Wenling et al. BMC Public Health (2024) 24:3134
https://doi.org/10.1186/s12889-024-19967-9

BMC Public Health

RESEARCH Open Access

Analysis of the relationship between the quality of antenatal care examinations and the incidence of preterm birth and low birth weight

Hu Wenling[1], Di Jiangli[1*], Huang Aiqun[1], Zhao Wei[1], Hu Huanqing[1] and Chen Sidi[1]

Abstract

Background Antenatal care (ANC) plays a crucial role in ensuring maternal and child safety and reducing adverse delivery outcomes. This study aimed to analyze the association between the quality of ANC and the occurrence of preterm birth and low birth weight in a sample of the population from 16 regions in 8 provinces in China.

Methods Data from all closed cases of pregnant women and newborns reported in the Maternal and Child Health Monitoring System from January 1, 2018, to December 31, 2018, in 16 monitoring regions across 8 provinces in China were collected and included in the analysis, resulting in a total of 49,084 pregnant women and 49,026 newborns.

Results The mean number of ANC visits was 6.95 ± 3.45. By percentage, 78.79% of the women received ANC examinations at least five times. The percentage of normative ANC examinations and the percentage of qualified ANC examinations was 30.98% and 8.0% respectively. The gestational age($\chi^2 = 229.305$, $p<0.001$), birth weight ($\chi^2 = 171.990$, $p<0.001$) and the occurrence of neonatal complications ($\chi^2 = 53.112$, $p<0.001$) were all significantly related to the number of ANC visits to mothers. There was a correlation between gestational age ($\chi^2 = 1021.362$, $p<0.001$;$\chi^2 = 194.931$, $p<0.001$) and birth weight ($\chi^2 = 259.009$, $p<0.001$; $\chi^2 = 70.042$, $p<0.001$) with normative ANC and qualified ANC examinations. As the number of ANC examinations increased, the rates of preterm birth and low birth weight decreased. Pregnant women who did not receive normative ANC examinations had a higher risk of preterm birth and neonatal low birth weight compared to those who did; Adjusted Odds Ratio (95%CI) was 23.33(16.97~32.07) and 1.61(1.37~1.90) respectively. Pregnant women who did not receive qualified ANC examinations had a higher risk of preterm birth and neonatal low birth weight compared to those who did; Adjusted Odds Ratio (95%CI) was 15.05(8.45~26.79)and 1.36 (1.02~1.82) respectively.

Conclusion The percentage of women who received normative ANC examination and qualified ANC examination is still low in China, and the quality of antenatal care significantly affects the occurrence of preterm birth and low birth weight in newborns.

Keywords Antenatal care, Pregnant women, Preterm birth, Low birth weight

*Correspondence:
Di Jiangli
dijiangli@chinawch.org.cn
[1]National Center for Women and Children's Health, National Health Commission of the People's Republic of China, Beijing, China

© The Author(s) 2024. **Open Access** This article is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License, which permits any non-commercial use, sharing, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if you modified the licensed material. You do not have permission under this licence to share adapted material derived from this article or parts of it. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit http://creativecommons.org/licenses/by-nc-nd/4.0/.

Birth weight and gestational age are key indicators of health care during pregnancy, as well as predictors of early-life and long-term morbidity and mortality [1, 2]. Children born preterm or with a low birth weight have a higher risk of childhood hypertension and neurodevelopmental disorders, as well as adulthood diseases and mortality [3, 4]. Thus, reducing these adverse birth outcomes is a global public health priority. Antenatal care (ANC) plays a crucial role in ensuring maternal well-being and is a crucial measure in reducing adverse delivery outcomes. From a life-course management perspective, poor maternal health during pregnancy can be transmitted to the fetus, increasing the risk of premature birth or low birth weight (LBW), and further impacting the general health of the newborn throughout their life. This forms a vicious cycle by causing poor outcomes in the succeeding generations. Providing the necessary interventions for ensuring a favorable pregnancy outcome during ANC can break this cycle [1].However, to achieve maximum effectiveness, the accessibility and quality of ANC must be ensured.

