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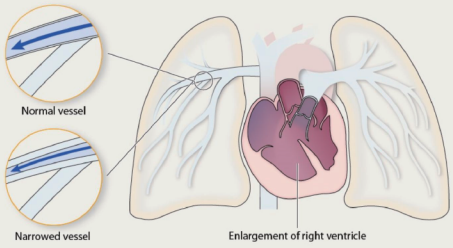
中国疾病预防控制中心周报

Pulmonary Heart Disease

Chronic obstructive pulmonary disease is the primary cause for pulmonary heart disease



Pulmonary heart disease in China remains a significant health concern that warrants further attention with the high prevalence of chronic obstructive pulmonary disease and the increasing rate of population aging.

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Cover Image: adapted from the US Centers for Disease Control and Prevention, https://www.cdc.gov/heartdisease/pulmonary_hypertension.htm#print.

Preplanned Studies

Effects of Short Interpregnancy Intervals on Adverse Pregnancy Outcomes — Haidian District, Beijing Municipality, China, 2017–2019

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Summary

What is already known about this topic?

Interpregnancy intervals (IPIs) that are either excessively long or short have been linked with an elevated risk of adverse perinatal outcomes. Presently, no pertinent guidelines have been established in China to provide clear direction with regard to optimal IPI.

What is added by this report?

A brief interpregnancy interval may elevate the risk of miscarriage, postpartum hemorrhage, and fetal distress among expectant women.

What are the implications for public health practice?

These results could inform prenatal consultations, guiding pregnant women towards an ideal interpregnancy interval of no less than 24 months.

Research has demonstrated that interpregnancy intervals (IPIs) that are notably short or prolonged could escalate the probability of adverse perinatal outcomes (*1*–*2*). Particularly, short IPIs (SIPIs) may dramatically amplify the risk of negative pregnancy results (*3*) and potentially bring about temporary or enduring complications for the fetus (*4*). This prospective cohort study aimed to examine the pregnancy outcomes amongst various IPI groups of expectant mothers in Beijing's Haidian District, along with the effects of SIPIs on adverse pregnancy outcomes. These include gestational diabetes mellitus, gestational hypertension, preeclampsia, gestational metabolic syndrome, preterm birth, low birth weight, small size for gestational age, miscarriage, postpartum hemorrhage, fetal distress, and premature membrane rupture. Its ultimate goal was to equip clinicians with empirical data for counseling women on optimal pregnancy spacing. The study is comprised of 1,185 women who had registered a file with Beijing Haidian Maternal and Child Health Hospital and volunteered to contribute to a pregnancy cohort. Our findings revealed that a SIPI was a significant predictor for abortion, postpartum hemorrhage, and fetal distress. It is thus advised to enhance health education among women of childbearing ages, to avert excessively brief IPIs and thereby minimize adverse pregnancy outcomes.

With the inauguration of the universal two-child policy in 2016, followed by the introduction of the three-child policy in 2021, China has witnessed a substantial increase in the number of multiparous women. Consequently, an escalating number of couples are having more than one child, drawing attention to the significance of intervals between pregnancies. Recognized as a potentially modifiable risk factor with implications for perinatal and neonatal outcomes, IPI holds immense importance for both maternal and fetal health. To facilitate superior maternal healthcare and mitigate the incidence of undesirable maternal and fetal outcomes during a subsequent pregnancy, it is imperative to provide appropriate recommendations for the optimal duration of interval before a second pregnancy among women of reproductive age.

This prospective cohort study engaged 3,988 pregnant females at or earlier than 20 weeks of gestation. The engagement took place at Beijing Haidian Maternal and Child Health Hospital between October 2017 and November 2019. After excluding participants with first-time pregnancies, twin or multiple pregnancies, and those lacking information on gravidity or IPI, the final subject group consisted of 1,185 individuals (Supplementary Figure S1, available in https://weekly.chinacdc.cn/). Key demographic characteristics, including maternal age, height, and pre-pregnancy weight, along with pregnancy-related details such as education, occupation, gravidity, parity, accidental pregnancy, contraceptive use, and a history of adverse pregnancy, were gathered through in-person administration of questionnaires. Pregnancy outcomes and associated complications were sourced directly

from the hospital case database. All the participants provided consent by signing an informed consent form. The study design was authorized by the pertinent ethics review committee.

In this study, IPI was considered the duration between the conclusion of the preceding delivery — encompassing live births, miscarriages, stillbirths, and abortions — and the start of the subsequent pregnancy. Guidelines from the World Health Organization (WHO) suggest a wait time of at least 24 months from a live birth before embarking on a subsequent pregnancy (*5*). Adhering to these recommendations, subjects were divided into three categories: very short IPI (VSIPI, <12 months) (*6*–*7*), short IPI (SIPI, 12–23.9 months), and normal IPI (NIPI, ≥24 months). The parallel double entry of the survey data was performed using EpiData software (version 3.1, EpiData Association, Odense, Denmark). IBM SPSS (version 26.0; IBM Corp., Armonk, NY, USA) was employed for statistical evaluations. Categorical variables were represented in terms of count (*n*) and percentage (%). A comparison of the risk for negative pregnancy outcomes among different groups was facilitated through Pearson's χ^2 test. Post adjustments for maternal age, education, income, pre-pregnancy body mass index (BMI), adverse maternal history, among other potential confounders, the association between IPI and unfavorable pregnancy outcomes was analyzed via multinomial logistic regression. The results are presented as odds ratios (*OR*s) alongside 95% confidence intervals (*CI*s). A *P*-value less than 0.05 was regarded as indicative of statistical significance.

Table 1 outlines the sociodemographic and maternal attributes of the research subjects. The age range of the participants was from 21–47, with an average age of 35.1±4.1, and they were on average at 11.2±2.2 weeks of gestation when included in the study. Of the 1,185 subjects, 188 (15.9%) had a VSIPI, 217 (18.3%) had a SIPI, while the remaining 780 (65.8%) had an NIPI. The educational background of the participants was predominantly high, with the majority employed as educators, healthcare professionals, or government and corporate workers. Hence, they are broadly representative of high knowledge sectors across the country.

Table 2 illustrates that the prevalence of PTB, LBW, SGA, and PROM in the NIPI group was inferior compared to those in the VSIPI and SIPI groups; however, this discrepancy failed to have statistical significance. In contrast, a significant variation was noted in the incidence of complications such as gestational hypertension, miscarriage, postpartum hemorrhage, and fetal distress across the three subgroups of pregnant women.

Table 3 explicates the impact of VSIPI and SIPI on GHTN, miscarriage, postpartum hemorrhage, and fetal distress. Despite SIPI being identified as a risk factor for miscarriage and fetal distress, the difference lacked statistical significance. A marked rise in the risk for all adverse pregnancy outcomes was observed in the VSIPI group compared to the NIPI group, encompassing miscarriage (*OR*: 13.388, 95% *CI*: 4.421–40.537), postpartum hemorrhage (*OR*: 1.653, 95% *CI*: 1.077–2.535), and fetal distress (*OR*: 1.523, 95% *CI*: 1.031–2.250). However, the odds for gestational hypertension were reduced in the VSIPI group (*OR*: 0.310, 95% *CI*: 0.117–0.821) compared to the NIPI group. Thus, it can be concluded that an excessively brief IPI serves as a risk factor for miscarriage, postpartum hemorrhage, and fetal distress.

DISCUSSION

The present study found that 34.18% of pregnant women in Haidian District had an IPI shorter than the WHO recommended two years. This constitutes approximately one-third of the study's participants. These percentages are similar to the 36.2% of the pregnant women with SIPIs in a California birth cohort, yet lower than Ohio's reported 63.49%. The findings indicate that an SIPI may significantly heighten the risk of maternal miscarriage, particularly if the interval is a very short interpregnancy interval (VSIPI ≤ 12 months). Consequently, this can substantially increase the risk for undesirable pregnancy outcomes and complications such as postpartum hemorrhage and fetal distress. These results parallel the findings of a previous study, which reported a heightened risk of premature rupture of membranes (*OR*: 1.69, 95% *CI*: 1.28–2.39) and miscarriage in pregnant women with an IPI less than six months (*8*). A substantial birth cohort study conducted in California showed that pregnant women with a VSIPI (i.e., less than one year after a live birth) have significantly elevated risk for postpartum hemorrhage (*OR*: 1.71, 95% *CI*: 1.65–1.78) (*9*).

