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INTERNATIONAL WOMEN'S DAY

Foreword

Preplanned Studies

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This week's issue was organized by Guest Editor Linhong Wang.

Foreword

Towards Equity in Women's Health: Bridging Promises, Action, and Progress

Heling Bao[1]; Linhong Wang[2,3,#]

Women's health equity refers to the equitable achievement of optimal health outcomes for all women, irrespective of gender, socioeconomic status, race, geographic location, or other social determinants of health. This concept emphasizes dismantling systemic barriers and customizing interventions to address the diverse needs of women throughout their life course (*1*). Bridging women's health disparities yields substantial economic and societal benefits. The World Health Organization (WHO) estimates that eliminating gender health gaps could contribute 12 trillion US dollars (USD) to the global economy by 2040 (*2*). Globally, progress remains uneven. While high-income countries have made significant advances in reducing maternal mortality, profound disparities persist in low-resource settings. Moreover, challenges endure even in developed regions, where socioeconomically disadvantaged populations experience disproportionately higher rates of preventable diseases such as cervical cancer (*3*). Current impediments include fragmented health policies, inadequate funding for gender-specific research, and cultural stigmas that restrict healthcare access. For instance, merely 5% of global health research addresses conditions specific to women (*4*), perpetuating critical gaps in evidence-based care. The World Economic Forum 2024 identifies nine key health conditions that collectively account for one-third of the women's health gap: breast cancer, cervical cancer, menopause, endometriosis, premenstrual syndrome, postpartum hemorrhage, maternal hypertensive disorders, migraine, and ischemic heart disease (*5*). Addressing these disparities necessitates progressing beyond universal commitments to implementing targeted interventions that address inequities in treatment approaches, care delivery systems, data collection, and funding allocation — a central theme in advancing women's health equity.

This special issue comprises five pivotal studies addressing the three leading contributors to the global women's health gap: breast cancer, cervical cancer, and menopausal syndrome. Breast cancer remains the predominant cause of cancer-related mortality among women, while cervical cancer — though highly preventable — continues to claim numerous lives due to inequitable access to vaccines and screening services. Menopause, despite being a natural physiological transition, receives inadequate attention in health systems worldwide, despite its profound impact on women's physical and mental well-being (*6*). For cervical cancer elimination, Zhang et al. estimated cervical cancer screening rates based on national surveillance data, revealing persistent coverage disparities, particularly in rural and resource-limited settings (*7*), while Gao et al. assessed human papillomavirus (HPV) infection severity and cervical lesion prevalence utilizing screening data from 23 provincial-level administrative divisions (PLADs) (*8*). Together, these investigations provide actionable evidence to accelerate China's cervical cancer elimination strategy. Bao et al. examined the relationship between socioeconomic status (SES) and breast cancer incidence through cohort analysis, underscoring the necessity for SES-stratified prevention approaches (*9*). Complementing this research, Liu et al. analyzed breast nodule detection rates using healthcare big data across 31 PLADs in China, advocating for risk-tailored screening programs that prioritize high-burden regions (*10*). Finally, Yong et al. investigated the prevalence and severity of menopausal symptoms in women aged 40–60, challenging the long-standing neglect of post-reproductive health in policy agendas (*11*). Collectively, these studies illuminate critical pathways to close the women's health gap: from SES-informed cancer prevention strategies to equitable screening expansion and comprehensive life-course care. By translating robust evidence into targeted interventions, we advance toward bridging promises with measurable progress.

China has made significant strides in narrowing women's health disparities through initiatives including substantial reductions in maternal and infant mortality rates, implementation of nationwide breast and cervical cancer screening programs, and the recent incorporation of adolescent health and menopause management into national women's health guidelines. However, substantial challenges persist: pronounced gender and urban-rural disparities in vulnerability and healthcare access remain evident, while systemic barriers — including fragmented health financing mechanisms and insufficient prioritization of women's health issues — continue to undermine equity goals. Additionally, women's health equity represents not merely a healthcare concern but also an economic and workforce imperative. To accelerate progress, six strategic priorities warrant immediate attention. First, enhancing comprehensive data collection systems to capture the nuanced needs of diverse female populations is essential. Second, expanding support for basic science and clinical research focused on women-specific conditions is critical to address persistent gaps in evidence-based care. Third, developing sex-based healthcare delivery systems will ensure more tailored and effective services across the lifespan. Fourth, implementing accessible solutions can effectively bridge geographic and socioeconomic barriers to care. Fifth, directing substantial resources into women's health fields will create sustainable infrastructure to support these comprehensive efforts. Finally, ensuring workplace accommodations for pregnant, postpartum, and menopausal women is vital to promote long-term well-being and productivity. By prioritizing these strategic actions, China can establish global leadership in addressing the women's health gap.

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Corresponding author: Linhong Wang, linhong@chinawch.org.cn.