The maternal and child health service system was one of the earliest health service systems established in the country since the founding of the People's Republic of China. Under the service system, MCH (maternal and child health) hospitals and maternity and children's hospitals stand as the backbone providing the core MCH services; the urban and rural community - based primary health facilities deliver the basic MCH services as the foundation of the system; and the large and medium-sized general hospitals and relevant research and teaching institutions provide the key technical support, providing women and children with a continuum of proactive services and management from birth to old age, covering both physical and mental health, guided by the concept of the life-cycle care and three levels of preventive care. The systematic maternal care management refers to the whole range of health care services for women and their infants from the time they are ready for pregnancy to 42 days after childbirth. It includes systematic care during the pre-pregnancy, pregnancy, childbirth, and puerperium stages. In the 1980s, it began to implement the systematic maternal care management through pilots in the urban and rural areas, and then achieved the full coverage of systematic maternal care management nationwide in a relatively short period of time, and released a series of guiding documents, specific requirements for the conduct of prenatal check-ups are clearly defined. Since 2009, the systematic maternal care management has been incorporated into the National Essential Public Health Service Programme, and implemented through the MCH service network consisting of hospitals of various levels and types charged with their respective responsibilities to provide of free basic antenatal care for pregnant women. China has gradually established a systematic and standardized maternal care management system and service model. Although ANC care are known to be effective in improving maternal or neonatal outcomes, the quality of ANC care is not yet supported by some evidence from studies in China.

Some studies have confirmed that standardized prenatal examinations during pregnancy can effectively improve the quality of prenatal care, reduce the incidence of pregnancy complications, and also improve both the pregnancy outcomes of pregnant women and the birth outcomes of newborns [5–8]. But, these studies lack strict definitions of quality indicators for ANC examinations from the perspective of maternal health management in China or are limited to studying specific populations in certain regions. In our study, two indicators – normative ANC and qualified ANC examination – which clearly defined the key points for timing, frequency, and items of ANC examination were used to measure the quality in order to comprehensively reflect the actual quality of the ANC examination in the monitoring area. This study aims of providing evidence at the national level for policy-making by the goverment through analyses the relationship between ANC examination quality and the occurrence of preterm births and low birth weight.

Methods

Data collection

The data of this study were drawn from the Maternal and Newborn Health Monitoring System (MNHMS) set up by the National Center for Women and Children's Health (NCWCH), the data was collected from the Maternal and Child Care Records from 16 regions of 8 provinces in 2018. The 8 provinces were Hebei, Liaoning, Hunan, Hubei, Fujian, Guangdong, Sichuan, Yunnan, and two districts/counties were selected from each province. More details can be learned from our previous study [5]. Our study was approved by the Ethics Committee of the National Center for Women and Children's Health, Chinese Center for Disease Control and Prevention (No. FY2015-007).

Data cleaning

A total of 52,144 women who delivered live births between January 1, 2018, and December 31, 2018 had received at least 1 antenatal examination during antenatal care. Women whose key information and indicators were missing (3060 persons) were excluded. In the end, the data of 49,084 pregnant women and 49,026 newborns were analyzed in this study. All pregnant women who were residents or who had lived more than six months at these places were enrolled at their first antenatal care (ANC) visit [5], and the information of delivery was collected from their delivery registrations. The pregnancy information collected included age, pregnancy-labor history, antenatal visits, mode of delivery and pregnancy outcomes. The newborns' information collected included sex, gestational age, birth weight, and health status.

Measures

In 2016, WHO envisioned a world where "every pregnant woman and newborn receives quality care throughout the pregnancy, childbirth and the postnatal period", in which antenatal care models with a minimum of 8 contacts are recommended to reduce perinatal mortality and improve women's experience of care [9]. China also proposed guidelines and regulations to regulate antenatal health services [10, 11] and implemented throughout the country. These guidelines suggested that all pregnant women attend no less than 5 times at antenatal health services provided by formal medical institutions. The guideline of pre-pregnancy and pregnancy care (2018) formulated by the Chinese Medical Association (CMA) recommends 7 ~ 11 ANC sessions. All these documents have specified the contents and requirements of the ANC examination. According to the Guidelines for Maternal Health Care Service (GMHCC) and the National Basic Public Health Service Project (BPHS) of China, two indicators were used to measure the quality of antenatal care in this study: normative ANC and qualified ANC examination. For this study, the key indicators are interpreted as follow:

(1) **Normative ANC examination** is taken to mean that pregnant women receive at least five ANC examinations in accordance with the given time required in the GMHCC and BPHS rules.

(2) **Qualified ANC examination** is taken to mean that pregnant women receive routine blood, urine, liver function, renal function, hepatitis B, syphilis, and HIV tests at their first ANC examination, and receive routine blood and urine tests at the rest of the four ANC examinations.

(3) Infants born with a birth weight less than 2500 g are defined as **low birth weight**(LBW).

(4) Infants born before 37 weeks of gestation are defined as **preterm birth**(PB).

(5) Newborns who experience conditions such as infection, birth asphyxia, respiratory distress, intracranial hemorrhage, and congenital abnormalities at birth are classified as **newborn complications**.

(6)**Normal pregnancy** is defined as: Spontaneous in onset, low-risk at the start of labour and remaining so throughout labour and delivery. The infant is born spontaneously in the vertex position between 37 and 42 completed weeks of pregnancy. After birth mother and infant are in good condition.

