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Announcements

The 16th National Birth Defects Prevention Day — September 12, 2020

Birth defects (BDs) can be defined as abnormalities of structure or function that occur during intrauterine life and can be identified prenatally, after birth, or later in infancy (*1*). The World Health Organization (WHO) indicated that every year an estimated 6% of babies worldwide are born with a BD, and over 300,000 deaths occur in infants within 4 weeks due to BDs (*2*). BDs are a global problem, and China has a high incidence of BDs as every year an estimated 0.9 million children — 6% of total national births — are born with BDs (*3*). BDs can contribute to long-term disability, which may have significant impacts on individuals, families, healthcare systems, and societies.

Fortunately, experience showed that about 70% of BDs can either be prevented or that affected children can be offered care (*4*). Therefore, in 2005, the Chinese government declared that September 12 would annually be "National Birth Defects Prevention Day" (NBDPD) to raise awareness of this serious problem and advocate for more BDs prevention, surveillance, care, and research. This year, NBDPD has become even more significant because of the coronavirus disease 2019 (COVID-19) pandemic. Therefore, the theme of the coming 16th NBDPD in 2020 will be "United against the pandemic, safeguarding new life."

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Vital Surveillances

National Perinatal Prevalence of Selected Major Birth Defects — China, 2010–2018

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ABSTRACT

Introduction: An estimated of 900,000 infants are born with birth defects each year in China causing a substantial disease burden. This study aimed to depict the epidemiological patterns of selected major birth defects in Chinese perinatal births and provide important baseline data for future prevention.

Methods: Data from the Chinese Birth Defects Monitoring Network (CBDMN) during 2010–2018 were used to analyze the epidemiological pattern in the prevalence of 15 major birth defects and the trends over time.

Results: In the period of 2010–2018, the top 10 most frequently-occurring birth defects in China included congenital heart diseases (CHDs), polydactyly, cleft lip with or without palate (CL/P), club foot, syndactyly, hydrocephalus, hypospadias, limb reduction defects (LRD), anotia/microtia, and anorectal atresia/stenosis. There was a decrease in the prevalence of neural tube defects, CL/P, hydrocephalus, LRD, gastroschisis, and omphalocele, but there were increases in the prevalence of CHDs, cleft palate, hypospadias, club foot, polydactyly, and syndactyly. The prevalence of most birth defects varied significantly by maternal age, area types (urban/rural), and geographic regions.

Conclusions and Implications for Public Health Practice: The findings indicated that the comprehensive prevention of birth defects should focus on these selected birth defects, elderly pregnant women, rural areas, and western regions.

INTRODUCTION

Birth defects (BDs) affect 4%–8% of births worldwide (*1*). The estimated prevalence in China is

5.6%, with approximately 900,000 infants born with various defects each year (*2*). BDs are the leading cause of infant mortality in China, accounting for about 20% of deaths (*2*–*3*). Other adverse outcomes include premature death in early life, disabilities, impaired physical and mental well-being, negative effects on quality of life, which result in a substantial disease burden on families and societies (*1*–*2*,*4*). According to the Global Burden of Disease Study in 2017, BDs are the tenth leading cause of disability-adjusted life years (DALYs) among women and ninth among men (*5*). As a global public health problem, BDs have been of major concern to governments, health professionals, and the public.

Although several genetic, behavioral, and environmental risk factors have been identified, the underlying causes of most BDs were unclear (*1*–*2*). BDs surveillance played an important role in exploring possible risks, monitoring dynamic changes in prevalence, and providing evidence for interventions (*4*). With rapid socioeconomic development in China, birth policies, family income, maternal nutrition, prenatal care, and socioeconomic and demographic factors have varied significantly. However, reliable data on the prevalence of major BDs was limited. Using 2010–2018 data extracted from the Chinese Birth Defects Monitoring Network (CBDMN) (*4*,*6*–*8*), we aimed to analyze the epidemiological pattern in the prevalence of 15 major BDs and their trends over time.

METHODS

CBDMN is a nationwide hospital-based BDs surveillance network that covers 763 member hospitals in 327 counties or districts in 31 provincial-level administrative divisions (PLADs). CDBMN collects information on live births, stillbirths, and elective terminations of pregnancies at or above 28 weeks of gestation occurring in member hospitals. More than 2 million births were covered each year representing over 10% of live births in China (*6*). All anomalies diagnosed during the perinatal period (from 28 weeks of gestation to Day 7 after birth) are required to be included in the system and coded by health professionals according to the Tenth Revision of International Classification of Diseases (ICD-10). Details of data collection and quality control have been described previously (*4*,*6*–*8*).

We selected 15 frequently-occurring major BDs in China for the current analysis, including neural tube defects (NTDs, Q00, Q01, and Q05), hydrocephalus (Q03), anotia/microtia (Q16.0 and Q17.2), congenital heart diseases (CHDs, Q20–Q26), cleft palate (CP, Q35), cleft lip with or without palate (CL/P, Q36–Q37), anorectal atresia/stenosis (Q42), hypospadias (Q54), club foot (Q66.0), polydactyly (Q69), syndactyly (Q70), limb reduction defects (LRD, Q71–Q73), omphalocele (Q79.2), gastroschisis (Q79.3), and Down syndrome (Q90). The perinatal prevalence rate was defined as the number of cases per 10,000 live and still perinatal births in the specified period. We calculated the prevalence rates by calendar year, maternal age (<20, 20–24, 25–29, 30–34, and ≥ 35 years), infant sex (female *vs.* male), maternal residence area type (urban/rural), and geographic regions (eastern, central, and western). The rules for urban/rural and geographic classifications in the CBDMN were described previously (*6*–*8*).

We used R 3.5.3 (R Development Core Team 2019) for data cleaning and analysis. Pearson chi-squared tests were used to examine differences of prevalence between various groups, and linear chi-squared tests were used to determine the time trends. The 95% confidence intervals (95% CI) for prevalence rates were estimated according to Poisson distribution. The statistical significance level (α) was set at 0.05.

RESULTS

From 2010 to 2018, a total of 18,040,393 perinatal births were recorded, of whom 52.8% were males and 47.1% were females. Overall, 2.2% of births were born to women <20 years, and 11.3% were born to women ≥35 years. The newborns whose mothers resided in rural areas accounted for 45.7%, while infants whose mothers lived in urban areas accounted for 54.3%; 32.1% of births were born to women residents of the eastern region, while 37.2% and 30.7% of births were born to women in the central and western regions, respectively.

As shown in Table 1 and Table 2, the top 10 most frequently occurring BDs included CHDs, polydactyly, CL/P, club foot, syndactyly, hydrocephalus, hypospadias, LRD, anotia/microtia, and anorectal atresia/stenosis. The prevalence rates of selected major BDs varied significantly by maternal age, maternal residence, infant sex, and geographic regions. We found a higher prevalence rate in the advanced maternal age group for CHDs, CP, hypospadias, and Down syndrome, whereas gastroschisis prevalence in the younger maternal-age group (<20 years of old) was much higher. Regarding

TABLE 1. Prevalence* (95% CI) of selected major birth defects by maternal age and infant sex in China, 2010–2018.