The primary strength of this prospective cohort study lies in its accurate depiction of the IPIs and fundamental circumstances of pregnant women in Beijing's Haidian District. Notably, it investigates the impact of various degrees of SIPI on negative

TABLE 1. Sociodemographic and maternal characteristics of pregnant women in Haidian District, 2017–2019.*

Characteristics	VSIPI *n* (%)	SIPI *n* (%)	NIPI *n* (%)	χ^2	*P*†
n	188	217	780		
Age group (years)				28.786	<0.001
<30	26 (13.9)	18 (8.4)	50 (6.4)		
30–34	95 (50.5)	110 (51.1)	317 (40.8)		
≥35	67 (35.6)	87 (40.5)	410 (52.8)		
Education§				9.965	0.041
Primary	59 (31.6)	57 (26.3)	272 (34.9)		
Secondary	88 (47.0)	94 (43.3)	336 (43.1)		
Higher	40 (21.4)	66 (30.4)	172 (22.0)		
Ethnic				1.114	0.573
Han ethnicity	174 (92.6)	202 (93.1)	736 (94.4)		
Ethnic minority	14 (7.4)	15 (6.9)	44 (5.6)		
Occupation				4.497	0.343
Farmer, worker and server	44 (23.8)	48 (22.3)	220 (28.6)		
Institution staff	99 (53.5)	120 (55.8)	389 (50.7)		
Other	42 (22.7)	47 (21.9)	159 (20.7)		
Per capita household income in Chinese Yuan (CNY)				15.378	0.018
<50,000	31 (18.2)	26 (13.6)	164 (24.2)		
50,000–99,999	51 (30.1)	65 (34.0)	229 (33.7)		
100,000–149,999	48 (28.2)	61 (31.9)	163 (24.0)		
≥150,000	40 (23.5)	39 (20.5)	123 (18.1)		
Prepregnancy BMI (kg/m^2)				1.711	0.789
Underweight (<18.5)	22 (12.2)	25 (12.0)	80 (10.7)		
Normal (18.5–23.9)	124 (68.9)	135 (64.6)	505 (67.4)		
Overweight (≥24)	34 (18.9)	49 (23.4)	164 (21.9)		
Gravidity				0.834	0.659
2	104 (55.3)	120 (55.3)	453 (58.1)		
≥3	84 (44.7)	97 (44.7)	327 (41.9)		
Parity				104.410	<0.001
Primipara	144 (76.6)	134 (61.8)	302 (38.7)		
Multipara	44 (23.4)	83 (38.2)	478 (61.3)		
Accidental pregnancy				10.016	0.007
No	131 (70.1)	151 (71.2)	470 (61.4)		
Yes	56 (29.9)	61 (28.8)	296 (38.6)		
Maternal contraceptive use				5.664	0.059
No	174 (93.0)	209 (96.3)	753 (96.8)		
Yes	13 (7.0)	8 (3.7)	25 (3.2)		
Gestational weight gain >18 kg				0.557	0.757
No	155 (83.8)	177 (83.9)	654 (85.5)		
Yes	30 (16.2)	34 (16.1)	111 (14.5)		
Adverse pregnancy history				10.346	0.006
No	149 (79.3)	175 (80.6)	679 (87.1)		
Yes	39 (20.7)	42 (19.4)	101 (12.9)		
Last pregnancy outcome				169.996	<0.001
Vaginal delivery	11 (6.0)	28 (13.0)	260 (33.7)		
Cesarean section	9 (4.9)	12 (5.5)	158 (20.5)		
Spontaneous or induced abortion	163 (89.1)	176 (81.5)	353 (45.8)		

Abbreviation: VSIPI=very short interpregnancy interval (<12 months); SIPI=short IPI (12–23.9 months); NIPI=normal IPI (≥24 months); BMI=body mass index.

* Owing to unavailable information, the sum of demographic characteristics at each level may deviate from the number of cases within each category.

† Pearson's chi-square test.

§ Education: Primary (college degree or below), secondary (undergraduate degree), or higher (master's degree or above).

TABLE 2. Univariate analysis of the interpregnancy interval and adverse pregnancy outcomes* among pregnant women in Haidian District, 2017–2019.

Pregnancy outcome/complication	VSIPI *n* (%)	SIPI *n* (%)	NIPI *n* (%)	χ^2	*P*
GDM				1.493	0.474
No	126 (73.7)	153 (78.9)	543 (77.4)		
Yes	45 (26.3)	41 (21.1)	159 (22.6)		
GHTN				7.475	0.024
No	163 (96.4)	187 (94.0)	639 (90.6)		
Yes	6 (3.6)	12 (6.0)	66 (9.4)		
PE				1.435	0.488
No	181 (96.3)	210 (96.8)	762 (97.7)		
Yes	7 (3.7)	7 (3.2)	18 (2.3)		
GMS				1.238	0.538
No	158 (84.0)	190 (87.6)	677 (86.8)		
Yes	30 (16.0)	27 (12.4)	103 (13.2)		
Gestational metabolic disorders				1.845	0.397
No	89 (47.3)	112 (51.6)	362 (46.4)		
Yes	99 (52.7)	105 (48.4)	418 (53.6)		
PTB				0.610	0.737
No	180 (95.7)	206 (94.9)	736 (94.4)		
Yes	8 (4.3)	11 (5.1)	44 (5.6)		
LBW				0.123	0.941
No	182 (96.8)	209 (96.3)	751 (96.3)		
Yes	6 (3.2)	8 (3.7)	29 (3.7)		
SGA				1.615	0.446
No	180 (95.7)	211 (97.2)	743 (95.3)		
Yes	8 (4.3)	6 (2.8)	37 (4.7)		
Miscarriage				60.534	<0.001*
No	167 (88.8)	211 (97.2)	774 (99.2)		
Yes	21 (11.2)	6 (2.8)	6 (0.8)		
Postpartum hemorrhage				7.126	0.028
No	145 (77.1)	185 (85.3)	662 (84.9)		
Yes	43 (22.9)	32 (14.7)	118 (15.1)		
Fetal distress				10.571	0.005
No	126 (67.0)	153 (70.5)	603 (77.3)		
Yes	62 (33.0)	64 (29.5)	177 (22.7)		
PROM				1.639	0.441
No	138 (73.4)	171 (78.8)	597 (76.5)		
Yes	50 (26.6)	46 (21.2)	185 (23.5)		

Abbreviation: VSIPI=very short interpregnancy interval (<12 months); SIPI=short IPI (12–23.9 months); NIPI=normal IPI (≥24 months); GDM=gestational diabetes mellitus; GHTN=gestational hypertension; PE=preeclampsia; GMS=gestational metabolic syndrome; PTB=preterm birth; LBW=low birth weight; SGA=small for gestational age; PROM=premature rupture of membranes.

* The research encompasses various adverse pregnancy outcomes including GDM, GHTN, PE, GMS, PTB, LBW, SGA, miscarriage, postpartum hemorrhage, fetal distress, and PROM.

pregnancy outcomes. This diverges from earlier IPI-related studies, where the focus was largely on maternal pregnancy complications and postpartum issues. Conversely, prior research chiefly centered on poor infant birth outcomes such as low birth weight, premature birth, and small size for gestational age,

TABLE 3. Association between adverse pregnancy outcomes* and interpregnancy intervals among pregnant women in Haidian District, 2017–2019.

Adverse pregnancy outcomes	SIPI			VSIPI		
	aOR†	95% *CI*	*P*	*aOR*†	95% *CI*	*P*
GHTN	0.618	0.286–1.335	0.221	0.310	0.117–0.821	0.018
Miscarriage	2.481	0.663–9.280	0.177	13.388	4.421–40.537	<0.001
Postpartum hemorrhage	0.988	0.624–1.564	0.959	1.653	1.077–2.535	0.021
Fetal distress	1.446	0.993–2.106	0.055	1.523	1.031–2.250	0.035

Abbreviation: VSIPI=very short interpregnancy interval (<12 months); SIPI=short IPI (12–23.9 months); a*OR*=adjusted odds ratio; *CI*=confidence interval; GHTN=gestational hypertension.

* Adverse outcomes of pregnancy include GHTN, miscarriage, postpartum hemorrhage, and fetal distress.

† This analysis has been adjusted for factors including maternal age, education level, per capita income of the household, pre-pregnancy BMI, parity, occurrences of accidental pregnancy, history of maternal adversity, and outcomes of the most recent pregnancy.

among others. According to a previous study (*10*), older women with an SIPI were more prone to very preterm births and bearing babies with extremely low birth weights. Another study (*11*) echoed these results, highlighting a significantly increased risk for preterm birth among women with an SIPI. Our study did identify variations in low birth weight (LBW), preterm birth (PTB), and small for gestational age (SGA) incidence among the IPI groups. However, these findings were not statistically significant, suggesting that further research may be necessary to understand this association.

The precise mechanism that explains the role of IPI length in the emergence of adverse perinatal outcomes remains undetermined. Numerous researchers have put forth hypotheses to elucidate this phenomenon (*12*). The nutritional deficiency hypothesis is widely recognized and suggests that nutrients in a pregnant woman facing depletion are predominantly distributed to the mother, thereby compromising the fetus (*13*). An excessively short IPI means the mother has inadequate recovery time after enduring the stress of the initial pregnancy and subsequent postpartum lactation. Her nutritional reserves might not have fully replenished to the optimum level, resulting in a deficiency of critical nutrients potentially leading to unfavorable pregnancy outcomes. Additionally, a plausible explanation for prolonged intervals leading to negative outcomes is the physiological regression hypothesis, suggesting that pregnancy enhances a mother's capacities that support growth (including numerous changes in the physiological and anatomical reproductive system). If another child is not conceived for an extended duration, these capacities might gradually regress post birth, leading to a woman's physiological characteristics becoming similar to those of first-time mothers. Past investigations have identified an excessively long IPI as a risk factor for gestational hypertension (GHTN) among other adverse pregnancy outcomes. This may elucidate our findings indicating that an excessively short IPI may act as a protective factor against GHTN.

This study has several limitations that stem primarily from the numerous and intricate confounding factors that influence the interval of pregnancy, such as gestational weight gain. Some confounding factors result from reproductive behaviors and histories, while others are impacted by incalculable cultural and societal norms that offer challenges for precise control measures during research; these factors were not effectively controlled in our study. Moreover, the use of self-reported questionnaires could lead to information bias.

Furthermore, given the adjustments to China's birth policy, a substantial number of women giving birth multiple times might have an IPI exceeding ten years, equating to an IPI of 60 months or more in our definition. However, the longest interval range our questionnaire provided was an IPI of greater than two years, thereby lumping these women with all those whose pregnancy intervals were over two years. This methodology may inadvertently fold women with longer intervals into the NIPI population, potentially downplaying the negative effects of significant SIPI and VSIPI on GDM, PTB, SGA, LBW, and other outcomes.

This limitation may have resulted in an underestimation of the harm associated with an SIPI and a VSIPI, further emphasizing the necessity for meticulous control of IPI. A larger sample size and more precise grouping of IPIs could potentially reveal statistically significant differences.

In conclusion, SIPIs are positively correlated with multiple adverse pregnancy outcomes and maternal and infant complications. Therefore, it is imperative to strengthen health education regarding optimal IPIs

within the target population. By promoting the use of postpartum contraception, we can significantly mitigate potential maternal and fetal health issues caused by SIPI.