(7) **Abnormal pregnancy** is defined as: A pregnancy that is complicated and affected by an abnormal finding or disease condition in either the fetus and/or the mother.

(8) **Birth defect**: a physical or biochemical defect that is present at birth and may be inherited or environmentally induced.defined as structural or functional anomalies that occur during intrauterine life and can be identified prenatally, at birth, or sometimes may only be detected later in infancy.

Statistical analysis

Analysis of data was performed with the SPSS software (SPSS, version 18.0). Descriptive statistics of all study variables were calculated as proportions and *chi*-square for categorical variables. Logistic regression models were used to estimate the odds ratios(OR) and corresponding 95% confidence interval(95%CI), measuring the associations of preterm birth and low birth weight with the frequency and the quality of ANC, as well as the model that included other maternal and infants features(Table 1) were fitted, and the corresponding estimates were respectively denoted(adjusted ones). The dependent variables PB and LBW are based on normal gestational age infants (37w-42w) and normal birth weight (2500–4000 g) as the reference. A cutoff p value of <0.05 was considered of statistical significance, and all p-values were bilateral.

Table 1 Variable assignment introduction

Variables	Variables Assignment Description
Normalized ANC	0 = No 1 = Yes
Qualified ANC	0 = No 1 = Yes
Number of ANC visits	1 = 1-2times 2 = 3-4times 3 = 5times 4 = 6-7times 5 = 8times 6 => 8 times
Maternal Age	Continuous variable
Maternal Education	1 = Junior high or lower 2 = Senior high 3 = University or above
Pregnancy-labor history	1 = Normal pregnancy 2 = Abnormal pregnancy
Mode of delivery	1 = Vaginal delivery 2 = Cesarean section
Gestational weeks of birth	Continuous variable
Birth weight	Continuous variable
Birth defect	0 = No 1 = Yes
Neonatal complications	0 = No 1 = Yes

Results

Table 2 shows the characteristics of the 49,084 women and 49,026 newborns included in this study. The average age of these women was 28.76±4.72 years. A total of 16,341 (33.29%) women had a history of abnormal pregnancy, and the proportion of cesarean deliveries was 45.67%. The delivery outcomes were 49,026 live births (99.88%) and 58 stillbirths (0.12%). The mean number of ANC visits was 6.95±3.45. By percentage, 78.79% (38,675) of the women received ANC examinations at

Table 2 Characteristics of the pregnant women and newborns

Variables	*N*	%(95%CI)
Characteristics of the pregnant women		
Age		
≤ 19	697	1.42(1.32–1.52)
20–34	42,344	86.27(85.96–86.57)
≥ 35	6043	12.31(12.02–12.60)
Education		
Junior high or lower	14,463	29.47(29.06–29.87)
Senior high	15,485	31.55(31.14–31.96)
University or above	18,919	38.54(38.11–38.97)
Unknown	217	0.44(0.38–0.50)
Pregnancy-labor history		
Normal pregnancy	11,301	23.02(22.65–23.40)
Abnormal pregnancy	16,341	33.29(32.87–33.71)
Missing	21,442	43.68(43.25–44.12)
Mode of delivery		
Vaginal delivery	26,596	54.18(53.74–54.63)
Cesarean section	22,414	45.66(45.22–46.11)
Missing	74	0.15(0.12–0.19)
Delivery outcome		
Live birth	49,026	99.88(99.85–99.91)
Stillbirth	58	0.12(0.09–0.15)
Number of ANC visits		
≥ 5	38,675	78.79(78.43–79.16)
≥ 8	19,603	39.94(39.50-40.37)
>11	5597	11.40(11.12–11.68)
Quality of ANC visits		
Normalized ANC		
Yes	15,207	30.98(30.57–31.39)
No	33,877	69.02(68.61–69.43)
Qualified ANC		
Yes	3941	8.03(7.79–8.27)
No	45,143	91.97(91.73–92.21)
Characteristics of newborns		
Gestational weeks of birth		
<37w	2405	4.91(4.71–5.10)
37w-42w	45,990	93.81(93.59–94.02)
>42w	631	1.29(1.19–1.39)
Birth weight(g)		
<2500 g	1798	3.67(3.50–3.83)
2500–4000 g	45,181	92.16(91.92–92.40)
>4000 g	2047	4.18(4.00-4.35)
Birth defect		
No	48,899	99.74(99.70-99.79)
Yes	127	0.26(0.21–0.30)
Neonatal complications		
No	48,696	99.33(99.25–99.40)
Yes	330	0.67(0.60–0.75)

least five times, 39.93% (19,603) of the women received ANC examinations at least eight times and 11.40% (5597) of the women received ANC examinations more than 11 times. The percentage of normalized ANC examinations and the percentage of qualified ANC examinations was 30.98% and 8.03% of all examinations, respectively. The average gestational age and birth weight of newborns were 39week+2 and 3270.80 g respectively. A total of 2405 (4.91%) newborns were PB infants, and 1798 (3.67%) newborns were LBW infants.