Item	Maternal age at delivery (years)					Infant sex		Total
	<20	20–24	25–29	30–34	≥35	Female	Male	
NTDs	8.9(8.0–9.8)	3.9(3.8–4.2)	2.0(1.9–2.1)	2.1(2.0–2.3)	3.1(2.9–3.4)	3.1(3.0–3.2)	2.3(2.3–2.5)	2.7(2.7–2.8)
Anencephalus	2.9(2.4–3.4)	1.0(0.9–1.1)	0.5(0.4–0.5)	0.5(0.4–0.6)	0.8(0.7–0.9)	0.8(0.7–0.9)	0.5(0.5–0.6)	0.7(0.6–0.7)
Spina Bifida	4.8(4.2–5.6)	2.4(2.3–2.6)	1.3(1.2–1.4)	1.3(1.2–1.4)	1.9(1.7–2.1)	1.8(1.8–1.9)	1.5(1.4–1.6)	1.7(1.6–1.7)
Encephalocele	1.2(0.9–1.6)	0.6(0.5–0.7)	0.3(0.3–0.3)	0.3(0.3–0.4)	0.4(0.3–0.5)	0.4(0.4–0.5)	0.3(0.3–0.4)	0.4(0.4–0.4)
Hydrocephalus	8.7(7.8–9.6)	6.2(5.9–6.4)	4.6(4.4–4.7)	4.7(4.5–4.9)	5.4(5.1–5.8)	4.6(4.5–4.8)	5.5(5.4–5.7)	5.1(5.0–5.2)
Anotia/microtia	2.9(2.4–3.5)	2.7(2.6–2.9)	2.7(2.6–2.9)	3.0(2.8–3.1)	3.3(3.0–3.5)	2.4(2.3–2.5)	3.3(3.2–3.4)	2.9(2.8–2.9)
CHDs	45.8(43.8–48.0)	47.7(47.0–48.4)	57.7(57.2–58.2)	64.4(63.6–65.1)	76.4(75.2–77.6)	57.8(57.3–58.3)	60.3(59.8–60.8)	59.2(58.9–59.6)
TGA	0.7(0.4–1.0)	0.7(0.6–0.8)	0.8(0.7–0.8)	0.8(0.8–0.9)	1.0(0.9–1.2)	0.6(0.5–0.6)	1.0(1.0–1.1)	0.8(0.8–0.9)
VSD	8.0(7.2–8.9)	9.2(8.9–9.5)	11.3(11.1–11.5)	12.7(12.3–13.0)	15.9(15.3–16.4)	12.3(12.1–12.5)	11.1(10.9–11.3)	11.7(11.5–11.8)
ASD	29.3(27.7–31.0)	28.6(28.1–29.2)	36.3(35.9–36.8)	41.0(40.5–41.7)	48.7(47.8–49.7)	36.1(35.7–36.5)	38.2(37.8–38.6)	37.2(36.9–37.5)
AVSD	1.8(1.4–2.3)	1.6(1.5–1.7)	1.6(1.5–1.7)	1.7(1.6–1.8)	2.2(2.0–2.4)	1.8(1.7–1.9)	1.6(1.5–1.7)	1.7(1.6–1.8)
TOF	0.9(0.6–1.3)	1.3(1.2–1.4)	1.2(1.1–1.3)	1.4(1.3–1.5)	2.0(1.8–2.2)	1.2(1.2–1.3)	1.4(1.4–1.5)	1.3(1.3–1.4)
PDA	15.3(14.2–16.6)	15.7(15.3–16.1)	20.1(19.8–20.4)	22.4(22.0–22.8)	26.8(26.1–27.5)	19.7(19.4–20.0)	21.1(20.8–21.4)	20.4(20.2–20.6)
CP	2.3(1.8–2.8)	2.4(2.3–2.6)	2.6(2.5–2.8)	2.7(2.6–2.9)	2.9(2.7–3.2)	3.3(3.2–3.4)	2.1(2.0–2.2)	2.6(2.6–2.7)
CL/P	16.5(15.3–17.8)	11.0(10.7–11.4)	6.8(6.6–7.0)	7.0(6.7–7.2)	9.3(8.9–9.7)	6.8(6.6–7.0)	9.4(9.2–9.6)	8.2(8.1–8.4)
CL	6.0(5.2–6.8)	4.3(4.1–4.6)	2.9(2.8–3.0)	3.0(2.8–3.1)	3.6(3.4–3.9)	2.8(2.7–3.0)	3.8(3.7–3.9)	3.3(3.3–3.4)
CLP	10.6(9.6–11.6)	6.7(6.4–6.9)	4.0(3.8–4.1)	4.0(3.8–4.2)	5.6(5.3–6.0)	3.9(3.8–4.1)	5.7(5.5–5.8)	4.9(4.8–5.0)
Anorectal atresia/stenosis	3.2(2.7–3.8)	2.9(2.7–3.0)	2.5(2.4–2.7)	2.8(2.7–3.0)	3.7(3.4–4.0)	1.9(1.8–2.0)	3.5(3.4–3.7)	2.8(2.8–2.9)
Hypospadias§	3.8(3.2–4.4)	4.0(3.9–4.3)	4.9(4.7–5.0)	5.6(5.4–5.9)	6.7(6.3–7.0)	–	9.6(9.4–9.8)	5.1(5.0–5.2)
Club foot	9.4(8.4–10.4)	6.5(6.2–6.8)	5.7(5.5–5.8)	5.5(5.3–5.7)	6.3(6.0–6.7)	5.7(5.6–5.9)	6.1(6.0–6.3)	5.9(5.8–6.1)
Polydactyly	23.0(21.6–24.5)	17.7(17.3–18.1)	17.1(16.8–17.4)	17.0(16.6–17.4)	18.6(18.0–19.2)	14.2(13.9–14.4)	20.4(20.1–20.7)	17.5(17.3–17.7)
Syndactyly	5.9(5.1–6.7)	5.2(4.9–5.4)	5.6(5.5–5.8)	6.0(5.8–6.3)	5.7(5.4–6.1)	4.9(4.7–5.0)	6.3(6.2–6.5)	5.7(5.5–5.8)
LRD	4.8(4.1–5.5)	3.6(3.5–3.9)	3.0(2.9–3.1)	3.1(3.0–3.3)	4.0(3.7–4.2)	2.9(2.8–3.0)	3.5(3.4–3.7)	3.3(3.2–3.4)
Omphalocele†	1.5(1.1–1.9)	0.9(0.8–1.0)	0.8(0.8–0.9)	1.0(0.9–1.1)	1.5(1.4–1.7)	1.0(0.9–1.0)	0.9(0.9–1.0)	1.0(0.9–1.0)
Gastroschisis†	5.3(4.6–6.1)	1.6(1.5–1.7)	0.5(0.4–0.5)	0.4(0.3–0.5)	0.6(0.5–0.7)	0.7(0.7–0.8)	0.8(0.7–0.9)	0.8(0.8–0.8)
Down syndrome	0.6(0.4–0.9)	0.8(0.7–0.9)	1.0(0.9–1.1)	1.3(1.2–1.5)	4.7(4.4–5.0)	1.3(1.2–1.4)	1.6(1.5–1.7)	1.5(1.4–1.5)

Abbreviations: CI=confidence interval; NTDs=neural tube defects; CHDs=congenital heart diseases; TGA=transposition of great arteries; VSD=ventricular septal defect; ASD=atrial septal defect; AVSD=atrioventricular septal defect; TOF=tetralogy of Fallot; PDA=patent ductus arteriosus; CP=cleft palate; CL/P=cleft lip with or without palate; CL=cleft lip without palate; CLP=cleft lip with palate; LRD=limb reduction defects.

* Per 10,000 perinatal births.

† Except omphalocele and gastroschisis, all selected major birth defects varied significantly by infant sex ($p<0.01$); All selected major birth defects varied significantly by maternal age ($p<0.01$).

§ The prevalence rate of hypospadias was defined as the number of case per 10,000 male perinatal births during the specified period.

TABLE 2. Prevalence* (95% CI) of selected major birth defects by urban-rural areas and geographic regions in China, 2010–2018.

Item	Maternal residence		Geographic location			Total
	Urban	Rural	Eastern	Central	Western	
NTDs	1.6(1.5–1.7)	4.0(3.9–4.2)	1.5(1.4–1.6)	2.8(2.6–2.9)	3.9(3.8–4.1)	2.7(2.7–2.8)
Anencephalus	0.4(0.3–0.4)	1.0(1.0–1.1)	0.4(0.3–0.4)	0.5(0.5–0.6)	1.1(1.1–1.2)	0.7(0.6–0.7)
Spina Bifida	1.0(1.0–1.1)	2.4(2.3–2.5)	1.0(0.9–1.1)	1.9(1.8–2.0)	2.1(2.0–2.3)	1.7(1.6–1.7)
Encephalocele	0.2(0.2–0.3)	0.6(0.5–0.6)	0.2(0.2–0.2)	0.4(0.3–0.4)	0.6(0.6–0.7)	0.4(0.4–0.4)
Hydrocephalus	4.6(4.5–4.8)	5.7(5.5–5.9)	4.4(4.2–4.6)	5.4(5.3–5.6)	5.5(5.3–5.7)	5.1(5.0–5.2)
Anotia/microtia	3.2(3.1–3.3)	2.5(2.4–2.6)	2.9(2.8–3.0)	2.3(2.2–2.4)	3.5(3.3–3.7)	2.9(2.8–2.9)
CHDs	71.8(71.3–72.4)	44.2(43.8–44.7)	74.3(73.6–75.0)	50.2(49.7–50.8)	54.3(53.7–54.9)	59.2(58.9–59.6)
TGA	0.9(0.9–1.0)	0.6(0.6–0.7)	1.3(1.2–1.4)	0.7(0.6–0.8)	0.4(0.4–0.5)	0.8(0.8–0.9)
VSD	14.2(14.0–14.4)	8.6(8.4–8.8)	17.2(16.8–17.5)	9.3(9.1–9.5)	8.8(8.5–9.0)	11.7(11.5–11.8)
ASD	45.5(45.1–46.0)	27.3(27.0–27.7)	44.7(44.2–45.3)	32.6(32.1–33.0)	35.0(34.5–35.5)	37.2(36.9–37.5)
AVSD	2.0(1.9–2.1)	1.3(1.3–1.4)	1.4(1.3–1.5)	1.4(1.3–1.5)	2.4(2.2–2.5)	1.7(1.6–1.8)
TOF	1.5(1.4–1.6)	1.1(1.1–1.2)	1.7(1.6–1.9)	1.4(1.3–1.5)	0.9(0.8–0.9)	1.3(1.3–1.4)
PDA	25.3(25.0–25.6)	14.6(14.4–14.9)	28.1(27.7–28.5)	15.8(15.5–16.1)	18.1(17.7–18.4)	20.4(20.2–20.6)
CP	3.0(2.9–3.1)	2.2(2.1–2.3)	3.4(3.3–3.6)	2.2(2.1–2.3)	2.3(2.2–2.4)	2.6(2.6–2.7)
CL/P	6.3(6.1–6.5)	10.5(10.3–10.7)	6.4(6.2–6.6)	8.6(8.4–8.8)	9.7(9.4–9.9)	8.2(8.1–8.4)
CL	2.8(2.7–2.9)	4.0(3.8–4.1)	2.8(2.7–3.0)	3.4(3.2–3.5)	3.9(3.7–4.1)	3.3(3.3–3.4)
CLP	3.5(3.4–3.6)	6.5(6.4–6.7)	3.5(3.4–3.7)	5.2(5.1–5.4)	5.8(5.6–6.0)	4.9(4.8–5.0)
Anorectal atresia/stenosis	2.9(2.8–3.1)	2.7(2.6–2.8)	3.0(2.8–3.1)	2.8(2.7–3.0)	2.7(2.5–2.8)	2.8(2.8–2.9)
Hypospadias§	6.3(6.1–6.4)	3.6(3.5–3.8)	6.7(6.5–6.9)	4.3(4.1–4.4)	4.4(4.2–4.6)	5.1(5.0–5.2)
Club foot	5.7(5.6–5.9)	6.2(6.1–6.4)	6.2(6.0–6.4)	5.1(4.9–5.3)	6.7(6.5–6.9)	5.9(5.8–6.1)
Polydactyly	18.9(18.6–19.2)	15.8(15.6–16.1)	18.0(17.6–18.3)	16.4(16.1–16.7)	18.3(18.0–18.7)	17.5(17.3–17.7)
Syndactyly	6.7(6.5–6.8)	4.4(4.3–4.6)	6.8(6.6–7.0)	5.1(5.0–5.3)	5.1(4.9–5.3)	5.7(5.5–5.8)
LRD	3.1(3.0–3.2)	3.6(3.5–3.7)	2.9(2.8–3.1)	3.4(3.2–3.5)	3.6(3.5–3.8)	3.3(3.2–3.4)
Omphalocele†	1.0(1.0–1.1)	1.0(0.9–1.0)	0.9(0.9–1.0)	1.0(0.9–1.0)	1.1(1.0–1.2)	1.0(0.9–1.0)
Gastroschisis	0.5(0.5–0.5)	1.2(1.1–1.2)	0.5(0.5–0.6)	0.9(0.8–0.9)	1.0(0.9–1.1)	0.8(0.8–0.8)
Down syndrome	1.7(1.7–1.8)	1.1(1.1–1.2)	1.7(1.6–1.8)	1.2(1.1–1.3)	1.6(1.5–1.7)	1.5(1.4–1.5)