Conflicts of interest: No conflicts of interest.

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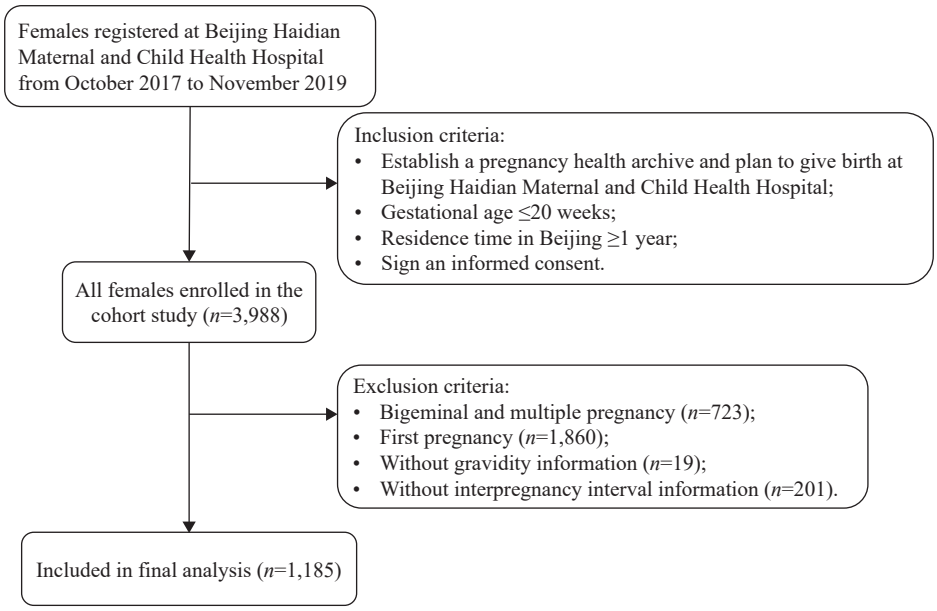
SUPPLEMENTARY MATERIAL



SUPPLEMENTARY FIGURE S1. Flowchart representing the participation of individuals in the study.

Preplanned Studies

Unhealthy Eating Behaviors During Pregnancy and Gestational Weight Gain — Huai'an City, Jiangsu Province, China, 2020–2021

Zifan Zhang[1,&]; Weijie Ding[2,&]; Hui Wang[1,2]; Yangyang Cheng[1]; Yue Zhang[1]; Xiaoqin Zhu[2,#]; Xiaolin Xu[1,3,#]

Summary

What is already known about this topic?

Maintaining a healthy diet and appropriate weight during pregnancy is crucial for both the expectant mother and the fetus. Unhealthy eating behaviors (UEBs) such as eating out frequently are becoming increasingly prevalent across the globe. However, there is a dearth of research investigating the relationship between UEBs and gestational weight gain (GWG) specifically in the context of Chinese women.

What is added by this report?

The study revealed that a majority of pregnant women reported experiencing one or more UEBs such as eating fast, eating three meals irregularly, eating away from home, and skipping breakfast. A positive association was also observed between the number of UEBs and elevated odds of experiencing excessive GWG.

What are the implications for public health practice?

The uptake of emerging UEBs is prevalent among pregnant women in China. It is recommended that healthy eating behavior become the focal point of gestational weight management in clinical practice. Moreover, preconception care should take into account customized health education and promotion programs.

Both excessive and inadequate gestational weight gain (GWG) are related to adverse maternal and neonatal health outcomes. Recent studies indicate an escalating trend in the prevalence of excessive GWG in China. One such study, using data from the China Nutrition and Health Surveys, reported that 57% of women had excessive GWG, and 13.7% of women had inadequate GWG (*1*). Currently, there appears to be a rise in unhealthy eating behaviors (UEBs) among the Chinese youth population such as skipping breakfast, eating fast, or frequently eating away from home. Multiple dietary guidelines globally have emphasized the critical role of avoiding UEBs to optimize GWG (*2*). However, very few studies have explored the relationship between these UEBs and GWG, particularly in relation to Chinese women and the newly released GWG guidelines from the Chinese Nutrition Society (CNS). The present study utilized data from 8,218 pregnant women in Huai'an City, Jiangsu Province collected between 2020–2021 to estimate the association between UEBs and GWG. The results indicated that 51.7% of women reported one or more UEBs and in addition, 55.8% of women experienced excessive GWG. Both single and multiple UEBs were found to be associated with excessive GWG. These findings underscore the public health necessity and clinical relevance of considering UEBs in the management and intervention of gestational weight, as well as in health education as part of preconception care.

The study sample comprised 27,923 pregnant women who gave birth between July 1, 2020, and June 30, 2021, in Huai'an, Jiangsu Province. The population distribution was approximately equal in terms of rural and urban residents and economic statuses. The per capita gross domestic product in Huai'an paralleled the national average. These individuals' profiles were logged in the Maternity Information System (MIS), which includes data on basic maternal characteristics, maternal disease history, pregnancy outcomes, and basic neonatal and anthropomorphic characteristics. Of these constituents, 8,218 were solicited to take part in the Grandmothers, Mothers, and Their Children's Health (GMATCH) inquiry, and their data was incorporated in the present analysis. Comprehensive characteristics for the participating and non-participating individuals are depicted in Supplementary Table S1 (available in https://weekly.chinacdc.cn/). This investigation received approval from the Huai'an Maternal and Child Health Care Center Ethics Committee (Approval Number: 2021060), and written informed consent was acquired from all enrollees before the study initiation.

Four eating behaviors were assessed through a self-administered questionnaire. The conditions encompassed: eating fast (less than 15 minutes), eating

meals on an irregular basis, eating away from home at least once a week, and skipping breakfast at least once a week. UEBs were classified as eating fast (under 15 minutes) (*3*), eating three meals irregularly (*2*), eating away from home at least once weekly (*4*), and skipping breakfast at least once weekly (*4*). To ensure adequate sample size, the number of UEBs was categorized into three groups: 0, 1, and at least 2. Pre-pregnancy body mass index (BMI) was computed using self-reported height and weight data prior to pregnancy. BMI ranges were subdivided into underweight (below 18.5 kg/m^2), normal weight (between 18.5 and 23.9 kg/m^2), overweight (between 24.0 and 27.9 kg/m^2), and obese (28 kg/m^2 or greater) (*5*). GWG was calculated as the differential between pre-pregnancy weight, as self-reported, and the weight measured prior to delivery. GWG was categorized into three groups — inadequate, appropriate, and excessive — in accordance with CNS guidelines (*5*).

The relationships between individual and multiple UEBs and GWG were analyzed using logistic regression, presenting odds ratios (*OR*s) along with a 95% confidence interval (*CI*). For our reference group, we considered adequate GWG. Factors including maternal age, pre-pregnancy BMI, educational attainment, employment status, family income, geographical residence, physical activity level, parity, eating fast, eating three meals irregularly, eating away from home, and skipping breakfast were accounted for when adjusting the regression models. To test for a linear trend, we modeled UEB categories as a continuous variable. Stratified analyses were undertaken to assess if pre-pregnancy BMI altered the associations between multiple UEBs and GWG. Given the high prevalence of excessive GWG, using logistic regression could potentially lead to overestimated associations, hence suggesting the use of modified Poisson regression as an alternate solution. We implemented a modified Poisson regression to ascertain the relative risk association by categorizing the inadequate and adequate into a non-excessive group, measured against the excessive group. Our computations were performed using SAS (version 9.1, SAS Institute, Cary, NC), and we deemed *P*-values less than 0.05 to be statistically significant.

Among 8,218 pregnant participants, 55.8%, 38.2%, and 6.0% experienced excessive GWG, adequate GWG, and inadequate GWG, respectively. Out of these, 4,245 women (51.7%) reported one or more UEBs. Within this subgroup, 40.9% reported eating away from home at least one time per week. Among the women with one or more UEBs, 2,466 (58.1%) and 256 (6.0%) demonstrated excessive and inadequate GWG respectively. Women who experienced excessive GWG tended to have an elevated pre-pregnancy weight, increased weight gain during pregnancy, higher total GWG, and were typically normal weight or overweight prior to pregnancy. These women were also likely to exhibit higher education levels, elevated income, rural residency, and frequently engage in UEBs such as eating fast, eating away from home at least one time per week, and skipping breakfast at least one time per week (Table 1).

Compared to women reporting zero UEBs, those with one and two or more UEBs demonstrated an increased likelihood of excessive GWG by 18% (*OR*=1.18, 95% *CI*: 1.07–1.30) and 35% (*OR*=1.35, 95% *CI*: 1.14–1.59) respectively (P_{trend}<0.001) (Table 2). Each individual UEB was linked with increased odds of excessive GWG. Notably, eating fast (*OR*=1.15, 95% *CI*: 1.00–1.32) and eating away from home (*OR*=1.13, 95% *CI*: 1.03–1.25) were associated with excessive GWG even in fully adjusted models.

In the analysis stratified by pre-pregnancy BMI, among women with a normal pre-pregnancy BMI, those reporting ≥2 UEBs showed a significantly larger propensity for excessive GWG (*OR*=1.53, 95% *CI*: 1.24–1.90) in the fully adjusted model. Furthermore, overweight women reporting one UEB manifested larger odds of excessive GWG (*OR*=1.32, 95% *CI*: 1.06–1.66) (Table 3). The results of the modified Poisson regression were congruous with those of the odds ratio from the logistic regression. Detailed outcomes are presented in the Supplementary Tables S2–S3 (available in https://weekly.chinacdc.cn/).