[1] Institute of Medical Information, Chinese Academy of Medical Sciences & Peking Union Medical College, Beijing, China; [2] National Center for Chronic and Non-communicable Disease Control and Prevention, Chinese Center for Disease Control and Prevention, Beijing, China; [3] Chinese Association of Women and Child Health Studies, Beijing, China.

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Linhong Wang
Professor and Chief Expert of the National Center for Chronic and Noncommunicable Disease Control and Prevention, China CDC, Beijing, China
Chinese Association of Women and Child Health Studies, Beijing, China

Preplanned Studies

Cervical Cancer Screening Rates Among Chinese Women — China, 2023–2024

Mei Zhang[1]; Limin Wang[2]; Xiao Zhang[1]; Chun Li[1]; Zhenping Zhao[1]; Mengting Yu[1]; Maigeng Zhou[2]; Jing Wu[2,#]; Linhong Wang[2]

Summary

What is already known about this topic?

The Chinese government has established targets for cervical cancer screening coverage among women of appropriate age: 50% by 2025 and 70% by 2030. Previous data from 2018–2019 indicated that 36.8% of women aged 35–64 years had been screened in China.

What is added by this report?

In 2023–2024, screening rates reached 51.5% among women aged 35–64 years, 57.9% among women aged 35–44 years, and 36.8% among women aged 20 years and above. Rural screening coverage (48.2%) approached but remained slightly below the 50% target. Several regions, particularly in the Eastern, Central, and Southern regions have achieved the 2025 target. Significant determinants of low cervical cancer screening coverage among Chinese women encompassed lower educational attainment, unemployment status, limited household income, lack of health insurance coverage, and absence of health check-ups.

What are the implications for public health practice?

Intensified implementation of the Action Plan to Accelerate Elimination of Cervical Cancer is needed, particularly in rural areas with suboptimal screening rates. Enhanced health education and service delivery should target women of lower socioeconomic status to facilitate their active participation in screening programs.

ABSTRACT

Introduction: The Chinese government has established targets of 50% cervical cancer screening coverage by 2025 and 70% by 2030 for women of appropriate age. This study aimed to assess screening coverage across mainland China and analyze key sociodemographic and geographic determinants.

Methods: A nationally and provincially representative cross-sectional survey was conducted among adults from 31 provincial-level administrative divisions in China between August 2023 and May 2024. Following data cleaning, 96,819 female participants were included in the analysis. Cervical cancer ever-screening rates were calculated for the overall population and by subgroups. All results were weighted to provide more accurate population-level estimates.

Results: In 2023–2024, 51.5% of women aged 35–64 years had undergone cervical cancer screening at least once, with rates of 57.9% among women aged 35–44 years and 36.8% among women aged 20 years and above. Screening coverage in rural areas (48.2%) remained slightly below but approached the 50% target. Several regions (specifically, the Eastern, Central, and Southern regions) have achieved the 2025 target. Significant determinants of low cervical cancer screening coverage among Chinese women encompassed lower educational attainment, unemployment status, limited household income, lack of health insurance coverage, and absence of health check-ups (P<0.05 for all comparisons).

Conclusions: Intensified efforts are needed to implement the Action Plan to Accelerate Elimination of Cervical Cancer, particularly in rural areas. Additionally, enhanced health education and service provision should target women of lower socioeconomic status to promote their active participation in screening programs.

Cervical cancer is the second most common cancer in women of reproductive age worldwide, particularly in developing countries (*1*). Globally, an estimated 662,044 cases (age-standardized incidence rate, ASIR: 14.12/100,000) and 348,709 deaths (age-standardized mortality rate, ASMR: 7.08/100,000) from cervical cancer occurred in 2022, representing the fourth leading cause of cancer morbidity and mortality in women. Notably, China accounts for 23% of global cases and 16% of deaths (*2*). To address this significant global burden, the World Health Organization (WHO) launched the Global Initiative for Accelerated Elimination of Cervical Cancer in 2020, establishing national 90-70-90 targets for 2030, including screening 70% of women aged 35–45 years at least once in their lifetimes (*3*). In China, the National Public Health projects for cervical and breast cancer screening among women of eligible aged 35-64 years were initiated in 2009. Subsequently, in 2023, the Chinese central government released the Action Plan to Accelerate the Elimination of Cervical Cancer (2023–2030), setting screening coverage targets for women of appropriate age at 50% by 2025 and 70% by 2030 (*4*). However, our previous studies have indicated that cervical cancer screening rates in China remain suboptimal (*5*–*6*). The present study utilizes the latest nationally and provincially representative survey data to estimate screening coverage across Chinese mainland and analyze key sociodemographic and geographic determinants through logistic regression models based on complex sampling design. Our findings suggest that China as a whole have already achieved the 2025 target of screening 50% of women aged 35–64 years by 2024. Nevertheless, significant gaps remain in cervical cancer screening coverage to meet the 2030 target in rural areas and northeastern China. The study further demonstrates that women living in rural areas and those with low income, limited education, or unemployment are less likely to access cervical cancer screening services, thus requiring enhanced governmental attention and intervention.