Abbreviations: CI=confidence interval; NTDs=neural tube defects; CHDs=congenital heart diseases; TGA=transposition of great arteries; VSD=ventricular septal defect; ASD=atrial septal defect; AVSD=atrioventricular septal defect; TOF=tetralogy of Fallot; PDA=patent ductus arteriosus; CP=cleft palate; CL/P=cleft lip with or without palate; CL=cleft lip without palate; CLP=cleft lip with palate; LRD=limb reduction defects.

* Per 10,000 perinatal births.

† Except omphalocele, all selected major birth defects varied significantly by urban-rural areas (p<0.01); All selected major birth defects varied significantly by geographic location (p<0.05 for anorectal atresia/stenosis and omphalocele; p<0.01 for the rest).

§ The prevalence rate of hypospadias was defined as the number of case per 10,000 male perinatal births during the specified period.

the prevalence by maternal age groups, a gradual U-shape was identified for NTDs, hydrocephalus, anotia/microtia, CL/P, club foot, polydactyly, syndactyly, LRD, anorectal atresia/stenosis and omphalocele. A higher prevalence in males was found for hydrocephalus, anotia/microtia, CHDs, CL/P, anorectal atresia/stenosis, club foot, polydactyly, syndactyly, LRD, and Down syndrome, while a higher prevalence for females was observed for NTDs and CP.

Significant urban/rural differences in prevalence were identified for several defects. The prevalence of anotia/microtia, CHDs, CP, anorectal atresia/stenosis, hypospadias, polydactyly, syndactyly, and Down syndrome appeared higher in urban areas than in rural areas, while the prevalence of NTDs, hydrocephalus, CL/P, club foot, LRD, and gastroschisis were higher in rural areas. With respect to a geographic disparity in prevalence, the highest prevalence of CHDs, CP, anorectal atresia/stenosis, hypospadias, and syndactyly, and Down syndrome were found in the eastern region, whereas the highest rates of NTDs, hydrocephalus, CL/P, anotia/microtia, club foot, polydactyly, LRD, omphalocele, and gastroschisis were in the western region.

Figure 1 illustrated the time trends in the prevalence of selected BDs. The prevalence of NTDs, hydrocephalus, CL/P, LRD, omphalocele and gastroschisis decreased during 2010–2018. The defect with the largest decline in prevalence was gastroschisis, followed by NTDs and CL/P, with a decline of 78.8%, 77.3%, and 56.4%, respectively. The prevalence of CHDs, CP, polydactyly, syndactyly, hypospadias, and club foot increased. Compared with rates in 2010, the prevalence of CHDs, syndactyly, and polydactyly in 2018 increased by 171.4%, 60.7%, and 41.2%, respectively. Notably, the prevalence of anotia/microtia, anorectal atresia/stenosis, and Down syndrome remained stable over time.

DISCUSSION

Using 2010–2018 CBDMN data of over 18 million births, we described the epidemiological pattern of 15 selected major BDs at the national level, with special interests in trends over time and perinatal prevalence by maternal age, maternal residence, infant sex, and geographic region. These data will help to clarify the current epidemiological distributions of the top ten most frequent congenital anomalies in the Chinese population and will help determine the disorders and populations that should be prioritized for prevention.

Compared with previous CBDMN data, the overall

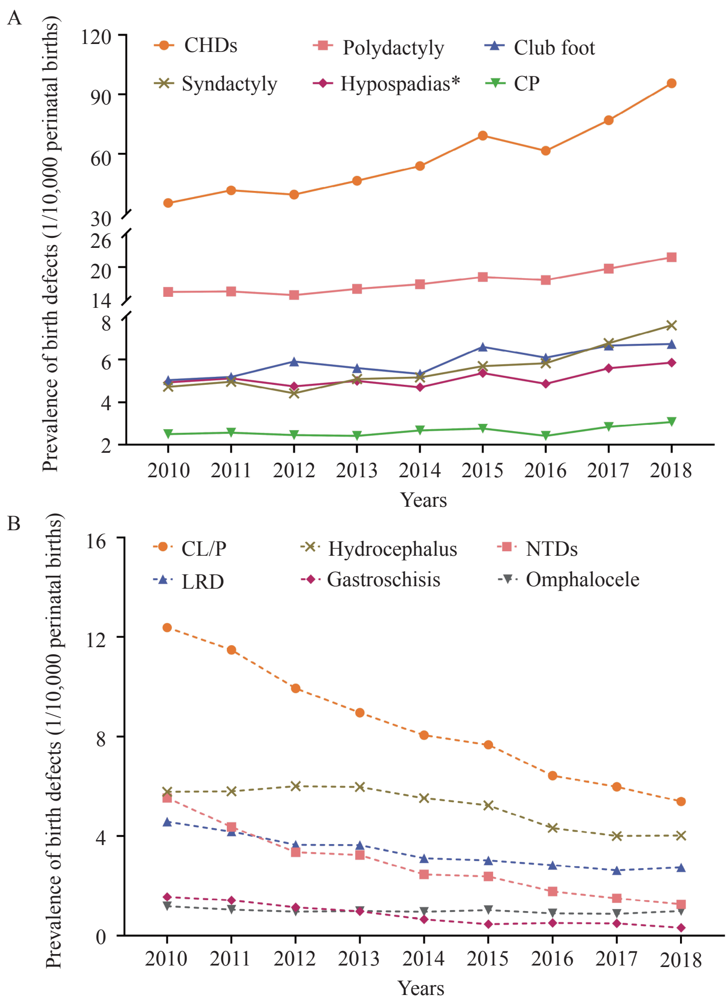

FIGURE 1. Prevalence (1/10,000 perinatal births) of selected major birth defects in China, 2010–2018. (A) Significant increasing trends in the prevalence of six types of birth defects; (B) Significant decreasing trends in the prevalence of six groups of birth defects. * The prevalence of hypospadias was defined as the number of case per 10,000 male perinatal births during the specified period. Abbreviations: CHDs=congenital heart diseases; CP=cleft palate; CL/P=cleft lip with or without palate; NTDs=neural tube defects; LRD=limb reduction defects.

prevalence of CHDs, polydactyly, syndactyly, CP and hypospadias were higher, while the rates of NTDs, hydrocephalus, LRDs, gastroschisis and Down syndrome were lower (*2*,*4*,*6*–*8*). Similar results have been noted in several recent studies in China based on provincial or local hospital-based surveillance data (*9*–*10*). Our prevalence data on CHDs, CL/P, hydrocephalus, hypospadias, anorectal atresia/stenosis and CP, were also comparable to those from hospital-based monitoring systems in Israel, Japan, and Spain (*11*). Notably, the prevalence of CHDs, CL/P, and anotia/microtia in China were higher than those in the United States and some European countries, but Down syndrome prevalence was significantly lower (*11*–*13*). The considerable variations among studies can be explained by ethnicity, socioeconomic factors, environmental exposures, lifestyle risk factors and heterogeneities of surveillance systems or study designs such as differences in inclusion and exclusion criteria, diagnostic capability, and follow-up time.

A growing number of epidemiological studies reveal that greater risks or higher prevalence of certain BDs happen in younger or older women. In the current analysis, we identified an U-shaped pattern for 10 types of anomalies (NTDs, CL/P, etc., Table 1), and increased prevalence of 4 defects with maternal age (CHDs, Down syndrome, CP, and hypospadias). Maternal-age-specific prevalence patterns varied by the types of BDs, which might be partially due to the changing maternal age distribution following by the implementation of the two-child policy (*9*). In our study, significant urban-rural and geographic disparities were found for nearly all the selected BDs, which could be explained by differences in occupational exposures, socioeconomic levels, and healthcare among people living in different area types and regions. Similar findings have been noted in other reports, indicating considerable health inequalities in China (*4*,*6*–*8*,*10*). Therefore, BDs prevention and healthcare services in rural and western regions need to be further improved (*14*).

Consistent with previous studies in China, an increasing prevalence for CHDs, CP, polydactyly, syndactyly, and hypospadias during 2010–2018 was found (*2*,*9*–*10*). Indeed, the increased overall CHD prevalence can be largely attributed to substantial increases in several mild lesions (i.e. small ventricular septal defect, atrial septal defect, and patent ductus arteriosus, etc.). Improvements in diagnostic capabilities, disease screening, and the widespread use of echocardiography can lead to the earlier identification of mild lesions or asymptomatic CHD subtypes and lead to a higher detection rate of CHDs in the perinatal period (*9*–*10*,*12*–*13*). Changes in environmental exposures like exogenous estrogenic endocrine disruptors have been reported to be associated with increased hypospadias prevalence (*10*,*13*), but the exact reasons for increased prevalence of CP, polydactyly, and syndactyly were unclear. The decreasing prevalence of NTDs, hydrocephalus, LRD, and gastroschisis might reflect the combined effect of strengthened primary and secondary prevention (i.e. the National Folic Acid Supplementation Program and prenatal screening and diagnosis for structural malformations and Down syndrome) in China (*2*,*9*–*10*). Given the high prevalence of these defects, we believe further etiological studies are needed, and postnatal care, surgical correction, rehabilitation, and social support should be strengthened.