Table 3 shows the ANC examination status of mothers before the newborns with different characteristics. The results showed that gestational weeks(χ^2=229.305, P<0.001), birth weight (χ^2=171.990, P<0.001) , neonatal complications (χ^2=53.112, P<0.001) were related to the number of ANC visits. There was a correlation between gestational age (χ^2=1021.362, P<0.001;χ^2=194.931, P<0.001) and birth weight (χ^2=259.009, P<0.001; χ^2=70.042, P<0.001) with normative ANC and qualified ANC examinations.

Single-factor logistic regression analysis showed that the number and quality of ANC examinations were related to the incidence of PB and LBW. Compared to pregnant women who received more than 8 ANC examinations, those who received 1–2 ANC examinations had a higher risk of PB; Adjusted Odds Ratio(95%CI)was 3.03(2.53~3.63). With the increase in the number of ANC examinations, the incidence of PB and LBW decreased. Among the pregnant women who underwent normative and qualified ANC examinations, the incidence of PB (0.29% and 0.36%, respectively) and the incidence of LBW (1.27% and 1.30%, respectively) were lower than among those who did not have such examinations (6.97% and 5.30%; 4.74% and 3.87%, respectively). The pregnant women who did not receive normative ANC examinations had a higher risk of PB and LBW compared to those who did; Adjusted Odds Ratio(95%CI) was 23.33(16.97~32.07)and 1.61(1.37~1.90)respectively. Pregnant women who did not receive qualified ANC examinations had a higher risk of PB andLBW compared to those who did; Adjusted Odds Ratio(95%CI) was 15.05(8.45~26.79)and 1.36 (1.02 ,1.82) respectively. A multivariate logistic regression analysis model showed that after controlling for maternal age, maternal education, history of pregnancy and delivery, mode of delivery, neonatal complications, birth weight, gestational age at birth were related to the occurrence of PB and LBW. (Tables 4 and 5) .

The scatterplot analysis of the relationship between the number of ANC examinations and gestational age and birth weight showed that with an increase in the number of ANC examinations, there is a pyramid-shaped trend. With the increase in the number of antenatal examinations, the incidence of adverse pregnancy outcomes decreases. However, the gestational weeks and birth weight were maintained in a reasonable range after reaching a certain number of ANC examinations.(Figures 1 and 2).

Discussion

Newborns who are preterm or have LBW account for most neonatal deaths worldwide [12]. This is a major global public health challenge. However, birth weight and gestational age are key indicators of health care during

Table 3 The ANC examination status of mothers before the birth of newborns with different characteristics

Variables	Number of ANC visits, *N*(%)		Normalized ANC, *N*(%)		Qualified ANC, *N*(%)	
	<5	≥ 5	Yes	No	Yes	No
Gestational weeks of birth						
<37w	806(7.76)	1599(4.14)	44(0.29)	2361(6.98)	14(0.36)	2391(5.30)
37w-42w	9451(90.99)	36,539(94.57)	14,994(98.66)	30,996(91.63)	3885(98.68)	42,105(93.38)
>42w	130(1.25)	501(1.30)	160(1.05)	471(1.39)	38(0.97)	593(1.32)
	χ^2 = 229.305, *P*<0.001		**χ^2 = 1021.362, *P*<0.001**		**χ^2 = 194.931, *P*<0.001**	
Birth weight(g)						
<2500 g	603(5.81)	1195(3.09)	193(1.27)	1605(4.74)	51(1.30)	1747(3.87)
2500–4000 g	9382(90.32)	35,799(92.65)	14,371(94.56)	30,810(91.08)	3734(94.84)	41,447(91.92)
>4000 g	402(3.87)	1645(4.26)	634(4.17)	1413(4.18)	152(3.86)	1895(4.20)
	χ^2 = 171.990, *P*<0.001		**χ^2 = 359.009, *P*<0.001**		**χ^2 = 70.042, *P*<0.001**	
Birth defect						
No	10,359(99.73)	38,540(99.74)	15,162(99.76)	33,737(99.73)	3927(99.75)	44,972(99.74)
Yes	28(0.27)	99(0.26)	36(0.24)	91(0.27)	10(0.25)	117(0.26)
	χ^2 = 0.056, *P* = 0.812		**χ^2 = 0.419, *P* = 0.517**		**χ^2 = 0.004, *P* = 0.948**	
Neonatal complications						
No	10,371(99.85)	38,325(99.19)	15,041(98.97)	33,655(99.49)	3920(99.57)	44,776(99.31)
Yes	16(0.15)	314(0.81)	157(1.03)	173(0.51)	17(0.43)	313(0.69)
	χ^2 = 53.112, *P* = 0.001		**χ^2 = 42.677, *P* = 0.001**		**χ^2 = 3.728, *P* = 0.053**	