This study utilized data from a national and provincial representative survey conducted in 2023–2024 to estimate current cervical cancer screening rates among adult women in China. Participants aged 18 years and above were selected from 298 districts/counties across all 31 provincial-level administrative divisions (PLADs) through a multi-stage and cluster randomized sampling method. The sampling methodology for survey districts/counties and participants has been described elsewhere (*7*–*8*). Trained local health staff conducted interviews using computer-assisted personal interviewing (CAPI). Female participants were asked about their history of cervical cancer screening, including the month and year of their most recent screening, if applicable. Among 198,303 adults selected for interview, 188,388 completed the survey, yielding a 95.0% response rate. We excluded 82,130 male participants, 196 female participants younger than 20 years, and 9,243 female participants with missing sociodemographic data or unclear responses regarding cervical cancer screening history, resulting in a final analytical sample of 96,819 female participants. The ever-screening rate was defined as the percentage of individuals in the total population who had undergone at least one screening in their lifetime. We calculated the percentages of participants screened within various intervals: previous 1 year, previous 2 years, previous 3 years, previous 5 years, and ever in lifetime. Design-based multivariate logistic regression analysis was employed to identify predictors of ever-screening uptake among women aged 35–64 years. Standard errors (SE) were estimated using Taylor linearization with finite population correction. Statistical significance was determined using two-sided $P<0.05$. All results were weighted using weights that incorporated multistage sampling weight, non-response weight, and post-stratification weight based on the seventh national census (2020) population to ensure representativeness at both national and provincial levels. All statistical analyses were performed using SAS (version 9.4, SAS Institute Inc., Cary, USA).

The final analysis encompassed 96,819 female participants aged 20 years and above. Among these participants, 48.2% resided in urban areas, 10.1% held college degrees, and 39.0% had undergone health examinations within the previous three years (Table 1).

In 2023–2024, 36.8% [95% confidence interval (*CI*): 35.5%, 38.1%] of Chinese adult women had undergone cervical cancer screening at least once in their lifetime. The ever-screening rates were 52.6% (95% *CI*: 50.8%, 54.4%) among women aged 30–49 years, 57.9% (95% *CI*: 55.9%, 60.0%) among women aged 35–44 years, and 51.5% (95% *CI*: 49.7%, 53.3%) among women aged 35–64 years (Table 2). The highest ever-screening rate was observed in the 35–44 age group, with rates declining to 4.7% among women aged 75 years and older. According to the data, 35.2%, 32.7%, and 24.2% of women had undergone cervical cancer screening at least once in the previous 5 years, the previous 3 years, and the previous year, respectively. Across all age groups and screening intervals, screening coverage was consistently higher among urban women compared to those living in rural areas (Table 2).

Lower cervical screening rates among women aged

TABLE 1. Sociodemographic characteristics of female participants aged 20 and above in the survey in China, 2023–2024.

Characteristics	No. of participants (*N*=96,819)	Proportion (%)
Age group (years)		
20–24	1,260	1.3
25–34	5,968	6.2
35–44	10,304	10.6
45–54	19,219	19.9
55–64	27,965	28.8
65–74	24,765	25.6
≥75	7,338	7.6
30–49	21,544	22.3
35–64	57,488	59.4
Residence		
Urban	46,634	48.2
Rural	50,185	51.8
Geographic region		
Northern	14,149	14.6
Northeastern	9,371	9.7
Eastern	24,626	25.4
Central	12,390	12.8
Southern	9,583	9.9
Southwestern	14,603	15.1
Northwestern	12,097	12.5
Education		
Primary or less	51,592	53.3
Secondary	24,615	25.4
High	10,835	11.2
College or above	9,777	10.1
Household income per capita (CNY)		
Q1 (<7,500)	16,649	17.2
Q2 (7,500–15,999)	18,616	19.2
Q3 (16,000–29,999)	15,630	16.2
Q4 (≥30,000)	19,300	19.9
Don't know/refused	26,624	27.5
Employment status		
Employed	57,249	59.1
Housework	24,932	25.8
Retired	4,414	4.6
Unemployed	10,224	10.5
With health insurance coverage		
No	2,310	2.4
Yes	94,509	97.6
Self-assessed health status		
Poor or fair	51,941	53.6
Good	44,878	46.4
Have health examination in the previous 3 years		
Yes	37,729	39.0
No	59,090	61.0

Abbreviation: CNY=Chinese Yuan.

TABLE 2. Cervical cancer screening coverages in women aged 20 years and above by age groups in China, 2023–2024.

