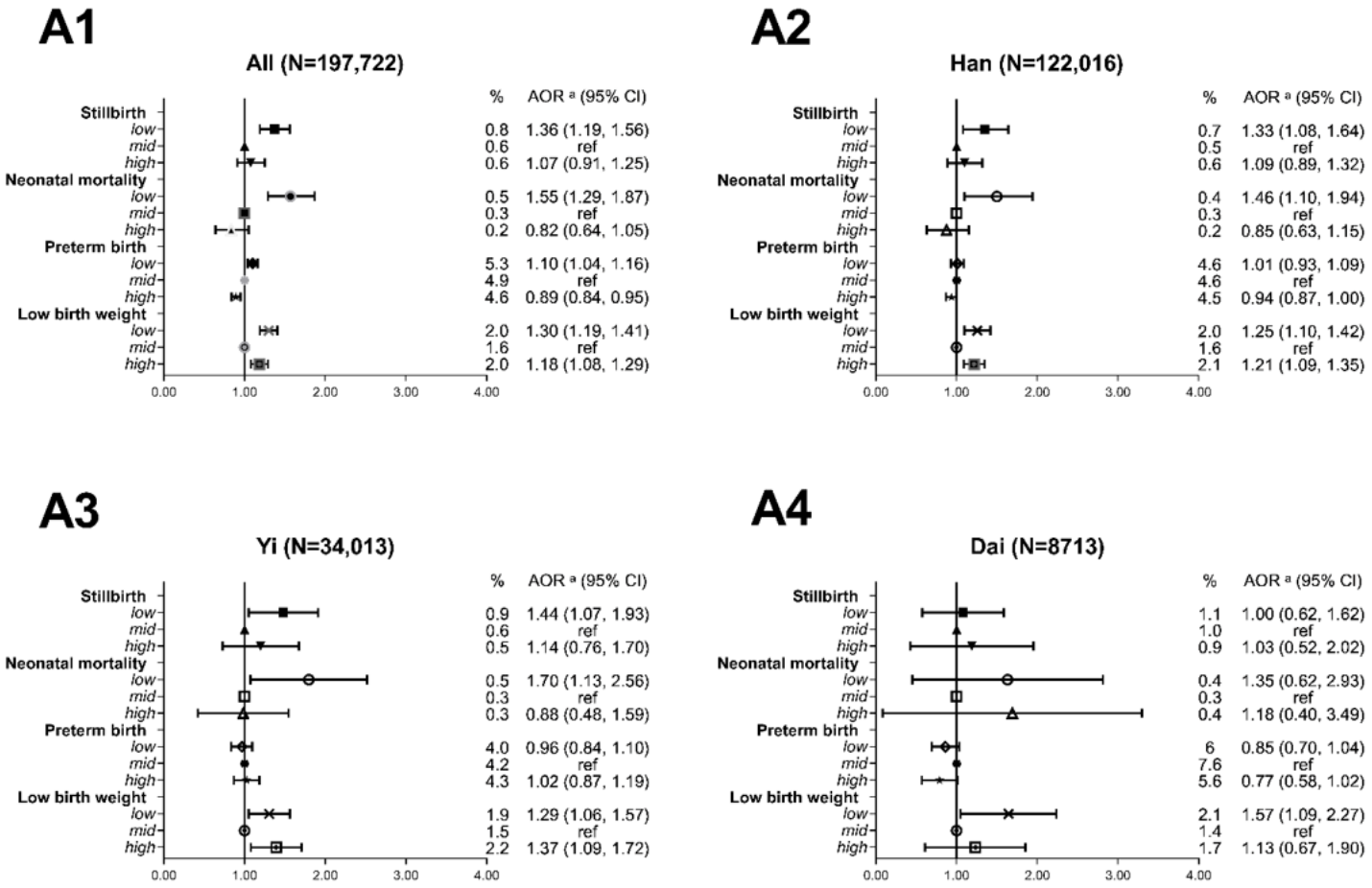

Figure 3

Ethnic disparities in the associations between maternal education and adverse pregnancy outcomes a Adjusted for maternal ethnicity, parity, maternal age, work, maternal BMI, economic stress, smoking in early pregnancy, folate using, IUD use, prior adverse outcomes. Adjusted analyses only include observations with complete information about all covariates.