This study was subject to some limitations. The calculation of perinatal prevalence rate in the current analysis excluded cases <28 weeks of gestation. The rates mainly reflected the effect of combinations of risk factors and primary and secondary preventions and could not be simply explained as an indicator of disease risk. Hospital-based CBDMN data may introduce referral bias, but the impact could be minimal because of the high hospital delivery rate in China (≥99.9%) (*15*). Since the follow-up time period was relatively short (28 weeks of gestation to Day 7 after birth), CBDMN had limited ability to obtain reliable data on congenital metabolic diseases, functional abnormalities, and outcomes in the infancy period. However, considering the large sample size and wide geographic coverage, this data can well represent the epidemiological characteristics of most structural malformations in China.

In summary, we presented the prevalence patterns of 15 major BDs during 2010–2018, mainly focusing on the time trends and the prevalence of the top ten most frequently occurring structural malformations by maternal and infant characteristics. These findings will contribute to health policy making and future BDs prevention by providing important baseline references.

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Preplanned Studies

Selected Structural Birth Defects — Shanxi Province, China, 2000–2019

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Summary

What is already known about this topic?

To reduce the high prevalence of neural tube defects (NTDs) in rural areas of the country, the Ministry of Health of China (currently known as the National Health Commission) initiated a nationwide folic acid supplementation program in 2009. The prevalence of NTDs have decreased from 118.9/10,000 births to 31.5/10,000 in northern China from 2000 to 2014.

What is added by this report?

Based on a population-based birth-defect surveillance system, the prevalence of selected structural birth defects in 5 counties in northern China decreased significantly from 182.8/10,000 births to 119.3/10,000 during the past two decades. Perinatal (28 gestational weeks or more) structural birth defects decreased from 83.9% of total birth defects in 2000 to 59.9% in 2019.

What are the implications for public health practice?

Improving the compliance of periconceptional folic acid supplementation, the fortification of staple foods with folic acid, and the health education surrounding early prenatal check-ups should be considered to further reduce the risk of birth defects in the population.

Birth defects, including congenital structural or functional abnormalities, remained a main cause of death among infants and represented a significant clinical and public health challenge (*1*). Periconceptional folic acid supplementation has been shown to effectively reduce the risk of pregnancies complicated with neural tube defects (NTDs) (*2*) and limb reduction (*3*). The prevalence of NTDs have decreased from 118.9/10,000 births to 31.5/10,000 in northern China from 2000 to 2014 and pre-perinatal (<28 gestational weeks) NTDs accounted for 60% of all NTDs (*4*).The trends of other birth defects among this population and the correlation with the folic-acid supplement program and population policy change had not been reported. This study aimed to examine the trends of selected structural birth defects (Supplementary Table S1, available in http://weekly.chinacdc.cn/) in 5 counties in Shanxi Province during 2000–2019 based on a population-based birth-defect surveillance system. The results showed that the prevalence of selected structural birth defects in the study area decreased significantly from 182.8/10,000 to 119.3/10,000 during the past two decades.

Data from a population-based birth-defect surveillance system that covered 5 counties (Pingding, Xiyang, Taigu, Zezhou, and Shouyang) in Shanxi Province from 2000 to 2019 were analyzed in this study (Supplemental Figure S1, available in http://weekly.chinacdc.cn/). Details of the birth defects surveillance system were described in our previous publication (*4*). Briefly, the system was established in the early 2000s, and more than 20,000 births were covered each year. All pregnant women residing in the study area for more than 1 year were monitored. All livebirths or stillbirths of 28 or more complete gestational weeks and pregnancy terminations at any gestational age following the prenatal diagnosis of birth defects were included. The surveillance data covered more than 95% of live births and data quality was ensured. Information on the diagnostic criteria of birth defects (coded according to International Statistical Classification of Diseases and Related Health Problems, 10th revision), sex, gestational weeks, birth outcome and maternal residence was collected. The study protocol was reviewed and approved by the Institutional Review Board of Peking University.

The prevalence at birth of birth defects by year/period, by type, and by gestational week's group was compared using chi-squared tests. Perinatal prevalence (cases of 28 or more gestational weeks) and pre-perinatal prevalence (cases before 28 gestational weeks) were calculated, and 5 periods of time were demarcated according to population policy and public strategy. Two-tailed $p \leq 0.05$ was considered statistically significant. All statistical analyses were performed using the SPSS package (version 18.0, SPSS Inc., Chicago, IL, USA).

From 2000 to 2019, a total of 293,573 births were covered and 4,748 infants with 5,845 cases of structural birth defects (an infant may have multiple birth defects) were recorded in the system.

Perinatal structural birth defects decreased from 83.9% of all birth defects in 2000 to 59.9% in 2019 (Figure 1A) (Pearson chi-squared tests: 62.958, $p<0.05$) and the perinatal prevalence decreased dramatically from a peak of 139.6/10,000 births in 2003 to 74.7/10,000 in 2019 (Figure 1B).

Prevalence of nervous system defects was the highest and decreased from 169/10,000 births to 35/10,000 in the past two decades. Musculoskeletal system defects remained the second most common birth defect and fluctuated between 29/10,000 to 39/10,000. Cleft lip with or without cleft palate ranked third and decreased from 27/10,000 to 17/10,000 during 2000–2019 (Table 1, Figure 2A).

Among the selected birth defects, NTDs including anencephaly, spina bifida, and encephalocele and congenital hydrocephalus decreased significantly (Figure 2B). Anencephaly decreased from 62/10,000 live births in 2000–2003 to 9/10,000 in 2016–2019, and congenital hydrocephalus decreased from 29/10,000 to 8/10,000 during this period. The prevalence of spina bifida and encephalocele was estimated to decrease 75% during 2000–2019.

For congenital abnormalities of the nervous system, the prevalence decreased during 2000–2019, especially for perinatal prevalence, while the pre-perinatal prevalence increased from 73/10,000 births in 2000–2003 to 91/10,000 in 2004–2008, and then decreased to 75/10,000 in 2009–2011 to 30/10,000 in 2016–2019 (Figure 2C).

DISCUSSION

A population-based birth-defect surveillance system showed that the prevalence of selected structural birth defects in the 5 counties in Shanxi Province decreased significantly from 182.8/10,000 to 119.3/10,000 in the past two decades. After introduction of the massive folic acid supplementation program in 2009, both the perinatal and prenatal prevalences decreased significantly, especially for congenital abnormalities of the nervous system.

During the study period, premarital physical check-ups were changed from mandatory to voluntary in 2003, and a nationwide folic acid supplementation program was initiated in 2009. Corresponding with the reduction in the number of premarital check-ups, the prevalence of birth defects before 28 weeks increased significantly in 2000–2003 compared to 2004–2008. After the change in policy, fewer women went to have a checkup and the opportunity for prophylaxis against birth defects was lost (*5*). Strengthening pre-pregnancy checkups and birth defect screening are important in preventing birth defects. To raise folic acid supplementation and to reduce the high prevalence of NTDs in rural areas of the country, the Ministry of Health of China (currently known as the National Health Commission) initiated a nationwide folic acid supplementation program in 2009 (*6*). The program provides folic acid supplements to all women who have a rural household registration (also known as hukou) and who plan to become pregnant. Our study showed that the prevalence of selected birth defects in 2009–2019 was significantly lower than that in 2000–2008, especially NTDs and cleft lip with/without cleft palate, which may be partly due to folic acid supplementation.

Our study found that the prevalence of defects of the nervous system in this area was still high as evidenced by the prevalence of 35/10,000 in 2019, which was significantly higher than national average level (*7*). Specifically, the prevalence of anencephaly in this study was found to be as high as 9/10,000 live births in 2016–2019 and 0.19/10,000 in Sichuan, China in 2010–2018. The prevalence of spina bifida was 15/10,000 in 2016 to 2019 in this study compared to 0.84/10,000 in Sichuan, China. The study conducted in Sichuan only captured perinatal pregnancies (more than 28 weeks), which may have contributed to lower prevalences as compared to this study (*7*). The folic acid supplementation rate increased significantly after 2009. However, most women began taking folic acid supplements after pregnancy, which was too late for the prevention of NTDs (*6*). Therefore, to improve the compliance of periconceptional folic acid supplementation, starting supplementation before the last menstrual period and supplementing for enough time are crucial for utilizing the maximum potential of the supplementation program. Fortifying staple foods with folic acid and improving health education on early prenatal check-up should be considered to further reduce birth defects risk in the population.