Table 4 Association between ANC examination and preterm birth incidence

Variables	Number of live births, *N* (%)	Preterm birth, *N*(%)	Single-factor model		Multifactor model	
			OR(95%CI)	*P*	aOR(95%CI)	*P*
Number of ANC visits						
1–2	5472(11.16)	402(7.35)	3.50(3.02,4.06)	<0.001	3.03 (2.53,3.63)	<0.001
3–4	4915(10.03)	404(8.22)	3.91(3.37,4.54)	<0.001	3.06 (2.57,3.66)	<0.001
5	7741(15.79)	410(5.30)	2.46(2.12,2.84)	<0.001	2.53(2.13,3.00)	<0.001
6–7	11,313(23.08)	608(5.37)	2.47 (2.16,2.83)	<0.001	2.52(2.16,2.95)	<0.001
8	4802(9.79)	252(5.25)	2.41 (2.04,2.84)	<0.001	2.24(1.86,2.71)	<0.001
>8	14,783(30.15)	329(2.22)	1		1	
Normalized ANC						
No	33,828(69.00)	2361(6.97)	26.37(19.56,35.55)	<0.001	23.33(16.97,32.07)	<0.001
Yes	15,198(31.00)	44(0.29)	1		1	
Qualified ANC						
No	45,089(91.97)	2391(5.30)	16.01(9.46,27.11)	<0.001	15.05(8.45,26.79)	<0.001
Yes	3937(8.03)	14(0.36)	1		1	

Note: The multifactor model included the factors for maternal age, education, birth defect, pregnancy-labor history, mode of delivery, neonatal complications, and birth weight

Table 5 Association between ANC examination and low birth weight infant incidence

Variables	Number of live births, *N* (%)	Low birth weight infant, *N* (%)	Single-factor model		Multifactor model	
			OR(95%CI)	*P*	aOR(95%CI)	*P*
Number of ANC visits						
1–2	5472(11.16)	298(5.45)	2.55(2.18,2.98)	<0.001	1.12(0.91,1.38)	0.277
3–4	4915(10.03)	305(6.21)	2.88(2.46,3.37)	<0.001	1.30(1.06,1.59)	0.010
5	7741(15.79)	284(3.67)	1.67(1.43,1.96)	<0.001	1.07(0.88,1.29)	0.519
6–7	11,313(23.08)	404(3.57)	1.63(1.41,1.89)	<0.001	1.01 (0.86,1.20)	0.876
8	4802(9.79)	175(3.64)	1.65(1.37,1.99)	<0.001	1.15 (0.94,1.42)	0.184
>8	14,783(30.15)	332(2.25)	1		1	
Normalized ANC						
No	33,828(69.00)	1605(4.74)	3.90(3.36,4.53)	<0.001	1.61(1.37,1.90)	<0.001
Yes	15,198(31.00)	193(1.27)	1		1	
Qualified ANC						
No	45,089(91.97)	1747(3.87)	3.03(2.30,3.99)	<0.001	1.36 (1.02 ,1.82)	0.034
Yes	3937(8.03)	51(1.30)	1		1	

Note: The multifactor model included the factors for maternal age, education, birth defect, pregnancy-labor history, mode of delivery, neonatal complications, and gestational weeks at birth

pregnancy, as well as predictors of early-life and long-term morbidity and mortality [13]. Therefore, the impact of the quality of antenatal care(ANC) examination on PB and LBW deserves further exploration. Most of the current epidemiological studies in China on the prevalence and temporal trends of PB and LBW are based on cross-sectional and hospital-based data. In these studies, the prevalence at the local or regional level ranged from 6 to 20% [14–18, 21], and there were significant regional differences. In an observational study of more than 90,000 women, Deng Kui et al. [19] found that the overall PB rate in China increased from 6.4% in 2012 to 8.8% in 2018. Tang Wen et al. [20] in 2014 analysed birth data from 441 medical institutions and showed that the rate of LBW births in China was 5.36%. This study showed that the incidences of PB and LBW births in 2018 were 4.91% and 3.67%, respectively. The proportions of both PB and LBW births were lower in our study than in these previous studies. The possible reason for this difference could be that this study enrolled pregnant women who had received at least one ANC examination during pregnancy. However, pregnant women who did not receive ANC often belong to a higher risk group for PB and LBW, so that their delivery information was not obtained in this study, leading to underestimated results.