DISCUSSION

This study discovered an elevated incidence of excessive GWG, with 55% of women in Huai'an City, Jiangsu Province, exceeding the Chinese Nutrition Society (CNS) guideline. Compared to prior studies adhering to the CNS guideline, this rate surpasses that found in Chengdu City, Sichuan Province (46%), yet it is somewhat lower than the rate in Xuzhou City, Jiangsu Province (61%) (*6*–*7*). Furthermore, the incidence aligns closely with the rate for China (57%) as reported according to the National Academy of Medicine guideline (*1*). Consequently, these results suggest that excessive GWG is prevalent among Chinese women, with a heightened occurrence in the developed region of Jiangsu Province.

TABLE 1. Characteristics of pregnant women based on recommended GWG in Huai'an City, Jiangsu Province, China, 2020–2021.

Characteristic	Total (*N*=8,218)	Inadequate (*N*=490)	Adequate (*N*=3,143)	Excessive (*N*=4,585)	*P*-value*
Age (mean±SD)	28.2±4.8	28.0±5.2	28.2±4.8	28.2±4.8	0.503
Pre-pregnancy weight (mean±SD)	58.7±9.2	59.2±10.8	57.0±8.3	59.7±9.4	<0.001
Trimester weight (mean±SD)	73.3±10.1	64.1±9.5	68.3±7.5	77.7±9.4	<0.001
Total GWG (mean±SD)	14.6±5.5	4.8±3.7	11.2±2.2	18.0±4.4	<0.001
Pre-pregnancy BMI, *n* (%)					<0.001
Underweight	638 (7.8)	73 (14.9)	292 (9.3)	273 (6.0)	
Normal weight	5,127 (62.4)	239 (48.8)	2,201 (70.0)	2,687 (58.6)	
Overweight	1,900 (23.1)	132 (26.9)	532 (16.9)	1,236 (27.0)	
Obese	553 (6.7)	46 (9.4)	118 (3.8)	389 (8.5)	
Parity, *n* (%)					0.575
0	3,350 (40.8)	198 (40.4)	1,287 (40.9)	1,865 (40.7)	
1	4,050 (49.3)	239 (48.8)	1,565 (49.8)	2,246 (49.0)	
≥2	818 (10.0)	53 (10.8)	291 (9.3)	474 (10.3)	
Education, *n* (%)					0.002
Middle school and below	528 (6.4)	46 (9.4)	189 (6.0)	293 (6.4)	
High school or technical secondary school	4,758 (57.9)	273 (55.7)	1,766 (56.2)	2,719 (59.3)	
Junior college and above	2,932 (35.7)	171 (34.9)	1,188 (37.8)	1,573 (34.3)	
Employment status, *n* (%)					0.665
Unemployed	179 (2.2)	10 (2.0)	67 (2.1)	102 (2.2)	
Employed or self-employed	3,713 (45.2)	217 (44.3)	1,392 (44.3)	2,104 (45.9)	
Others	4,326 (52.6)	263 (53.7)	1,684 (53.6)	2,379 (51.9)	
Distribution of family income (*n*, %)					0.007
Quartile 1 (lowest)	1,964 (23.9)	151 (30.8)	749 (23.8)	1,064 (23.2)	
Quartile 2	2,088 (25.4)	115 (23.5)	814 (25.9)	1,159 (25.3)	
Quartile 3	2,113 (25.7)	116 (23.7)	775 (24.7)	1,222 (26.7)	
Quartile 4 (highest)	2,053 (25.0)	108 (22.0)	805 (25.6)	1,140 (24.9)	
Residential area, *n* (%)					0.046
Urban	5,663 (68.9)	313 (63.9)	2,177 (69.3)	3,173 (69.2)	
Rural	2,555 (31.1)	177 (36.1)	966 (30.7)	1,412 (30.8)	
Physical Activity, *n* (%)					0.687
Rarely	722 (8.8)	48 (9.8)	289 (9.2)	385 (8.4)	
1–2 times/ week	606 (7.4)	32 (6.5)	222 (7.1)	352 (7.7)	
3–5 times/ week	1,576 (19.2)	88 (18.0)	606 (19.3)	882 (19.2)	
Everyday	5,314 (64.7)	322 (65.7)	2,026 (64.5)	2,966 (64.7)	
Number of UEBs, *n* (%)					<0.001
0	3,973 (48.4)	234 (47.8)	1,620 (51.5)	2,119 (46.2)	
1	3,391 (41.3)	206 (42.0)	1,246 (39.6)	1,939 (42.3)	
≥2	854 (10.4)	50 (10.2)	277 (8.8)	527 (11.5)	
Eating fast, *n* (%)					0.001
No	7,094 (86.3)	433 (88.4)	2,761 (87.8)	3,900 (85.1)	
Yes	1,124 (13.7)	57 (11.6)	382 (12.2)	685 (14.9)	
Eating three meals regularly, *n* (%)					0.108
Regular	8,002 (97.4)	477 (97.3)	3,075 (97.8)	4,450 (97.1)	
Irregular	216 (2.6)	13 (2.7)	68 (2.2)	135 (2.9)	
Eating away from home, *n* (%)					0.013
Rarely	4,859 (59.1)	289 (59.0)	1,921 (61.1)	2,649 (57.8)	
≥1 times/week	3,359 (40.9)	201 (41.0)	1,222 (38.9)	1,936 (42.2)	
Skipping breakfast, *n* (%)					0.028
Rarely	7,666 (93.3)	448 (91.4)	2,958 (94.1)	4,260 (92.9)	
≥1 times/week	552 (6.7)	42 (8.6)	185 (5.9)	325 (7.1)	

Abbreviation: BMI=body mass index; GWG=gestational weight gain; UEBs=unhealthy eating behaviors; SD=standard deviation.
* Differences between groups were assessed using the χ^2 test for categorical variables and ANOVA for continuous variables.

TABLE 2. Associations between UEBs and GWG among pregnant women in Huai'an City, Jiangsu Province, China, 2020–2021.

Unhealthy eating behaviors	Crude model (95% *CI*)*		Fully adjusted model (95% *CI*)	
	Inadequate (*N*=490)	Excessive (*N*=4,585)	Inadequate (*N*=490)	Excessive (*N*=4,585)
Number of UEBs[†]				
0	Ref	Ref	Ref	Ref
1	1.15 (0.94–1.40)	1.19 (1.08–1.31)	1.13 (0.92–1.38)	1.18 (1.07–1.30)
≥2	1.25 (0.90–1.74)	1.45 (1.24–1.71)	1.14 (0.81–1.60)	1.35 (1.14–1.59)
P-trend	0.102	<0.001	0.259	<0.001
Individual UEBs[§]				
Eating speed				
Not fast	Ref	Ref	Ref	Ref
Fast	0.95 (0.71–1.28)	1.27 (1.11–1.45)	0.86 (0.64–1.16)	1.15 (1.00–1.32)
Eating three meals regularly				
Regular	Ref	Ref	Ref	Ref
Irregular	1.23 (0.68–2.25)	1.37 (1.02–1.84)	1.01 (0.54–1.90)	1.23 (0.90–1.68)
Eating away from home				
Rarely	Ref	Ref	Ref	Ref
≥1 times/week	1.09 (0.90–1. 33)	1.15 (1.05–1.26)	1.09 (0.89–1.34)	1.13 (1.03–1.25)
Skipping breakfast				
Rarely	Ref	Ref	Ref	Ref
≥1 times/week	1.50 (1.06–2.13)	1.22 (1.01–1.47)	1.37 (0.95–1.98)	1.10 (0.90–1.34)

Abbreviation: UEBs=unhealthy eating behaviors; GWG=gestational weight gain; *CI*=confidence interval.
* Crude model: unadjusted.
[†] Adjusted for the maternal age, pre-pregnancy BMI, levels of education, employment status, family income, area of residence, physical activity, and parity.
[§] Data for individual UEBs were gleaned from a comprehensive model that incorporated all four UEBs, in addition to other relevant covariates. These covariates included factors such as maternal age, pre-pregnancy BMI, educational attainment, employment status, family income, geographic living area, level of physical activity, and parity.

The results of this study revealed an association between both individual and combined UEBs and excessive GWG, underscoring the significance of UEBs in the management and prevention of GWG. To our knowledge, this marks the first investigation quantifying the relationships between multiple UEBs and GWG; preceding research generally centered on individual behaviors. A previous study encompassing 50 low-income pregnant women in the United States demonstrated that those with a higher frequency of dining at fast-food establishments had a higher likelihood of experiencing excessive GWG (*8*). The association between eating fast and excessive GWG partially mirrored a prior study, wherein a meta-analysis posited that eating fast was linked to an elevated risk of obesity with a pooled *OR* of 2.15 (*CI*: 1.84–2.51) (*4*).

The association between multiple UEBs and excessive GWG aligns with prior research, which showed that UEBs amongst the Spanish population tend to coincide, and an accumulation of these UEBs can result in a greater risk of excessive body weight (*4*). Significantly, China has undergone rapid urbanization, leading to increased work hours and a decrease in time available for individuals to cook. This has been further escalated by the emerging online food delivery market in China, which has enhanced the availability and convenience of away-from-home food, potentially encouraging those partaking in multiple UEBs (*9*). This environmental influence can impact not only pregnant women but also those providing care for them, potentially cultivating multiple UEBs including eating away from home and eating fast, thereby increasing the risk of excessive GWG.

This study acknowledges certain limitations. First, data on UEBs were self-reported, potentially leading to recall bias or skewing towards socially desirable behaviors. Yet, a standardized questionnaire for UEBs is not available. This approach aligns with previous studies using similar questionnaires but varying design

TABLE 3. Associations between the number of UEBs and GWG across different pre-pregnancy BMI categories among pregnant women in Huai'an City, Jiangsu Province, China, 2020–2021.