The current study did not find that the change in population policy had an effect on the epidemiology of birth defects. There were 3 major waves of adjustment on population policy during 2000 and 2019. Compared with the transition of “one child” to “two-child” policy from 2011 to 2013, the prevalence of birth defects did not change significantly during the universal two-child policy started in 2016. So far, we did not observe the influence of population policy on the risk of birth defects in the population. Studies revealed longer interpregnancy interval (IPI>60 months) increased the risk of having an infant with a

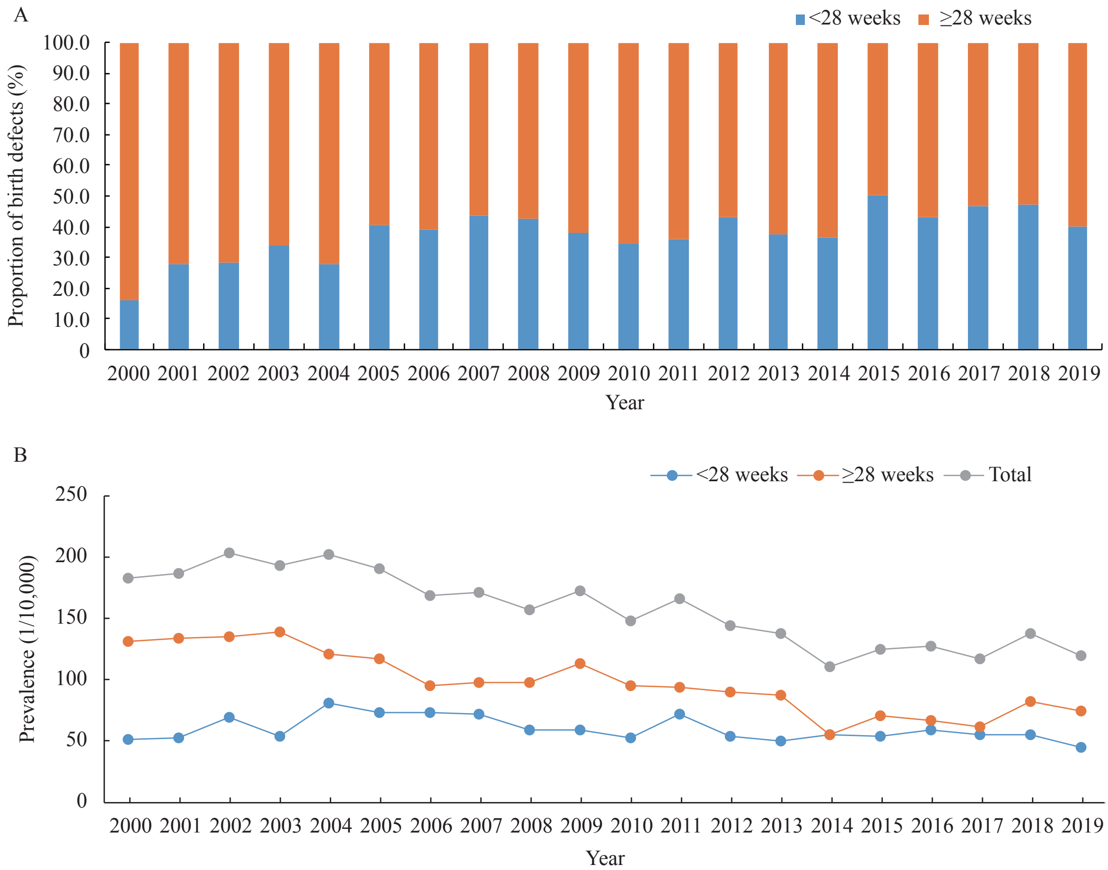

FIGURE 1. Selected structural birth defects by gestational weeks and year in 5 counties, Shanxi Province, China, 2000–2019. (A) Proportion of birth defects; (B) Prevalence of birth defects.

TABLE 1. Total number and prevalence (1/10,000) of birth defects by gestational weeks and system in 5 counties, Shanxi Province, China, 2000−2019.

ICD-10 code	Classification	Gestational weeks		
		<28 weeks	≥28 weeks	Total
1. Q00–Q07	The nervous system	1,987 (67.68)	1,206 (41.08)	3,193 (108.76)
2. Q10–Q18	Eye, ear, face and neck	1 (0.03)	139 (4.73)	140 (4.77)
3. Q20–Q28	The circulatory system	33 (1.12)	51 (1.74)	84 (2.86)
4. Q35–Q37	Cleft lip and cleft palate	81 (2.76)	614 (20.91)	695 (23.67)
5. Q38–Q45	The digestive system	4 (0.14)	119 (4.05)	123 (4.19)
6. Q50–Q56	Genital organs	0	79 (2.69)	79 (2.69)
7. Q60–Q64	The urinary system	3 (0.10)	7 (0.24)	10 (0.34)
8. Q65–Q79	The musculoskeletal system	122 (4.16)	816 (27.80)	938 (31.95)
9. Q80–Q89	Other congenital malformations	181 (6.17)	381 (12.98)	562 (19.14)
10. Q90–Q99	Chromosomal abnormalities	16 (0.55)	5 (0.17)	21 (0.72)
Total*		2,428 (82.71)	3,417 (116.39)	5,845 (199.10)

* The number of cases in this table was based on birth defect phenotypes, not the person. One person may have one more birth defects, so the total number of birth defects was greater than the cases.

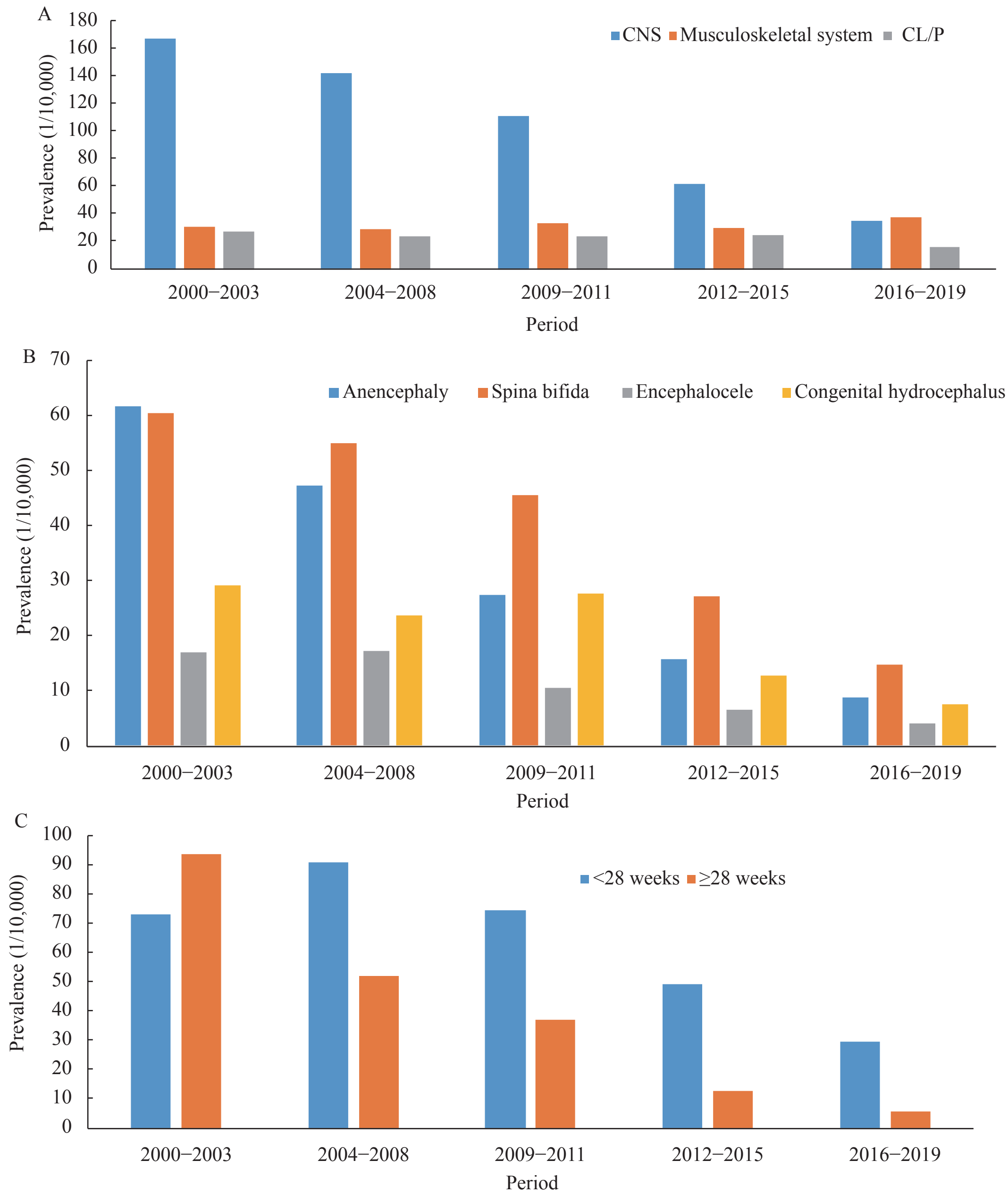

FIGURE 2. Prevalence of congenital abnormality by period in 5 counties, Shanxi Province, China, 2000–2019. (A) Pooled birth defects by system; (B) The nervous system defects by subtype; (C) The nervous system defects by gestational weeks. The 5 periods were divided according to population policy and public strategy, i.e., 2000–2003 (Period of mandatory pre-marital physical check-ups), 2004–2008 (Period of voluntary pre-marital physical check-ups and before folic acid supplementation), 2009–2011 (Period of after folic acid supplementation), 2012–2015 (Period of population policy transition) and 2016–2019 (Period of universal two-child policy). Abbreviations: CNS=central nervous system, CL/P=cleft lip and cleft palate.

birth defect (*8*). Advanced maternal age (AMA) increased the risk of aneuploidy, while AMA was associated with an overall decreased risk for major anomalies in the absence of aneuploidy (*9*). As more than 80% of subjects were from rural areas in the current study, age of childbearing was comparably young and the policy effect may not have been significant. Following the enactment of the universal two-child policy, the proportion of women with AMA increased, and the risk of birth defects deserves more study in the future.

The rank of birth defects in this population was different from a study conducted in Sichuan, a southern province in China, that showed congenital heart disease being the most prevalent birth defect (*7*). In our study, although the total prevalence of birth defects and the prevalence of several subtypes of birth defects decreased with time, congenital abnormalities of the nervous system, such as NTDs, was still the most prevalent birth defects, followed by defects of the musculoskeletal system, cleft lip and cleft palate, other system defects, and eye anomalies. The improvement of detection methods and changes in the diagnostic standard may have contributed to the increasing prevalence of congenital heart disease. The different patterns due to varying nutritional status, including but not limited to folate, among northern and southern China needs further study in the future.