PB and LBW are highly complex processes, influenced by multiple factors. Unlike previous studies, the indicators collected by this study were based on continuous and systematic monitoring of individual cases, rather than the statistical data collected at all levels. It showed that 78.79% of pregnant women received at least 5 ANC examinations. However, the proportion of women who received a normalized ANC examination or a qualified ANC examination was only 30.98% and 8.03%

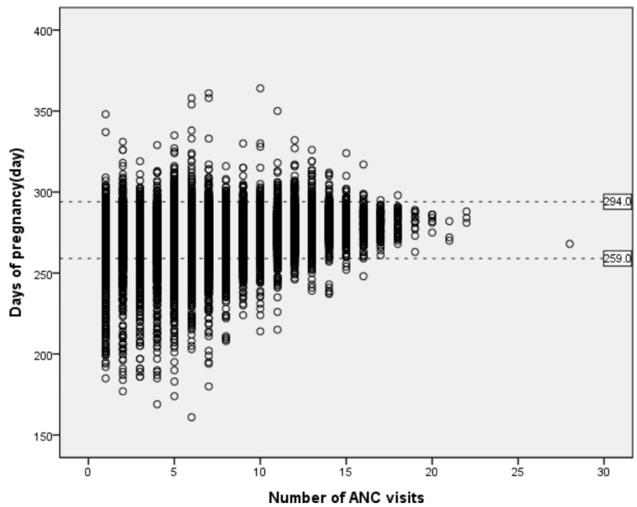

Fig. 1 Scatter diagram of the relationship between number of ANC examinations and gestational age

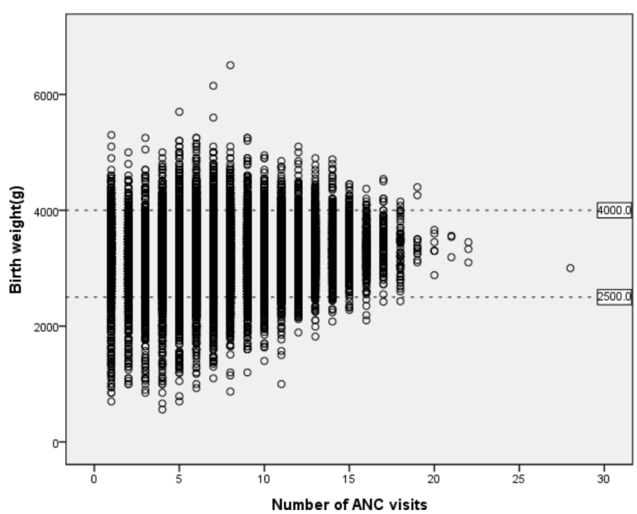

Fig. 2 Scatter diagram of the relationship between number of ANC examinations and birth weight

respectively. This a reminder that in order to achieve a high antenatal care coverage, many health institutions focus only on the number of ANC examinations, ignore the distribution and continuity of ANC services, and do not pay enough attention to the content and quality of ANC services [5].

This study explores the relationship between the quality of antenatal care and the occurrence of PB and LBW births in a large sample of the Chinese population. The results of this study show that compared with those who received normalized ANC examination or qualified ANC examination, pregnant women who did not receive such services had a higher risk of PB and LBW births. It suggests that the quality of ANC (reasonable number of visits, normalized ANC, and qualified ANC) is a protective factor against the occurrence of PB and LBW births. Similar results have been found in other studies. Zhou Miao et al. [7] found that normalized ANC examination was a protective factor for premature birth, and the incidence of PB in the normalized ANC examination group was lower than in the other group. Zhou Hong et al. [6], in their study of poor rural areas in western China, found that insufficient ANC visits and incomplete service items were associated with LBW births. Huang Aiqun et al. [21] while evaluating the association between ANC and adverse delivery outcomes found an increased risk of LBW births among pregnant women who received intermediate or inadequate ANC. Although these studies also mentioned the concept of normalized ANC examination, they did not cover the required items, content, frequency, and timing of ANC examinations, and some studies lacked representation of national population samples. Our study further showed that although the incidence of PB and LBW births decreased with increasing number of ANC examinations, the gestational age and birth weight remained in a similar range above a certain number of ANC examinations. Therefore, simply increasing the number of ANC visits will not necessarily improve the quality of birth outcomes.