Number of UEBs	Crude model (95% *CI*)*		Fully adjusted model (95% *CI*)†	
	Inadequate	Excessive	Inadequate	Excessive
Underweight				
0	Ref	Ref	Ref	Ref
1	1.30 (0.76–2.24)	1.03 (0.73–1.47)	1.23 (0.69–2.19)	1.14 (0.78–1.65)
≥2	1.19 (0.48–2.99)	1.47 (0.84–2.56)	1.18 (0.45–3.09)	1.59 (0.89–2.86)
Normal weight				
0	Ref	Ref	Ref	Ref
1	0.99 (0.75–1.32)	1.13 (1.00–1.27)	1.00 (0.76–1.35)	1.12 (1.00–1.27)
≥2	1.36 (0.84–2.18)	1.54 (1.25–1.90)	1.35 (0.83–2.19)	1.53 (1.24–1.89)
Overweight				
0	Ref	Ref	Ref	Ref
1	1.41 (0.94–2.11)	1.33 (1.07–1.66)	1.40 (0.92–2.13)	1.32 (1.06–1.66)
≥2	0.93 (0.50–1.74)	0.95 (0.69–1.30)	0.91 (0.48–1.72)	0.91 (0.66–1.02)
Obese				
0	Ref	Ref	Ref	Ref
1	1.05 (0.50–2.20)	1.64 (1.04–2.57)	1.12 (0.51–2.46)	1.54 (0.95–2.49)
≥2	0.79 (0.26–2.41)	1.76 (0.95–3.26)	0.97 (0.30–3.12)	1.54 (0.80–2.97)

Abbreviation: UEBs=unhealthy eating behaviors; GWG=gestational weight gain; *CI*=confidence interval; BMI=body mass index.
* Crude model: unadjusted.
† Fully adjusted model: adjusted for age, education, maternal employment status, family income, residential area, physical activity, and parity.

cut points, such as "number of times per month or per week" (*4*). Second, the self-reporting of pre-pregnancy height and weight could introduce potential bias to GWG and BMI measurements. However, these discrepancies are considered minor and still present an accurate representation of true BMI and GWG (*10*). Third, the study's participant demographic may not be entirely representative of the broader Chinese population due to recognized income disparities between western and eastern regions, such as Huai'an. Fourth, the absence of collected dietary data in this study curtails our ability to fully understand the association between UEBs and GWG. Finally, the cross-sectional nature of this study restricts its capacity to establish a causal relationship between UEBs and GWG.

In summary, there is an increased risk of excessive GWG among women exhibiting UEBs, particularly those of normal weight prior to their pregnancies. Notably, the odds of excessive GWG seem to amplify as the frequency of UEBs escalates. As such, intervening in UEBs provides a cost-effective approach to endorse healthier pregnancies. For instance, healthcare professionals could customize dietary plans and/or physical activities based on a woman's pre-pregnancy BMI. Furthermore, the promotion of wholesome eating behaviors could reinforce the prospects of healthier pregnancies. On a broader scale, policy interventions should consider tackling the growing trend of consuming food outside of the home, or at least enhancing the nutritional quality of such meals to cultivate a healthier food environment, especially for prospective mothers.

Conflicts of interest: The authors declare no conflicts of interest.

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SUPPLEMENTARY TABLE S1. Comparison of characteristics between pregnant women included in this study and those not included, from Huai'an City, Jiangsu Province, China, 2020–2021.

Characteristic	Total (*N*=26,098)	Excluded (*N*=17,880)	Included (*N*=8,218)	*P*-value*
Age (mean±SD)	28.4±4.7	28.6±4.6	28.2±4.8	<0.001
Pre-pregnancy weight (mean±SD)	59.1±9.0	59.3±9.0	58.7±9.2	<0.001
Trimester weight (mean±SD)	73.0±10.0	72.9±10.0	73.2±10.2	0.013
Total GWG (mean±SD)	14.0±5.4	13.6±5.4	14.6±5.5	<0.001
Pre-pregnancy BMI, *n* (%)				<0.001
Underweight	1,710 (6.6)	1,072 (6.0)	638 (7.8)	
Normal weight	16,657 (63.8)	11,530 (64.5)	5,127 (62.4)	
Overweight	5,999 (23.0)	4,099 (22.9)	1,900 (23.1)	
Obese	1,732 (6.6)	1,179 (6.6)	553 (6.7)	
Parity, *n* (%)				<0.001
0	12,156 (46.6)	8,806 (49.3)	3,350 (40.8)	
1	11,785 (45.2)	7,735 (43.3)	4,050 (49.3)	
≥2	2,157 (8.3)	1,339 (7.5)	818 (10.0)	
Education, *n* (%)				<0.001
Middle school and below	1,722 (6.6)	1,194 (6.7)	528 (6.4)	
High school or technical secondary school	14,543 (55.7)	9,785 (54.7)	4,758 (57.9)	
Junior college and above	9,833 (37.7)	6,901 (38.6)	2,932 (35.7)	
Employment status, *n* (%)				<0.001
Unemployed	577 (2.2)	398 (2.2)	179 (2.2)	
Employed or self-employed	14,024 (53.7)	10,311 (57.7)	3,713 (45.2)	
Others	11,497 (44.1)	7,171 (40.1)	4,326 (52.6)	
Residential area, *n* (%)				<0.001
Urban	19,424 (74.4)	13,761 (77.0)	5,663 (68.9)	
Rural	6,674 (25.6)	4,119 (23.0)	2,555 (31.1)	

Abbreviation: BMI=body mass index; GWG=gestational weight gain; SD=standard deviation.

* Differences between groups were assessed using the χ^2 test for categorical variables and Student's *t*-tests for continuous variables.

SUPPLEMENTARY TABLE S2. Association between UEBs and GWG among pregnant women in Huai'an City, Jiangsu Province, China, 2020–2021.

Unhealthy eating behaviors	Crude model (95% *CI*)*	Fully adjusted model (95% *CI*)
	Excessive	Excessive
	(*N*=4,585)	(*N*=4,585)
Number of UEBs[†]		
0	Ref	Ref
1	1.07 (1.03–1.12)	1.07 (1.02–1.11)
≥2	1.16 (1.09–1.23)	1.12 (1.05–1.19)
P-trend	<0.001	<0.001
Individual UEBs[§]		
Eating speed		
Not fast	Ref	Ref
Fast	1.11 (1.05–1.17)	1.07 (1.01–1.12)
Eating three meals regularly		
Regular	Ref	Ref
Irregular	1.24 (1.01–1.25)	1.08 (0.97–1.21)
Eating away from home		
Rarely	Ref	Ref
≥1 times/week	1.06 (1.02–1.10)	1.05 (1.01–1.09)
Skipping breakfast		
Rarely	Ref	Ref
≥ 1 times/week	1.06 (0.99–1.14)	1.02 (0.94–1.10)

Note: The results presented in this table were derived from a modified Poisson regression, wherein the inadequate and adequate categories were combined to form the non-excessive group, which was then compared with the excessive group.
Abbreviation: UEBs=unhealthy eating behaviors; GWG=gestational weight gain; *CI*=confidence interval.
* Crude model: unadjusted.
† Adjusted for the maternal age, pre-pregnancy BMI, levels of education, employment status, family income, area of residence, physical activity, and parity.
§ The retrieval of individual UEBs was accomplished via a comprehensively adjusted model incorporating all four UEBs. Additional covariates included maternal age, pre-pregnancy BMI, education levels, employment status, family income, residential area, physical activity, and parity.

SUPPLEMENTARY TABLE S3. Association between the number of UEBs and GWG among different pre-pregnancy BMI groups of pregnant women in Huai'an City, Jiangsu Province, China, 2020-2021.

Number of UEBs	Crude model (95% *CI*)*	Fully adjusted model (95% *CI*)†
	Excessive	Excessive
Underweight		
0	Ref	Ref
1	0.99 (0.81–1.20)	1.05 (0.86–1.29)
≥2	1.21 (0.92–1.58)	1.26 (0.95–1.66)
Normal weight		
0	Ref	Ref
1	1.06 (1.00–1.12)	1.06 (1.00–1.12)
≥2	1.19 (1.10–1.30)	1.19 (1.09–1.30)
Overweight		
0	Ref	Ref
1	1.08 (1.00–1.16)	1.07 (1.00–1.15)
≥2	0.98 (0.88–1.10)	0.97 (0.87–1.09)
Obese		
0	Ref	Ref
1	1.16 (1.02–1.31)	1.13 (0.99–1.28)
≥2	1.20 (1.04–1.39)	1.13 (0.97–1.32)

Note: The results presented in this table were derived from a modified Poisson regression, wherein the inadequate and adequate categories were combined to form the non-excessive group, which was then compared with the excessive group.
Abbreviation: UEBs=unhealthy eating behaviors; GWG=gestational weight gain; *CI*=confidence interval; BMI=body mass index.
* Crude model: unadjusted.
† Fully adjusted model: Adjusted for age, education, maternal employment status, family income, residential area, physical activity, and parity.

Vital Surveillances

Pulmonary Heart Disease Associated Mortality — China, 2014–2021

Yangyang Xu[1]; Zhe Liu[1]; Jinlei Qi[1]; Lijun Wang[1]; Maigeng Zhou[1]; Peng Yin[1,#]

ABSTRACT

Introduction: Over the latter half of the previous century, pulmonary heart disease (PHD) emerged as a significant public health issue in China. However, the current mortality rate is unknown. Utilizing the Multiple Cause of Death database, the present study aims to investigate the current state and progression of PHD-associated death in China.

Methods: Data from the China National Mortality Surveillance System were used to analyze progression in mortality rates attributable to PHD from 2014 to 2021. To standardize population structure for each year during the investigation period, demographic information from the 2020 census was employed as the reference population. Age-standardized mortality rates (ASMR) were determined based on sex, urban-rural area, and region. To identify trends in ASMR, a joinpoint regression analysis was executed.