This study was subject to some limitations. Due to the small selection area of a five mostly rural counties in Shanxi Province, the results were not generalizable to the province at large or to the country. The changes in policy may have affected different regions of the country differently and may have differing effects on urban populations.

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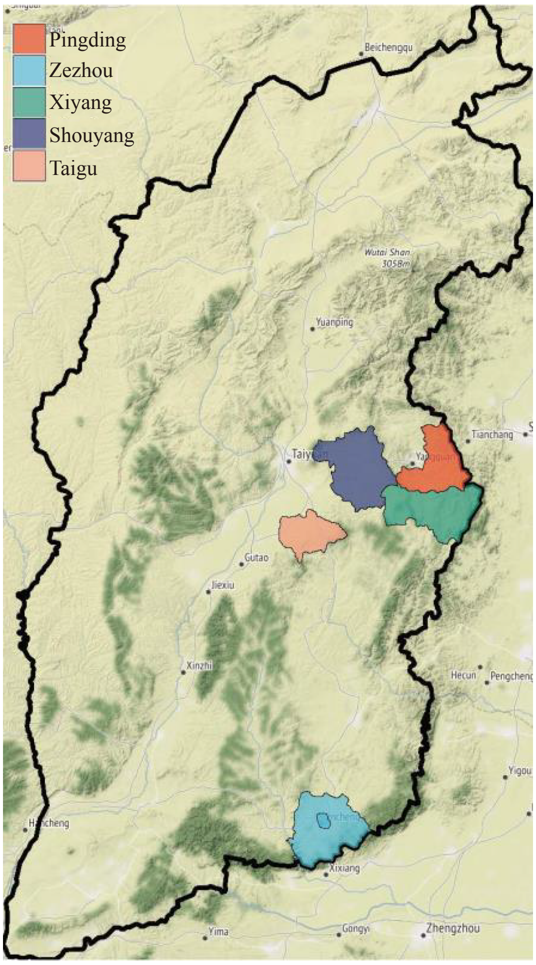
SUPPLEMENTARY TABLE S1. Classification (ICD-10 code) of selected types of birth defects in the surveillance system.

ICD-10 code	Classification	Birth defects
1. Q00–Q07	The nervous system	01 Anencephaly
		02 Spina bifida
		03 Encephalocele
		04 Congenital hydrocephalus
2. Q10–Q18	Eye, ear, face and neck	08 Deformity of external ear
3. Q20–Q28	The circulatory system	23 Congenital heart disease
4. Q35–Q37	Cleft lip and cleft palate	05 Cleft palate
		06 Cleft lip
		07 Cleft lip with cleft palate
5. Q38–Q45	The digestive system	09 Esophageal atresia or stenosis
		10 Anorectal atresia or stenosis (without anus)
6. Q50–Q56	Genital organs	11 Hypospadias
7. Q60–Q64	The urinary system	12 hydronephrosis
8. Q65–Q79	The musculoskeletal system	13 Clubfoot left and right
		14 Multiple fingers (toes)
		15 Combined fingers (toes)
		16 Limb reduction [including missing fingers (toes) and split hands (feet)]
		17 Congenital diaphragmatic hernia
		18 Omphalocele
		19 Congenital dislocation of hip joint
		20 Gastroschisis
9. Q80–Q89	Other congenital malformations	21 Fetal conjoined twins
		24 Others (state the name or detailed description of the disease)
10. Q90–Q99	Chromosomal abnormalities	22 Down syndrome (trisomy 21)



SUPPLEMENTARY FIGURE S1. The 5 counties of a population-based birth defect surveillance system in Shanxi Province,China, 2000−2019.

Preplanned Studies

The Utilization of Health Examination by Menopausal and Older Women — 6 Provinces, China, 2018

Bo Song[1]; Jiangli Di[1,#]; Gengli Zhao[2]; Yu Ma[1]; Linhong Wang[3,#]

Summary

What is already known about this topic?

Improving their utilization of health examination is important for improving the health of menopausal and older women.

What is added by this report?

Only 32.3% and 29.7% of women had been screened for cervical cancer and breast cancer, respectively. The overall utilization rate of health examination for menopausal and older women is low. The health examination services for menopausal and older women were utilized less in the western regions and in rural areas than in the eastern and central regions and in urban areas.

What are the implications for public health practice?

The imbalance of development is an important factor affecting the utilization of health examination for menopausal and older women. It is necessary to take effective measures to improve the level of service utilization in the western region and rural areas, in order to narrow the gap in health between different regions.

With the extension of human life expectancy and the intensification of the aging of the population, the number of menopausal and older women in China has increased sharply. According to the sixth census in 2010, the number of women aged 40–65 years old in China has reached 220 million (*1*). Menopause is a special period in a woman's life. With the gradual decline of ovarian function and the decline of hormone levels, menopausal women are prone to cardiovascular disease, diabetes, osteoporosis and other chronic diseases, which will affect their health and quality of life (*2*). Health examination is not only an important part of health care for menopausal and older women, but also an important means of detecting a variety of age related diseases in the early stages (*3*). In order to provide a scientific basis for targeted health care for older women and to promote the health of older women, a cross-sectional survey involving 5,049 women aged 50–70 years was conducted across eastern, central and western China. The main result of this study showed that the utilization rate of health examination for older women is low. The imbalance of development is an important factor affecting the utilization of health examination for menopausal and older women. The study was a cross-sectional survey in Jiangsu and Shandong, Hunan and Anhui, and Shaanxi and Sichuan provinces, which were selected to represent the three socio-economic regions of China: Eastern, Central and Western China. In each province one urban and one rural area was selected as investigation sites. Face-to-face interview questionnaires were completed by 5,049 women aged 50–70 years in the 6 provinces.

The average age of the respondents was 58.94±6.195 years. The main occupation of the cohort was farming, accounting for 55.2%, followed by retirees, accounting for 17.1%. Most of the participants (55.0%) had only primary school education or were illiterate, followed by those who had junior and senior high school education, accounting for 42.0%. The monthly income of the family was low — less than RMB 3,000 Yuan for 52.9%, followed by RMB 3,000–4,999 Yuan for 27.1%. The majority (89.9%) of the women were postmenopausal (Table 1).

Among the 5,049 women, 46.4% (95% CI: 45.0%–47.8%) of them reported never having undergone a regular physical examination (including examination of ultrasound, electrocardiogram, blood pressure, blood biochemistry, X-ray, bone mineral density, etc.) except for cervical cancer or breast cancer screening. The proportion in the western region (52.3%, 95% CI: 49.8%–54.8%) was higher than that in the eastern region (39.4%, 95% CI: 37.0%–41.8%) and the central region (47.8%, 95% CI: 45.4%–50.3%). There was significantly statistical difference among different regions (p<0.001). The proportion of women who had had a regular physical examination within one year in the eastern region (40.9%, 95% CI: 38.5%–43.3%) was significantly higher than that in the central and western regions (28.2%, 95% CI: 26.0%–30.4% and 28.2%, 95% CI: 26.0%–30.5%, respectively) (p<0.001). The proportion in rural areas (36.8%, 95% CI: 34.9%–38.7%) was significantly higher than that in urban areas (28.1%, 95% CI: 26.3%–30.0%) (p<0.001) (Table 2).

Of the 5,049 women, 64.2% (95% CI: 62.9%–65.6%) of them reported never having undergone breast or cervical cancer screening. The proportion of women who had never undergone breast or cervical cancer screening was highest in the western region (73.9%, 95% CI: 71.8%–76.0%), followed by the central region (60.5%, 95% CI: 58.1%–62.9%) and the eastern region (58.3%, 95% CI: 56.0%–60.7%) (p<0.001). Only 27.8% (95% CI: 26.6%–29.0%) of women reported having undergone both breast and cervical cancer screening. The proportion in the western region (14.7%, 95% CI: 13.0%–16.3%) was significantly lower than that in the central (35.5%, 95% CI: 33.2%–37.8%) and eastern regions (33.3%, 95% CI: 31.0%–35.5%) (p<0.001). The proportion in rural areas (26.5%, 95% CI: 24.8%–28.2%) was lower than that in urban areas (29.1%, 95% CI: 27.3%–30.9%) (p=0.015) (Table 2).

The proportion of women who had never undergone breast cancer screening (70.3%, 95% CI: 69.0%–71.6%) was higher than the proportion of women who had never undergone cervical cancer screening (67.7%, 95% CI: 66.4%–68.9%). The proportions of women in the western region who had never undergone cervical cancer screening (77.6%, 95% CI: 75.6%–79.6%) or breast cancer screening (83.8%, 95% CI: 82.0%–85.6%) were significantly higher than for those in the central (63.2%, 95% CI: 60.9%–65.5% and 62.5%, 95% CI: 60.2%–64.9%, respectively) and the eastern regions (62.3%, 95% CI: 60.0%–64.6% and 64.6%, 95% CI: 62.4%–66.9% respectively) (p<0.001). The proportion of women who had never been screened for cervical cancer in urban areas (69.6%, 95% CI: 67.8%–71.4%) was higher than that in rural areas (65.8%, 95% CI:

TABLE 1. Comparison of demographic characteristics of the respondents by region and area type — 6 provinces, China, 2018.