Poor perinatal health indicators are linked to health system factors such as healthcare coverage and access to health services [22]. A policy of service expansion was expected to improve perinatal outcomes through increased use of healthcare services leading to better care [13]. For this reason, China began to implement systematic maternal care management through pilots projects in urban and rural areas in the 1980s. In 2009, maternal health management was included in the National Basic Public Health Service Project, providing services such as basic antenatal care, and ANC examinations (one or more times). Coverage of ANC examinations increased from 83.7% of births in 1996 to 96.6% in 2018 [23]. However, despite the significant increase in the antenatal examination rate, however, the incidence of PB and LBW has not decreased. Currently, there are still more than one million preterm and low birth weight infants born each year in China. The most effective methods to prevent preterm birth depend on the obstetric history, which makes the identification of women at risk of preterm birth an important task for antenatal care providers [24]. Proper antenatal care coverage during pregnancy is also beneficial for preventing low birth weight in low and middle-income countries [25, 26]. If a quality assessmentthrough continuous ANC is not established, resulting in a late initiation of ANC, insufficient visits, and incomplete examination, pregnant women may not receive adequate ANC at the appropriate time. In this case, the benefits of antenatal examination in improving the occurrence of preterm birth and LBW adverse outcomes will not be maximized.

Using a relatively large sample is one of the major strengths of this study. Another strength is that the data source of this study is real-time monitoring data, and there is no recall bias. In addition, in our study, we used objective definitions of quality indicators for ANC examinations from the perspective of maternal health management in China. These definitions allow us to better reflect the real situation. There are inevitable limitations to this study that should be considered in this study: due to data limitations, this paper was not able to control the factors of pregnancy complications, nor could it distinguish iatrogenic preterm birth from spontaneous preterm birth, which may affect the effect value of the results.

Conclusions

This study shows that the impact of ANC on PB and LBW is not only related to the number of ANC visits but also closely related to the quality. Reinventing ANC as a flexible model, with content, frequency, and timing tailored to maternal and fetal risk, may reduce the frequency of adverse birth outcomes [27]. Without quality assurance, it would be difficult to achieve good outcomes and benefits even with a high number of ANC visits. Therefore, the government needs to strengthen the quality of ANC in policy-making, intervention measures, and assessment plans. Timeliness and standardization of ANC should be included in the assessment criteria to improve the effectiveness of ANC for high-risk populations. This will have a significant impact on reducing adverse birth outcomes.

Acknowledgements

We appreciate the efforts of all staff involved in data collection, data entry, and reporting in the monitoring areas. We acknowledge and thank the managers of the Maternal and Newborn Health Monitoring Program in the above monitoring areas, and all the pregnant women who participated and we acknowledge all the pregnant women whose experiences are the basis of this study.

Author contributions

W.L. Hu cleaned the data, contributed to the data analysis and wrote the article. J.L.Di contributed to the conception and design of the study and participated in the drafting and revising of the article. A.Q. Huang contributed to the conception and design of the study. All authors read and approved the final manuscript. W. Zhao, H. Q. Hu and S.D.Chen contributed to data collection and analysis.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Data availability

All data generated or analysed during this study are included in this published article.

Declarations

Ethics approval and consent to participate

The study was conducted in accordance with the Declaration of Helsinki and was undertaken following all relevant guidelines and regulations. The study was approved and exempt from informed consent by the Ethics Committee for Human Subjects Studies of the National Center for Women and Children's Health, Chinese Center for Disease Control and Prevention (FY2015- 007). The informed consent forms were waived because that all the information in the study was collected from Maternal and Child Care Handbook written by doctors in place of collecting data face-to-face with the objects, and the data we used did not identify individuals.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Received: 8 September 2023 / Accepted: 2 September 2024
Published online: 12 November 2024