Results: The ASMR of PHD exhibited a marked decrease, falling from 61.68 per 100,000 in 2014 to 28.53 per 100,000 in 2021. This downward trend was observable in both genders, all regions, and both urban and rural settings. The greatest ASMR values were documented in the western region. Comparative observations revealed a higher ASMR in rural areas versus urban ones and in males versus females. PHD-associated deaths predominantly occurred among older individuals, particularly those aged 80 and above. Chronic obstructive pulmonary disease (COPD) emerged as the principal underlying cause of death PHD-associated mortalities, accounting for between 87.41% and 93.42% of cases throughout the period 2014–2021.

Conclusions: There was a declining trend in PHD mortality in China from 2014 to 2021, with COPD accounting for a significant proportion of these deaths. Given the high prevalence of COPD and the escalating population aging in China, PHD remains a significant health concern that warrants further attention.

A recent retrospective study utilizing data from the China National Mortality Surveillance System has shed light on the mortality rates associated with pulmonary heart disease (PHD) in China. The study found that the age-standardized mortality rate of PHD has significantly decreased from 61.68 per 100,000 in 2014 to 28.53 per 100,000 in 2021. The analysis also revealed that PHD-related deaths primarily occur in older individuals, with those aged over 80 being the most affected. Chronic obstructive pulmonary disease (COPD) was identified as the main underlying cause of death in the majority of PHD cases. Despite the declining trend in mortality rates, the study emphasized the need for continued attention to PHD due to the high prevalence of COPD and the rapid population aging in China. This study provides valuable insights into the current status and trends of PHD-associated mortality, helping healthcare professionals and policymakers understand the impact of PHD on public health in China.

PHD, also referred to as cor pulmonale, is characterized by pulmonary arterial hypertension stemming from conditions, including chronic respiratory disease, chronic thromboembolic pulmonary hypertension, and other diseases impacting the lung's structure or function. This condition can result in right ventricular enlargement, potentially leading over time to right heart failure (*1*). PHD was a significant heart disease in China during the latter half of the previous century. From the 1990s, advancements in technology and methodologies have enhanced the treatment and survival rate of this condition. According to the third national retrospective survey on causes of death, the PHD mortality rate was 4.74 per 100,000 (*2*). However, this mortality rate was based on the underlying cause of death (UCoD) and did not accurately reflect the actual number of PHD related deaths, as many such instances were classified with chronic obstructive pulmonary

disease (COPD) as the UCoD. The proportion of PHD deaths attributed to COPD in the Chinese population remains uncertain. Thus, this analysis was conducted using data from the China National Mortality Surveillance System (NMSS) to provide a comprehensive update on PHD related mortality in recent years in China and to investigate the fundamental causes of PHD-related deaths.

METHODS

This research is a retrospective, population-based study of multiple causes of death (MCoD), utilizing mortality data extracted from the NMSS. This system encompasses 24.3% of China's overall population via 605 disease surveillance points (DSPs), providing representative data on both national and provincial levels. For further details on the NMSS, readers are referred to previously published descriptions (*3*). To maintain the validity and reliability of the mortality data, the following measures were implemented: workforce training, annual quality control engagements, on-site quality assessments, and the establishment of death registration regulations (*3*).

To address potential under-reporting, a retrospective survey was conducted triennially, which would then allow for adjustment of the mortality rate. In this present study, the mortality rates from 2014 through 2017 were adjusted using the underreporting rates from the same years, and the rates from 2018 through 2021 were adjusted using the 2017 under-reporting rate. The formula used for adjustment was: "adjusted mortality rate = crude mortality rate / (1 – under-reporting rate)".

For age-standardized mortality rates, each age group's crude mortality rates were first adjusted, after which direct standardization was applied. Data about the population of the disease surveillance points was obtained from the National Bureau of Statistics.

In this study, deaths associated with PHD were characterized as those having the International Classification of Disease-10th Version (ICD-10) codes I27.8 or I27.9 in either part of the medical certification section of the death certificate, irrespective of whether they were the UCoD or the associated (non-underlying) cause. Among the total PHD-associated deaths, the UCoD was categorized as follows: tumors (C00 −C97, D00 −D48); ischemic heart disease (I20 −I25); cerebrovascular disease (I60 −I69); COPD (J40−J44); and other primary causes of PHD including asthma (J45), bronchiectasis (J47), pneumoconiosis (J60–J66), tuberculosis sequelae (B90.9), obesity-hypoventilation syndrome (E66.2), cystic fibrosis (E84.0), sleep apnea syndrome (G47.3), idiopathic interstitial pulmonary fibrosis (J84.1), idiopathic pulmonary arterial hypertension (I27.0), kyphoscoliosis (M41), chronic thromboembolic pulmonary hypertension (I26.9); pulmonary heart disease (I27.8, I27.9); and other diseases. The selection of other primary PHD causes was guided by the 2018 PHD diagnosis and treatment guidelines (*4*). It should be noted that PHD, being an end-stage disease, is rarely classified as the UCoD. However, in some instances, it may be challenging to trace the primary disease leaving PHD as the only plausible UCoD, hence its inclusion as a separate category here.

The adjusted mortality rate (AMR) and age-standardized mortality rate (ASMR) were evaluated for the years 2014–2021. The demographic data from the 2020 census was utilized as a reference population to directly standardize the population structure throughout the study. The average annual percent changes (AAPCs) were computed using the Joinpoint regression, which facilitated a trend analysis of the ASMR, thereby enabling an exploration into alterations over time according to sex, urban-rural locations, and various regions. All these analyses were executed using the SAS software (version 9.4, SAS Institute Inc., Cary, NC, USA) and the Joinpoint Regression Program (version 4.9.0.1; National Cancer Institute, Rockville, MD, US).

RESULTS

In 2021, the total number of PHD associated death was 103,586 (61,634 males, and 41,952 females) across 605 DSPs, leading to an estimated 430,205 PHD deaths nationwide. The ASMR showed a decrease, falling from 61.68 per 100,000 in 2014 to 28.53 per 100,000 in 2021 (AAPC= −10.40 , 95% confidence interval (*CI*): −12.03 to −8.75), with a reduction of 53.74% (Table 1).

The ASMR exhibited a significant decline in males from 76.14 per 100,000 in 2014 to 38.14 per 100,000 in 2021 (AAPC=−9.31, 95% *CI*: −11.15 to −7.44). Similarly, in females, ASMR decreased from 49.26 per 100,000 in 2014 to 20.38 per 100,000 in 2021 (AAPC=−11.80, 95% *CI*: −13.24 to −10.33). The ASMR was reduced by 49.91% in males and 58.63% in females (Table 1).

Significant variations in the ASMR were reported across different regions. Over the study period, the

TABLE 1. Number of deaths, ASMR and AMR (per 100,000) of PHD by gender, urban-rural divide, and region in 605 DSPs in 2014 and 2021.

Category	2014			2021			AAPC for ASMR
	Number	AMR	ASMR	Number	AMR	ASMR	
Total	156,418	47.93	61.68	103,586	30.46	28.53	−10.40* (−12.03, −8.75)
Gender							
Male	87,784	52.54	76.14	61,634	35.51	38.14	−9.31* (−11.15, −7.44)
Female	68,634	43.10	49.26	41,952	25.20	20.38	−11.80* (−13.24, −10.33)
Urban-Rural							
Urban	39,456	30.39	41.10	25,720	16.94	16.68	−12.26* (−13.82, −10.67)
Rural	116,962	59.53	73.93	77,866	41.36	37.08	−9.17* (−10.95, −7.73)
Region							
East	53,685	37.47	44.69	28,223	17.88	16.28	−13.46* (−14.79, −12.11)
Central	44,398	45.07	60.42	29,230	30.35	27.50	−10.46* (−13.38, −7.43)
West	58,335	69.00	96.62	46,133	53.69	53.84	−7.95* (−11.09, −4.70)

Abbreviation: AAPC=average annual percent change; AMR=adjusted mortality rate; ASMR=age-standardized mortality rate; PHD=pulmonary heart disease; DSPs=disease surveillance points.
* $P<0.01$.

highest ASMR was observed in the west region, higher than that in the central and east regions (Table 1). From 2014 to 2021, there was a decrease in ASMR from 44.69 to 16.28 per 100,000 in the east region (AAPC=−13.46, 95% *CI*: −14.79 to −12.11). In the central region, it decreased from 60.42 to 27.50 per 100,000 (AAPC=−10.46, 95% *CI*: −13.38 to −7.43). The west region reported a decrease in ASMR from 96.62 to 53.84 per 100,000 (AAPC=−7.95, 95% *CI*: −11.09 to −4.70). The decrease of the ASMR corresponded to 63.57%, 54.49%, and 44.28%, respectively.

The ASMR exhibited a significant decrease in both urban and rural areas during the study period. Specifically, the ASMR in urban areas dropped from 41.10 per 100,000 to 16.68 per 100,000 (AAPC=−12.26, 95% *CI*: −13.82 to −10.67), representing a 59.42% decrease. Meanwhile, in rural areas, the ASMR descended from 73.93 per 100,000 to 37.08 per 100,000 (AAPC=−9.17, 95% *CI*: −10.95 to −7.37), reflecting a 49.84% reduction (Table 1).

Mortality rates associated with PHD escalated with age, demonstrating a sharp increase after 60–65 age group across all categories (Figure 1). The highest mortality rate was observed in individuals aged over 80. Throughout the study period, a decreasing trend was evident in the mortality rates across all age groups.

Table 2 presents a summary of the underlying causes of PHD-associated deaths from 2014 to 2021. Notably, COPD is identified as the leading underlying cause of these PHD-associated deaths, comprising the majority of total cases.