Demographic characteristic	Total n (%)	Region			Area type	
		Eastern n (%)	Central n (%)	Western n (%)	Urban n (%)	Rural n (%)
Age (years)						
50–55	1,949(38.6)	675(39.6)	669(40.1)	605(36.0)	915(36.3)	1,034(40.9)
56–60	968(19.2)	333(19.6)	328(19.7)	307(18.3)	502(19.9)	466(18.4)
61–65	1,140(22.6)	367(21.6)	367(22.0)	406(24.2)	612(24.3)	528(20.9)
≥66	992(19.6)	328(19.3)	303(18.2)	361(21.5)	494(19.6)	498(19.7)
Education degree						
Primary school education or illiterate	2,766(55.0)	1,094(64.3)	795(48.0)	877(52.5)	937(37.3)	1,829(72.7)
Junior and senior high school	2,109(42.0)	564(33.2)	789(47.7)	756(45.3)	1,425(56.8)	684(27.2)
College or above	151(3.0)	43(2.5)	71(4.3)	37(2.2)	147(5.9)	4(0.2)
Occupation						
Farmers	2,764(55.2)	898(53.1)	772(46.7)	1,094(65.9)	598(24.1)	2,166(86.0)
Retirees	856(17.1)	383(22.6)	238(14.4)	235(14.1)	627(25.2)	229(9.1)
Workers	470(9.4)	211(12.5)	152(9.2)	107(6.4)	424(17.1)	46(1.8)
Business and service staff	244(4.9)	68(4.0)	122(7.4)	54(3.3)	197(7.9)	47(1.9)
Professional and technical personnel	156(3.1)	46(2.7)	79(4.8)	31(1.9)	138(5.6)	18(0.7)
Others	515(10.3)	85(5.0)	290(17.5)	140(8.4)	502(20.2)	13(0.5)
Monthly income of the family (RMB)						
<3,000	2,644(52.9)	731(43.2)	744(44.8)	1,169(71.1)	1,062(42.7)	1,582(63.0)
3,000–4,999	1,355(27.1)	479(28.3)	537(32.3)	339(20.6)	768(30.9)	587(23.4)
5,000–7,999	586(11.7)	244(14.4)	250(15.1)	92(5.6)	379(15.2)	207(8.2)
≥8,000	412(8.2)	237(14.0)	130(7.8)	45(2.7)	277(11.1)	135(5.4)

63.9%–67.6%) (*p*=0.037). However, the proportion of women who had never had breast cancer screening in rural areas (72.9%, 95% CI: 71.1%–74.6%) was significantly higher than in urban areas (67.7%, 95% CI: 65.8%–69.5%) (*p*=0.001). (Table 2).

Of the reasons for not taking physical examination, absence of anybody to organize them accounted for the majority (52.9%, 95% CI: 50.8%–54.9%). The proportion of women in the western region reporting nobody to organize (57.9%, 95% CI: 54.6%–61.2%) was higher than the proportions in the eastern (47.6%, 95% CI: 43.7%–51.5%) and the central regions (51.7%, 95% CI: 48.2%–55.3%) (*p*<0.001). The other reasons included thinking it was not necessary (25.1 %, 95% CI: 23.4%–26.9%) and unwilling (18.5%, 95% CI: 16.9%–20.1%). The proportion of women who were unwilling in the eastern region (26.6%, 95% CI: 23.2%–30.0%) and rural areas (22.5%, 95% CI: 20.1%–25.0%) were higher than in the central (17.2%, 95% CI: 14.5%–19.8%) and the western regions (13.7%, 95% CI: 11.4%–16.0%), and in urban areas (14.6%, 95% CI: 12.6%–16.7%) (*p*<0.001) (Table 3).

Most of the women (53.7%, 95% CI: 51.9%–55.6%) were organized by village committees or community workers to participate in physical examination. Only 27.5% (95% CI: 25.8%–29.1%) of them went to hospitals for physical examination on their own initiative. The proportion of women organized by village committees or community workers in the eastern region (64.3%, 95% CI: 61.4%–67.2%) was significantly higher than that in the central (50.6%, 95% CI: 47.3%–53.9%) and the western regions (43.9%, 95% CI: 40.5%–47.2%) (*p*<0.001). The proportion of women going to hospitals on their own initiative in urban areas (35.9%, 95% CI: 33.3%–38.4%) was significantly higher than in the rural areas (19.0%, 95% CI: 16.9%–21.0%) (*p*<0.001). (Table 3).

DISCUSSION

The overall utilization rate of health examination by older women was low. Breast and cervical cancer screening and regular physical examination are one of the important elements of health care for menopausal and older women. However, this study found that the utilization of health examination services by menopausal and older women was low. Only 32.5% of women had received a regular physical examination within one year, which was lower than the overall result of the Fifth National Health Service Survey (43.3%) (*4*). Only 27.8% of women reported having been screened for both breast and cervical cancer in the past, and 32.3% and 29.7% of women had been screened for cervical cancer or breast cancer, respectively. The breast and cervical cancer screening rates were slightly higher than the results of the national sample survey in 2013 (22.5% and 26.7%, respectively) (*5*). However, the screening rate for breast (16.4%) and cervical cancer (15.2%) within one year were lower than those of the Fifth National Health Service Survey (26.5% and 24.3%, respectively) (*4*).

The village committee and community workers should play a greater role in organizing health examination to increase the participation rate. This study showed that a few (only 27.5%) menopausal and older women took the initiative to obtain health examination services. Many studies have shown that the lack of awareness was a major obstacle for women to participate in the examination. Women with older age, low education level, underemployment, low family income and lack of health insurance are less likely to take the initiative to seek a health examination (*6*–*7*). In this study, the most common reasons for not having a regular physical examination were the lack of organization, and feeling it was unnecessary or being unwilling. It reminds us that in order to enhance the service utilization of menopausal and older women and improve the participation rate, it is critical to encourage the village committee and community workers to play a role in organizing health examination, to carry out targeted health education for different groups of women.

The imbalance of regional economic development is an important factor affecting the utilization of services for menopausal and older women. Many studies have shown that the imbalance of regional economic development is an important factor restricting the utilization of services by menopausal and older women (*5*,*8*). The results of this study showed that menopausal and older women in the western region and in rural areas were less likely to utilize the health examination services than those in the eastern and central regions and in urban areas. This pattern may be related to the health awareness, education level, economic conditions of women and level of development of the health system (*7*). Therefore, we need to take effective measures to effectively improve the level of service utilization in the western region and rural areas, in order to narrow the gap in health between different age groups of women.

TABLE 2. Comparison of health examination among women aged 50-70 years by region and area type — 6 provinces, China, 2018.

Health examination	Total n (%, 95% CI)	Region					Area type			
		Eastern n (%, 95% CI)	Central n (%, 95% CI)	Western n (%, 95% CI)	χ^2	*P*	Urban n (%, 95% CI)	Rural n (%, 95% CI)	χ^2	*P*
Regular physical examination										
Never had	2,245 (46.4, 45.0−47.8)	648 (39.4, 37.0−41.8)	771 (47.8, 45.4−50.3)	826 (52.3, 49.8−54.8)	33.299	<0.001	1,103 (46.1, 44.1−48.1)	1,142 (46.7, 44.7−48.7)	1.355	0.244
Ever had within 1 year	1573 (32.5, 31.2−33.8)	673 (40.9, 38.5−43.3)	454 (28.2, 26.0−30.4)	446 (28.2, 26.0−30.5)	94.934	<0.001	673 (28.1, 26.3−30.0)	900 (36.8, 34.9−38.7)	65.517	<0.001
Ever had within 1–3 years	945 (19.5, 18.4−20.7)	303 (18.4, 16.5−20.3)	366 (22.7, 20.7−24.8)	276 (17.5, 15.6−19.4)	20.314	<0.001	569 (23.8, 22.1−25.5)	376 (15.4, 13.9−16.8)	78.834	<0.001
Ever had >3 years	73 (1.5, 1.2−1.9)	21 (1.3, 0.7−1.8)	21 (1.3, 0.7−1.9)	31 (2.0, 1.3−2.6)	3.976	0.137	46 (1.9, 1.4−2.5)	27 (1.1, 0.7−1.5)	9.890	0.002
Breast and cervical cancer screening										
Never had	3,230 (64.2, 62.9−65.6)	991 (58.3, 56.0−60.7)	1,003 (60.5, 58.1−62.9)	1,236 (73.9, 71.8−76.0)	53.154	<0.001	1,618 (64.4, 62.5−66.3)	1,612 (64.0, 62.2−65.9)	0.022	0.881
Had screening for one cancer	401 (8.0, 7.2−8.7)	143 (8.4, 7.1−9.7)	67 (4.0, 3.1−5.0)	191 (11.4, 9.9−12.9)	87.741	<0.001	163 (6.5, 5.5−7.5)	238 (9.5, 8.3−10.6)	28.055	<0.001
Had screening for both cancers	1,398 (27.8, 26.6−29.0)	565 (33.3, 31.0−35.5)	588 (35.5, 33.2−37.8)	245 (14.7, 13.0−16.3)	236.672	<0.001	731 (29.1, 27.3−30.9)	667 (26.5, 24.8−28.2)	5.860	0.015
Cervical cancer screening										
Never had	3,388 (67.7, 66.4−68.9)	1,056 (62.3, 60.0−64.6)	1,044 (63.2, 60.9−65.5)	1,288 (77.6, 75.6−79.6)	50.253	<0.001	1,737 (69.6, 67.8−71.4)	1,651 (65.8, 63.9−67.6)	4.366	0.037
Ever had within 1 year	822 (16.4, 15.4−17.4)	365 (21.5, 19.6−23.5)	284 (17.2, 15.4−19.0)	172 (10.4, 8.9−11.8)	102.898	<0.001	344 (13.8, 12.4−15.1)	478 (19.0, 17.5−20.6)	43.689	<0.001
Ever had within 1–3 years	516 (10.3, 9.5−11.1)	168 (9.9, 8.5−11.3)	220 (13.3, 11.7−15.0)	128 (7.7, 6.4−9.0)	37.116	<0.001	268 (10.7, 9.5−11.9)	248 (9.9, 8.7−11.0)	1.550	0.213
Ever had >3 years	282 (5.6, 5.0−6.3)	106 (6.3, 5.1−7.4)	104 (6.3, 5.1−7.5)	72 (4.3, 3.4−5.3)	11.617	0.003	148 (5.9, 5.0−6.9)	134 (5.3, 4.5−6.2)	1.390	0.238
Breast cancer screening										
Never had	3,523 (70.3, 69.0−71.6)	1,097 (64.6, 62.4−66.9)	1,034 (62.5, 60.2−64.9)	1,392 (83.8, 82.0−85.6)	93.312	<0.001	1,690 (67.7, 65.8−69.5)	1,833 (72.9, 71.1−74.6)	11.609	0.001
Ever had within 1 year	760 (15.2, 14.2−16.2)	325 (19.2, 17.3−21.0)	307 (18.6, 16.7−20.4)	128 (7.7, 6.4−9.0)	140.475	<0.001	396 (15.9, 14.4−17.3)	364 (14.5, 13.1−15.8)	2.695	0.101
Ever had within 1–3 years	444 (8.9, 8.1−9.6)	158 (9.3, 7.9−10.7)	210 (12.7, 11.1−14.3)	76 (4.6, 3.6−5.6)	92.514	<0.001	253 (10.1, 8.9−11.3)	191 (7.6, 6.6−8.6)	17.315	<0.001
Ever had >3 years	285 (5.7, 5.0−6.3)	117 (6.9, 5.7−8.1)	103 (6.2, 5.1−7.4)	65 (3.9, 3.0−4.8)	22.863	<0.001	158 (6.3, 5.4−7.3)	127 (5.0, 4.2−5.9)	6.744	0.009