References

1. Hanson MA, Gluckman PD. Early developmental conditioning of later health and disease: physiology or pathophysiology? Physiol Rev. 2014;94(4):1027–76. Accessed 17 Aug 2023.
2. Risnes KR, et al. Birthweight and mortality in adulthood: a systematic review and meta-analysis. Int J Epidemiol. 2011;40(3):647–61. Accessed 17 Aug 2023.
3. Juonala M, et al. Effect of birth weight on life-course blood pressure levels among children born premature: the Cardiovascular Risk in Young finns Study. J Hypertens. 2015;33(8):1542–8. Accessed 17 Aug 2023.
4. Markopoulou P, et al. Preterm Birth as a risk factor for metabolic syndrome and Cardiovascular Disease in Adult Life: a systematic review and Meta-analysis. J Pediatr. 2019;210:69–e805. Accessed 17 Aug 2023.
5. Hu W et al. Current status of antenatal care of pregnant women—8 provinces in China, 2018. BMC Public Health, 2021. 21(1). Accessed 17 Aug 2023.
6. Zhou H, et al. Quality antenatal care protects against low birth weight in 42 poor counties of Western China. PLoS ONE. 2019;14(1):e0210393. Accessed 17 Aug 2023.
7. Zhou M, et al. Relationship between normative antenatal care and preterm birth. Chin J Woman Child Health Res. 2015;26(03):422–5. Accessed 17 Aug 2023.
8. Wang H, et al. Modifying effect of maternal education level on association between the number of prenatal care visits and neonatal low birth weight. J Xi'an Jiao Tong University(Medical Sciences). 2019;40(01):144–8. Accessed 17 Aug 2023.
9. World Health Organization, WHO recommendations on antenatal carefor a positive pregnancy experience. 2016, World Health Organization: Geneva Switzerland. Accessed 17 Aug 2023.
10. National Health Commission of the People's Republic of China. Notice on the issuance of the National Basic Public Health Service Regulations. (Third Edition). 2016. http://www.nhc.gov.cn/cms-search/xxgk/getManuscriptXxgk.htm?id=d20c37e23e1f4c7db7b8e25f34473e1b. Accessed 17 Aug 2023.
11. National Health Commission of the People's Republic of China. Administration of healt-h care during pregnancy and childbirth, Guideline for Maternal Health Care Service.2011.http://www.nhc.gov.cn/wjw/ywfw/201306/61f0bee3af344623a566ab099fffbf34.shtml. Accessed 17 Aug 2023.
12. Ashorn P, et al. Small vulnerable newborns—big potential for impact. Lancet. 2023;401(10389):1692–706. Accessed 17 Aug 2023.
13. Epure AM, et al. Effect of covering perinatal health-care costs on neonatal outcomes in Switzerland: a quasi-experimental population-based study. Lancet Public Health. 2023;8(3):e194–202. Accessed 17 Aug 2023.
14. Gao J et al. Real world research on the growth pattern of preterm children with different birth weight. Chin J Pediatr, 2021(08): 665–71. Accessed 17 Aug 2023.
15. Ye C, et al. Risk factors for preterm birth:a prospective cohort study. Chin J Contemp Pediatr. 2021;23(12):1242–9. Accessed 17 Aug 2023.
16. Shen Q et al. Analysis of risk factors, complications and catch-up growth of premature infants, 2022, DaLi University. Accessed 17 Aug 2023.
17. Lin Sh, et al. Prevalence and disease burden of preterm birth in China from 1990 to 2019. Chin J Epidemiol. 2023;44(2):229–34. Accessed 17 Aug 2023.
18. Shen L et al. Prevalence of low birth weight and macrosomia estimates based on heaping adjustment method in China. Sci Rep, 2021.11(1). Accessed 17Aug 2023.
19. Deng K, et al. Preterm births in China between 2012 and 2018: an observational study of more than 9 million women. Lancet Glob Health. 2021;9(9):e1226–41. Accessed 17 Aug 2023.

20. Tang W, et al. Low birthweight in China: evidence from 441 health facilities between 2012 and 2014. J Matern Fetal Neonatal Med. 2017;30(16):1997–2002. Accessed 17 Aug 2023.
21. Huang A, et al. Attendance at prenatal care and adverse birth outcomes in China: a follow-up study based on maternal and Newborn's Health Monitoring System. Midwifery. 2018;57:26–31. Accessed 17 Aug 2023.
22. Erasun D, Alonso-Molero J, Gómez-Acebo I, Dierssen-Sotos T, Llorca J, Schneider J. Low birth weight trends in Organisation for Economic Co-operation and Development countries, 2000–2015:economic, health system and demographic conditionings. BMC Pregnancy Childbirth. 2021;21:13. Accessed 17 Aug 2023.
23. Report on the Development of Maternal and Child Health in China(. 2019) [J]. Chinese Journal of Women and Children Health,2019,05:1–8. http://www.nhc.gov.cn/fys/s7901/201905/bbd8e2134a7e47958c5c9ef032e1dfa2.shtml. Accessed 17 Aug 2023.
24. Koullali B, et al. Risk assessment and management to prevent preterm birth. Semin Fetal Neonatal Med. 2016;21(2):80–8. Accessed 17 Aug 2023.
25. Bellizzi S, Padrini S. Quality utilization of antenatal care and low birth weight: evidence from 18 demographic health surveys. East Mediterr Health J. 2020;26(11):1381–7. Accessed 17 Aug 2023.
26. Paul P, Zaveri A, Chouhan P. Assessing the impact of antenatal care utilization on low birthweight in India: analysis of the 2015–2016 National Family Health Survey. Child Youth Serv Rev. 2019;106:104459. Accessed 17 Aug 2023.
27. Krans EE, Davis MM. Preventing low birthweight: 25 years, prenatal risk, and the failure to reinvent prenatal care. Am J Obstet Gynecol. 2012;206(5):398–403. Accessed 17 Aug 2023.

Publisher's note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.