DISCUSSION

Our study's findings indicate a significant decrease in PHD-associated mortality rates across different genders, urban and rural locales, all regions from 2014 to 2021. This observable decrease could primarily be attributed to advancements in medical conditions, improvements in socioeconomic status, and awakening in health awareness. Moreover, with the expansion of basic health insurance coverage, more individuals are inclined to seek hospital services for their health-related concerns (*5*). Notably, the western region recorded the highest PHD mortality rate, surpassing the central and eastern regions. Contributing factors to this phenomenon include the slower developmental pace, relative scarcity of healthcare resources, and lower affordability in the western region. Additionally, the higher prevalence of risk factors such as smoking, household air pollution, high altitude, and COPD exacerbate the situation (*6*–*7*). Gender disparity in PHD mortality rates was also observed, with males exhibiting higher numbers than females. Such differences could possibly be linked to varying occupational exposures and smoking patterns among Chinese males. The ASMR was shown to be higher in rural areas as compared to urban locations; this discrepancy may be due to varying distribution of risk factors and disparities in medical conditions. Furthermore, the elevated PHD mortality rate among

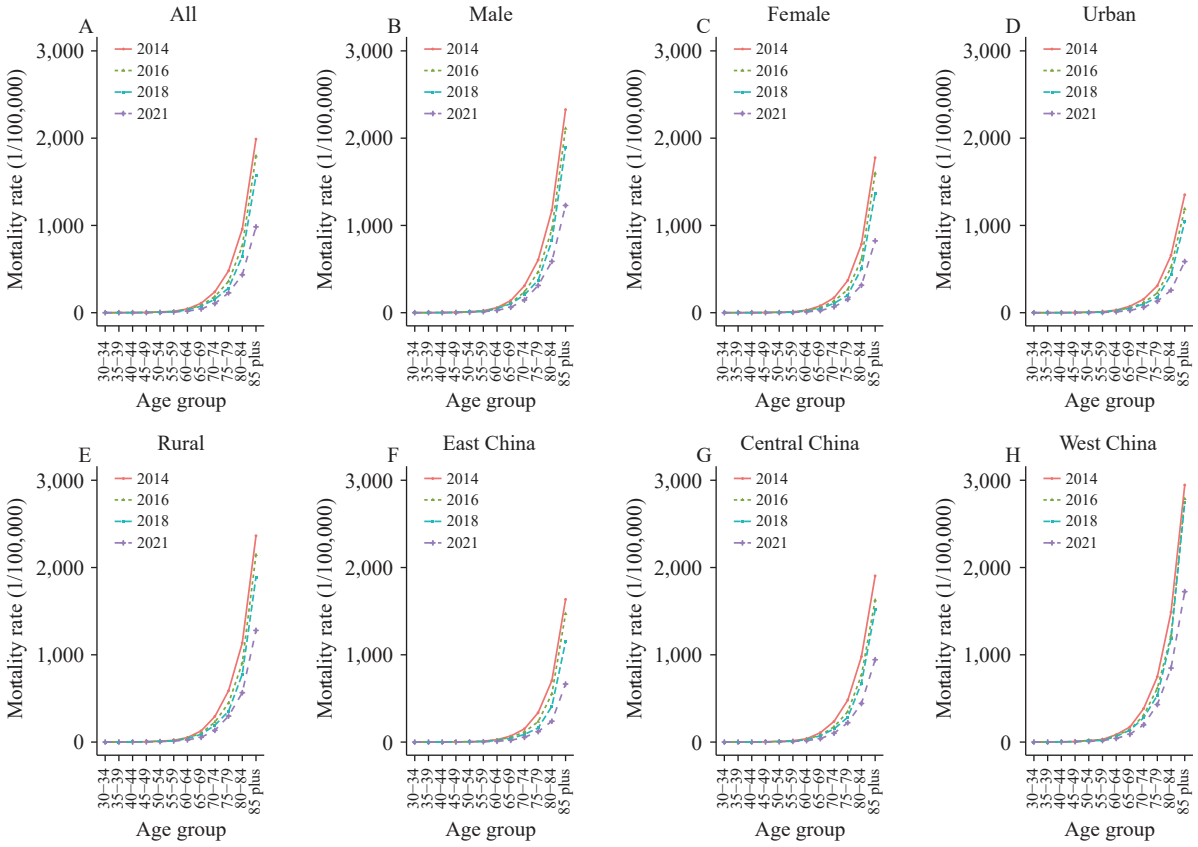

FIGURE 1. Trends in age-specific mortality rates for pulmonary heart disease in China in 2014, 2016, 2018, and 2021. Among age groups based on (A) all population, (B–C) sex (male and female), (D–E) residential area (urban or rural), and (F–H) region (East, Central or West China).

TABLE 2. Underlying causes of PHD-associated deaths among 605 DSPs in China from 2014 to 2021.

Underlying cause of death	2014, *n* (%)	2015, *n* (%)	2016, *n* (%)	2017, *n* (%)	2018, *n* (%)	2019, *n* (%)	2020, *n* (%)	2021, *n* (%)
	*N**=156,418	*N*=142,733	*N*=144,424	*N*=140,379	*N*=133,047	*N*=126,552	*N*=108,196	*N*=103,586
Chronic obstructive pulmonary disease	136,725 (87.41)	131,343 (92.02)	134,324 (93.01)	130,864 (93.22)	123,830 (93.07)	117,280 (92.67)	99,918 (92.35)	93,928 (90.68)
Pulmonary heart disease	14,161 (9.05)	5,918 (4.15)	4,221 (2.92)	3,767 (2.68)	3,651 (2.74)	3,638 (2.87)	3,423 (3.16)	5,051 (4.88)
Other primary disease of pulmonary heart disease	1,353 (0.86)	1,543 (1.08)	1,782 (1.23)	1,867 (1.33)	1,830 (1.38)	2,004 (1.58)	1,643 (1.52)	1,564 (1.51)
Ischemic heart disease	937 (0.60)	802 (0.56)	845 (0.59)	770 (0.55)	851 (0.64)	727 (0.57)	647 (0.60)	702 (0.68)
Tumors	605 (0.39)	593 (0.42)	612 (0.42)	604 (0.43)	592 (0.44)	530 (0.42)	519 (0.48)	441 (0.43)
Cerebrovascular disease	245 (0.16)	198 (0.14)	227 (0.16)	236 (0.17)	239 (0.18)	286 (0.23)	236 (0.22)	241 (0.23)
Other disease	2,392 (1.53)	2,336 (1.64)	2,413 (1.67)	2,271 (1.62)	2,054 (1.54)	2,087 (1.65)	1,810 (1.67)	1659 (1.60)

Abbreviation: PHD=pulmonary heart disease; DSPs=disease surveillance points.
* Total number of PHD-associated deaths.

the elderly population can largely be attributed to aging and advancements in PHD treatment.

During the 1970s, PHD featured heavily in overall mortality rates in China, frequently ranking first or second among all causes of death in many areas (*8*). The first national retrospective survey of causes of death indicated that PHD represented 61.08% of all heart disease cases, with a national ASMR of 63.72 per 100,000 in 1973–1975 (*9*). From 1990, the DSP system, an antecedent of the NMSS, initiated the collection of death data, releasing crude mortality rates based on the UCoD. Our study diverges from the

conventional approach of employing a single underlying cause of death database, preferring instead to use a multiple-cause death database to ascertain the mortality rate for PHD. Despite the challenges inherent in juxtaposing mortality rates from studies with differing definitions of the cause of death, an overall downward trend in PHD mortality was noted (crude mortality rate, 78.86 per 100,000 in 1973–1975 vs. 30.46 per 100,000 in 2021) considering that the mortality rate based on MCoD is higher than that based on UCoD for the same disease.

In the Global Burden of Disease Study 2010 (GBD2010), the entirety of PHD was reassigned to COPD prior to the year 2004. However, in the GBD2013 study, approximately 45% of PHD was reassigned to COPD before the same year. The primary disparity between these two GBD studies pertains to the methods of redistribution of what's known as "garbage codes." Wan et al. have commented on the redistribution of PHD and suggested that the proportional redistribution for COPD in GBD2010 seems somewhat more rational (*10*). Still, given that diseases such as asthma, pneumoconiosis, tuberculosis, and others have also partly accounted for PHD cases, the method in GBD2010 could potentially overestimate the redistribution proportion for COPD. Within our study, we noted that COPD contributed to over 90% of the total PHD cases, which might be somewhat higher than the estimated proportion of 80%–90% presented in earlier literature (*1*). This discrepancy could be attributed to the high prevalence and the significantly low early diagnosis and treatment rates for COPD patients observed in China (*11*).

This research delivers the latest PHD mortality statistics within the Chinese population, leveraging nationwide surveillance data. The scope of this analysis encapsulates all reported PHD-associated deaths, thus capturing a holistic picture of the PHD burden. It must be highlighted that commonly used UCoD analyses often omit other comorbidities. Limitations intrinsic to our study need acknowledgement as well. First, under-reporting, particularly in the western region, might lead to an underestimation of the PHD mortality rate. Second, the completeness of a deceased individual's prior disease history on the death certificate can also influence the calculation of mortality rates. For instance, when PHD patients directly die from acute myocardial infarction and the coder does not include PHD as a contributing cause of death listing in the part two of the medical certification section of the death certificate, PHD-associated mortality will be underestimated. Lastly, the diagnosis rate of PHD in rural areas may be sub-par, further leading to potential underestimation of mortality rates.

In conclusion, a decreasing trend in PHD mortality rate was observed in China from 2014 to 2021, with a substantial number of these fatalities attributed to COPD. Nonetheless, the high prevalence of COPD, coupled with the rising phenomenon of an aging populace, could pose some uncertainty towards future PHD mortality rates. Therefore, it is imperative for clinicians to closely monitor changes in cardiac structure and functionality, particularly in poorly controlled or treated COPD patients, thus mitigating the potential progression of COPD to PHD. Moreover, consistent surveillance and prompt updating of PHD mortality data is vital for enhancing preventive strategies and control measures.