TABLE 3. Comparison of participation status of the regular physical examination among women aged 50–70 years by region and area type — 6 provinces, China, 2018.

Item	Total n(%, 95% CI)	Region					Area type			
		Eastern n (%, 95% CI)	Central n (%, 95% CI)	Western n (%, 95% CI)	χ^2	*P*	Urban n (%, 95% CI)	Rural n (%, 95% CI)	χ^2	*P*
Reasons for not participating in physical examination										
Nobody to organize	1,201(52.9, 50.8−54.9)	306(47.6, 43.7−51.5)	401(51.7, 48.2−55.3)	494(57.9, 54.6−61.2)	66.217	<0.001	683(59.4, 56.6−62.3)	518(46.2, 43.2−49.1)	45.337	<0.001
Thinking it was not necessary	571(25.1, 23.4−26.9)	136(21.2, 18.0−24.3)	226(29.2, 26.0−32.4)	209(24.5, 21.6−27.4)	36.037	<0.001	260(22.6, 20.2−25.1)	311(27.7, 25.1−30.3)	9.110	0.003
Unwilling	421(18.5, 16.9−20.1)	171(26.6, 23.2−30.0)	133(17.2, 14.5−19.8)	117(13.7, 11.4−16.0)	16.447	<0.001	168(14.6, 12.6−16.7)	253(22.5, 20.1−25.0)	34.323	<0.001
Other	78(3.4, 2.7−4.2)	30(4.7, 3.0−6.3)	15(1.9, 1.0−2.9)	33(3.9, 2.6−5.2)	10.731	0.005	38(3.3, 2.3−4.3)	40(3.6, 2.5−4.7)	0.103	0.749
Forms of participating										
On their own initiative	759(27.5, 25.8−29.1)	169(16.2, 13.9−18.4)	276(31.4, 28.3−34.5)	314(37.4, 34.1−40.7)	67.032	<0.001	499(35.9, 33.3−38.4)	260(19.0, 16.9−21.0)	150.516	<0.001
Organized by work institution	363(13.1, 11.9−14.4)	139(13.3, 11.3−15.4)	137(15.6) (13.2−18.0)	87(10.4, 8.3−12.4)	21.521	<0.001	312(22.4, 20.2−24.6)	51(3.7, 2.7−4.7)	375.322	<0.001
Organized by village committees or community worker	1,484(53.7, 51.9−55.6)	671(64.3, 61.4−67.2)	445(50.6, 47.3−53.9)	368(43.9, 40.5−47.2)	150.418	<0.001	535(38.5, 35.9−41.0)	949(69.2, 66.8−71.7)	230.992	<0.001
Others (public welfare projects, et al.)	156 (5.6, 4.8−6.5)	65 (6.2, 4.8−7.7)	21 (2.4, 1.4−3.4)	70 (8.3, 6.5−10.2)	41.942	<0.001	45 (3.2, 2.3−4.2)	111 (8.1, 6.7−9.5)	55.846	<0.001

There were some limitations in this study. Firstly, self-reported information might be subjected to biases. Secondly, the study used convenience sampling, and data were collected in 12 counties/districts in 6 provinces, so the results might not be representative of the regional and national levels.

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Profiles

Guizhen Wu, China CDC's Chief Expert of Biosafety

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Guizhen Wu, China CDC's Chief Expert of Biosafety, has been working for nearly four decades in the field of public health emergencies and laboratory biosafety. Wu is the major planner and promoter of the laboratory biosafety management system in China. In 2018 as the Chairwoman, Wu hosted the 13th Asia-Pacific Biosafety Association (A-PBA) Biosafety Conference held in Beijing, which was the first international biosafety conference held in China. She was elected as the President of A-PBA on September 19, 2019.

Wu completed her undergraduate study at School of Public Health of Beijing Medical University in 1983. After graduation, she was engaged in the prevention and control of infectious diseases and the disposal of public health emergencies. Wu also studied from 1999 to 2000 as a senior visiting scholar at the Harvard School of Public Health (now the Harvard T.H. Chan School of Public Health). Wu obtained her Master of Laws at China University of Political Science and Law in 2003.

Wu is one of the pioneer planners and promoters in the establishment of a laboratory biosafety management system in China. After an incident of laboratory exposure of severe acute respiratory syndrome coronavirus (SARS-CoV) in 2004, she was selected to set up the first Office of Laboratory Management of China CDC and the first professional management team in the field of laboratory biosafety (LB) in China. With her pioneering efforts, a comprehensive, centralized, standardized, and scientific LB management system was established in China CDC and followed by establishment at all levels of CDCs. Since the promulgation and implementation of the Management Regulations on LB of Pathogenic Microorganisms by the State Council of China (Order No. 424 of the State Council), Wu and her team participated in drafting and revising more than 10 relevant laws, regulations, and standards and, as Editor-in-Chief, published more than 10 biosafety-related monographs including the recently published *Laboratory Biosafety Guide*.

Wu proposed a "pyramid-type" multilayer management structure of LB, by which a six-level LB management framework was built including biosafety laboratories, institutions with biosafety laboratories, relevant authorities, and regional, provincial, and national-level health administrative agencies. A laboratory information management system, including quality management and information storage, was integrated into laboratory biosafety for the first time. With her effort, the management, conservation, and utilization of biological resources have also been promoted to a national priority and the Preservation Centre for Bacteria (Virus) Species of China CDC was approved in 2017. Wu led the training and development of the first LB professional teams in China, and Wu has also been involved in guiding the construction and certification of the first batch of and subsequent BSL-3 laboratories at different levels of CDCs in China.

Wu took part in the emergency disposal of emerging infectious diseases, including the SARS epidemic, human infections of swine streptococcus, pandemic H1N1 influenza, the H7N9 avian influenza epidemic, and imported cases of Middle East respiratory syndrome (MERS), Zika virus disease, yellow fever, and Rift Valley fever, etc. During the Ebola outbreak in West Africa in 2014, Wu organized support for the mobile BSL-3 laboratory and the subsequent first fixed BSL-3 laboratory aided by the National Institute for Viral Disease Control and Prevention (IVDC) of China CDC in Sierra Leone, Africa, and tested tens of thousands of clinical samples, which advanced the infectious disease surveillance system of Sierra Leone.

To respond promptly to the initial outbreak of coronavirus disease 2019 (COVID-19) in late December, 2019, Wu led the specialists in IVDC to develop diagnostic reagents for the first time, sequence the virus genome within 24 hours, and successfully isolate the virus in 5 days. Wu successfully led the development of a safe and effective COVID-19 vaccine (still in Phase 3 clinical trials), with an estimated annual output of more than 220 million doses/year. These four major achievements have been recognized as China's major contributions to the global efforts against the COVID-19 pandemic. At the critical moment of the epidemic, she was always in the front lines of the response as she led the national team to the field of Wuhan first, to Suifenhe, Harbin, and Shulan, and then back to Beijing's Xinfadi Wholesale Market. With her outstanding performance in response to COVID-19, Wu was recently recognized and awarded by the State Council of China.

As a consultant, Wu provides an expert's perspectives for the Chinese national government. She is the key expert group leader of the National Key R&D Program of China "Biosafety key technology research and development"; Deputy Director of the Biosafety Assessment Expert Committee of Pathogenic Microorganism Laboratory of the National Health Commission (NHC); the Chairwoman of the Public Health Committee of China Women Medical Doctor Association; the Chairwoman of the Management and Utilization of Biological Resources of the Chinese Preventive Medicine Association; a national "March 8 Red-Banner Holders"; etc.

Wu was rewarded the Special Government Allowance from the State Council of China and awarded the Outstanding Young and Middle-Aged Expert by the Ministry of Health (now the NHC) of China. She has also won the National Prize for Scientific and Technological Progress (Special Class and First-Class) and the First-Class Award of Science and Technology in Chinese Medicine.

As China CDC's Chief Expert of Biosafety, Wu collaborates with the World Health Organization (WHO), European Biosafety Association (EBSA), and American Biological Safety Association International (ABSA). She continues to play a crucial role in guiding China's biosafety development and safeguarding the country in response to emerging and reemerging infectious diseases. As the first Editor-in-Chief, Wu initiated a scientific journal in English, namely *Biosafety and Health* in 2019, which periodically published the academic findings in the field of biosafety.

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