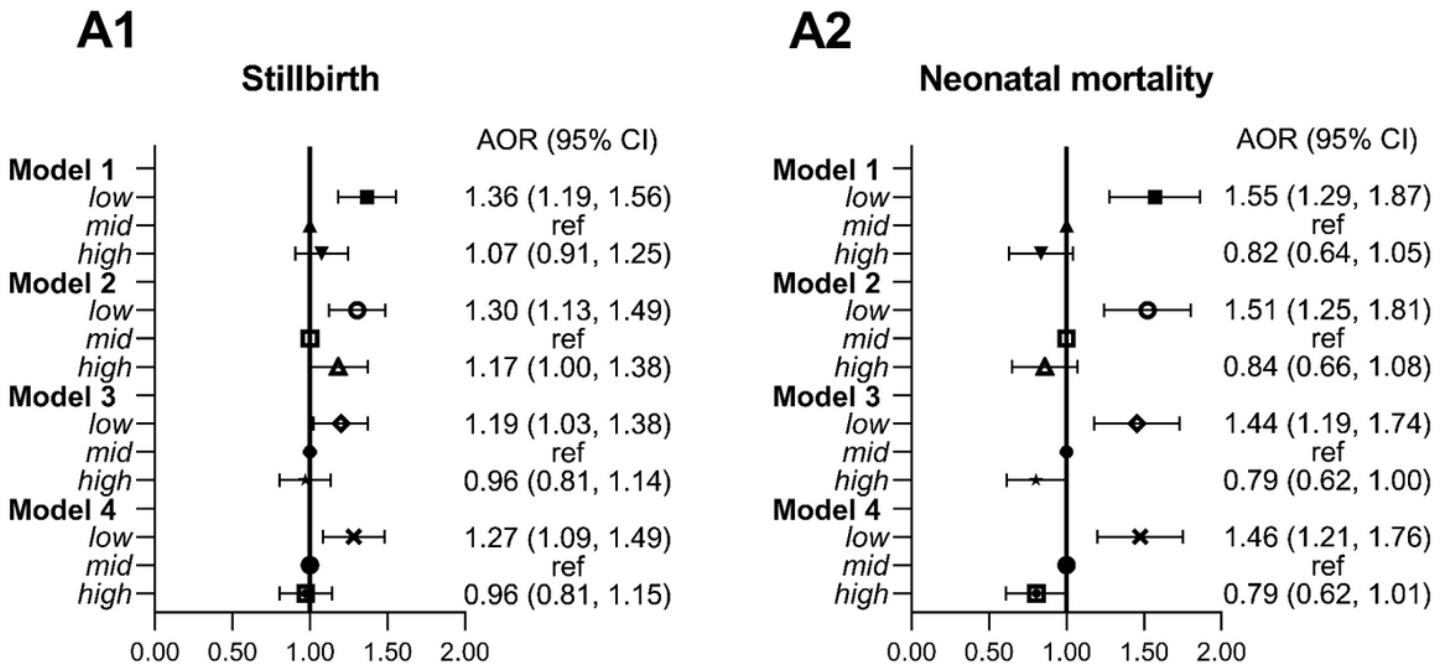

Figure 4

Associations between maternal education and stillbirth and Neonatal mortality when gestational age and birthweight controlled Model 1: multivariable models included all variables in Fig. 2 (see footnote “a”). Model 2: multivariable models included all variables in Fig. 2 (see footnote “a”) plus the gestation age. Model 3: multivariable models included all variables in Fig. 2 (see footnote “a”) plus birthweight. Model 4: multivariable models included all variables in Fig. 2 (see footnote “a”) plus the gestation age and birthweight.

Supplementary Files

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