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Perspectives

Exploring Pharmacogenetic Testing for Hypertension Management in China

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Hypertension, or high blood pressure, is a predominant precursor of premature mortality, affecting an estimated 270 million people in China alone, and is also a major global health concern (*1*). Hence, effective management of hypertension is vital for averting severe adverse cardiac or cerebrovascular incidents, decreasing early mortality rates, and curtailing disability. However, pharmacological treatments for hypertension demonstrate a notable variation in efficacy among individuals (*2*), which could partially explain the persistently low control rate of hypertension in China as observed from 2007 to 2018 (Figure 1) (*3*).

Blood pressure (BP) is a heritable determinant of risk for cardiovascular and cerebrovascular diseases, with genetic predisposition to BP variation ranging from 30% to 50% (*4*). The genetic architecture of BP comprises more than 30 known genes (*5*–*6*). For example, polymorphic variation in the CYP2D6 gene, which encodes a cytochrome p450 family member involved in phase I drug metabolism, has been shown to influence BP response to treatments such as diuretics, beta-blockers, angiotensin receptor blockers, and clonidine (*7*–*8*).

Pharmacogenetic testing (PGx) can offer valuable insights for personalized medicine by taking into account individual variations in medicinal responses. Currently, 27 different institutions in the US are engaged in implementing pharmacogenomics programs, some of which have been operational for over a decade (*9*). A study titled PREPARE, which took place across seven European countries, demonstrated that genotype-guided treatment using a 12-gene pharmacogenetic panel significantly reduced the occurrence of clinically relevant adverse drug reactions (*10*).

Despite these promising results, the benefits of PGx remain widely debated, partly due to potential biases that might be introduced (*10*). Furthermore, questions remain regarding its feasibility, acceptability, and effectiveness in real-world environments. Additionally, the integration of PGx knowledge into clinical settings has been slow. There is a paramount need for the development of personalized algorithms that can aid in both the choice and management of hypertension medication, thereby incorporating PGx into standard care.

In China, numerous direct-to-consumer PGx kits can be procured via e-commerce platforms. These kits offer tailored advice on medication usage, including antihypertensives (*11*). Several hospitals in developed regions, such as the Fuwai Hospital of the Chinese Academy of Medical Sciences, Peking University First Hospital, Peking University People's Hospital, and Xiangya Hospital Central South University, not to forget the Chronic Disease Prevention and Control Center of Shenzhen, have inaugurated precision medicine programs targeting major chronic ailments such as hypertension. Furthermore, initiatives like the *Pharmacogenomic Examination and Management of hypertension patients in China based on antihypertensive efficacy and adverse reactions* (China-PEM), have been established to encourage the uptake of pharmacogenetic testing (*12*).

PGx presents a unique opportunity to shift from a high-risk strategy to a population-based approach for hypertension management in primary healthcare settings. Current strategies for managing hypertension in China's primary healthcare system primarily target populations aged 35 years and older (*13*). However, data from the 2018 China Chronic Disease and Risk Factor Surveillance indicate that the prevalence of hypertension among individuals aged 18–34 years old has risen to 9.2%. Notably, the rates of awareness (16.0%), treatment (10.2%), and control (1.5%) in this age group significantly lag behind those of older ages (Figure 2). Although the implementation of the National Basic Public Health Service program in China has led to a hypertension control rate increase among individuals aged 18–69 years old from 5.8% to 13.7% between 2010 and 2018 (*3*), it remains markedly low compared to developed countries like the Republic of Korea, Canada, and Iceland (*14*). It is crucial to detect hypertension early in younger populations to prevent vascular aging and organ damage (*15*), but there is a striking lack of practical

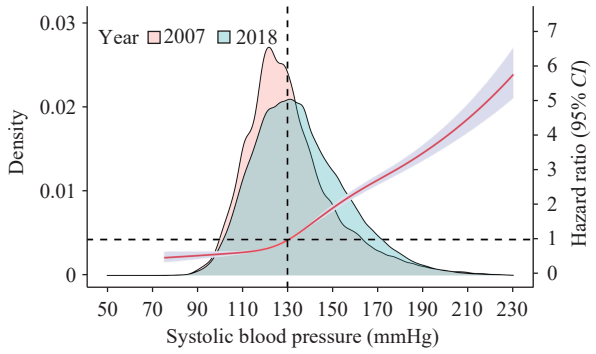

FIGURE 1. Density plot representing systolic blood pressure in the adult population for 2007 and 2018, alongside the unadjusted hazard ratio of all-cause mortality at varying levels of systolic blood pressure with 95% confidence interval (*CI*).
Note: red line indicates the hazard ratio, light blue shade indicates 95% *CI*.
Source of data: China Chronic Disease and Risk Factor Surveillance.

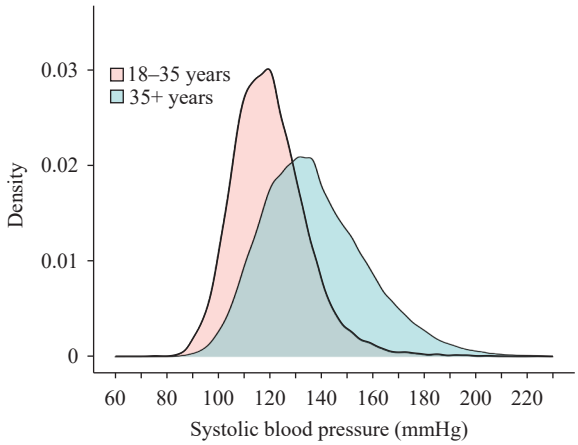

FIGURE 2. Density plot of systolic blood pressure among adults aged 18–35 and over 35 years.
Source of data: China Chronic Disease and Risk Factor Surveillance (2018).

methods to draw young hypertensive patients to primary healthcare institutions for screening, diagnosis, treatment, and control. The emergence of PGx presents a viable opportunity to engage younger individuals in primary healthcare settings for the treatment and management of hypertension.

While China has shown support for the use of PGx, there still remains a significant need for improvement in the guidelines that govern hypertension management. The State Council of China issued the *Medium-to-Long Term Plan for the Prevention and Control of Chronic Diseases (2017–2025)*, which expressed support for the promotion and utilization of emerging technologies and products such as PGx in mitigating chronic conditions (*16*). Additionally, in 2022, the National Health Commission and the State Administration of Traditional Chinese Medicine issued a Notice pushing for the bolstering of drug safety management, as well as the improvement of rational drug use (*17*). This involved the employment of PGx to identify potential medication risks, develop personalized medication plans, optimize drug selection, and accurately determine medication dosages. The 2017 *Guidelines for Rational Use of Antihypertensive Drugs (2nd Edition)* acknowledged the significant variance in drug responses amongst diverse individuals and advocated for the consideration of pharmacogenomics factors when prescribing antihypertensive medication. However, the *National Guideline for Hypertension Management in China (2019)* and the *Clinical Practice Guidelines for Hypertension Management in China (2022)* have yet to incorporate provisions related to the use of PGx in the administration of hypertensive treatment.

As next-generation sequencing technology continues to advance, the affordability of whole genome sequencing has significantly improved. This method has been widely adopted within China for the diagnosis and treatment of various ailments, including birth defects, malignant tumors, psychiatric disorders, and genetic metabolic disorders found in children. Several hospitals in China have developed PGx laboratories, complete with genetic counseling services.

However, there is a pressing need for an established management framework within the Chinese government. This would guide the application of PGx technology, transitioning from the discovery of novel genes to equitable health benefits for the population. Constructing an external system for appraising technical readiness levels is also critical to ensuring validity, quality, safety, and efficacy.

Further, an external quality control system should be designed for direct-to-consumer PGx testing kits. To effectively integrate PGx testing into clinical practice and avoid misinterpretation, healthcare professionals must receive thorough and detailed training. As public education and awareness campaigns are necessary for increasing understanding and acceptance of PGx testing, these too should be initiated.

Finally, integrating genetic testing into population-based surveillance can significantly augment our understanding of associations between genetics and the environment related to chronic diseases in China. This will inform the design of essential medication lists tailored to regional variations.

The advancement of PGx and precision medication

presents notable obstacles in achieving health equity in clinical practice throughout the expansive regions of China. In a bid to accomplish health equity, the UK has initiated a strategy that merges precision medicine and tiered diagnosis, incorporating PGx within the framework of the National Health Service. Data suggests that the average income and educational level of PGx users is higher, concurrently creating substantial challenges when extending the application of PGx in remote and economically disadvantaged regions of China. Consequently, the establishment of a learning-oriented primary healthcare service mechanism and toolkit becomes imperative for incorporating this knowledge into practice in China.

Genetic counseling is a health service that interprets genetic findings for individuals, and can be utilized in contexts such as genotype-guided medication selection, genetic risk screening, and disease diagnosis. It offers an essential source of information for decision-making in disease prevention and treatment. In several developed nations, certified genetic counseling professionals furnish this information to patients and their families. However, there's a considerable shortage of such professionals in Asia, leading to a widespread lack of understanding about genetic diseases among patients. In 2018, the Genetic Counseling Branch of the Chinese Society of Genetics was established in China, and the body issued the *ACMG Genetic Variant Classification Standards and Guidelines*. Since its inception, the branch has organized numerous training sessions in genetic counseling. Nevertheless, the confinement of genetic counseling services to only tertiary healthcare facilities impedes access and amplifies urban-rural disparities.

In conclusion, PGx is experiencing accelerated growth in China, providing an opportunity to engage young individuals with hypertension in primary healthcare settings. Despite policies promoting the use of PGx, there is a pressing need for hypertension management guidelines to embrace these advancements. The development of a learning-oriented primary healthcare service system, complete with tools to integrate genetic counseling into routine practice, is crucial in the Chinese context.

Conflicts of interest: No conflicts of interest.

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