Characteristics	Coverage (%) (95% *CI*)*			
	Screening ever in lifetime	Screening in the previous 5 years	Screening in the previous 3 years	Screening in the previous year
Total	36.8 (35.5, 38.1)	35.2 (34.0, 36.5)	32.7 (31.5, 33.9)	24.2 (23.2, 25.2)
Age group (years)				
20–24	7.5 (5.5, 9.4)	7.4 (5.4, 9.3)	7.0 (5.1, 8.9)	5.5 (3.6, 7.4)
25–34	32.7 (30.5, 34.9)	32.2 (30.0, 34.4)	30.4 (28.2, 32.6)	22.5 (20.5, 24.4)
35–44	57.9 (55.9, 60.0)	56.6 (54.6, 58.7)	53.3 (51.3, 55.3)	40.6 (38.6, 42.6)
45–54	56.2 (54.1, 58.4)	54.0 (51.8, 56.2)	50.0 (47.9, 52.2)	36.9 (35.0, 38.8)
55–64	38.0 (36.0, 40.0)	35.2 (33.3, 37.2)	31.9 (30.1, 33.8)	22.9 (21.4, 24.5)
65–74	12.6 (11.7, 13.5)	10.2 (9.3, 11.1)	8.7 (7.9, 9.5)	5.9 (5.3, 6.5)
≥75	4.7 (3.8, 5.6)	3.5 (2.7, 4.4)	3.2 (2.4, 4.0)	2.6 (1.9, 3.3)
30–49	52.6 (50.8, 54.4)	51.3 (49.5, 53.0)	48.2 (46.5, 49.9)	36.8 (35.3, 38.3)
35–64	51.5 (49.7, 53.3)	49.4 (47.7, 51.2)	45.9 (44.2, 47.5)	34.0 (32.6, 35.4)
Urban	38.8 (37.1, 40.4)	37.1 (35.5, 38.8)	34.5 (33.0, 36.1)	25.6 (24.3, 26.9)
30–49	53.8 (51.6, 56.1)	52.3 (50.1, 54.5)	49.4 (47.2, 51.5)	37.7 (35.8, 39.7)
35–44	59.0 (56.5, 61.5)	57.6 (55.0, 60.1)	54.3 (51.8, 56.8)	41.1 (38.6, 43.5)
35–64	53.3 (51.1, 55.4)	51.1 (48.9, 53.3)	47.4 (45.3, 49.5)	35.1 (33.3, 36.9)
Rural	33.1 (31.3, 34.9)	31.7 (29.9, 33.4)	29.3 (27.6, 30.9)	21.6 (20.1, 23.2)
30–49	49.8 (47.4, 52.2)	48.7 (46.4, 51.1)	45.5 (43.2, 47.8)	34.6 (32.3, 36.8)
35–44	55.2 (52.4, 58.0)	54.2 (51.5, 57.0)	50.9 (48.2, 53.7)	39.3 (36.5, 42.2)
35–64	48.2 (45.7, 50.7)	46.4 (43.9, 48.9)	43.1 (40.7, 45.4)	32.1 (29.9, 34.2)

Abbreviation: *CI*=confidence interval.

* Screening rates are all weighted percentages.

35–64 years were observed in those living in western China, those with less education (40.2%; 95% *CI*: 38.0%, 42.3%), those in the lowest income bracket (44.6%; 95% *CI*: 42.1%, 47.1%), those without health insurance (24.3%; 95% *CI*: 20.4%, 28.3%), and those without health examinations during the past 3 years (38.8%; 95% *CI*: 36.9%, 40.8%). Regional data indicated that three regions (specifically, the Eastern, Central, and Southern regions) had achieved the 50% screening target, followed by the Southwestern region with a screening rate of 49.8%. In contrast, the Northeastern region exhibited substantially lower screening coverage, remaining below 40% (Table 3).

Multivariate logistic regression analysis revealed that, compared to women without health insurance, having health insurance was strongly associated with an increased likelihood of screening uptake [odds ratio (*OR*): 2.70; 95% *CI*: 2.15%, 3.40%]. Similarly, having undergone a health examination in the previous 3 years was also associated with a significantly higher likelihood of screening (*OR*: 2.17; 95% *CI*: 2.03%, 2.32%) (Table 3).

DISCUSSION

Analysis of the current study demonstrates that in 2023–2024, 36.8% of women aged 20 years and above in China have undergone cervical cancer screening at least once in their lifetime. For women aged 30–49 years and 35–64 years, the 2025 target of 50% cervical cancer screening coverage has been surpassed. Nevertheless, screening uptake remains suboptimal, particularly in rural areas, certain PLADs, and among women of lower socioeconomic status.

Since the inception of China's first national free cervical cancer screening program for rural women aged 35–64 years in 2009, the country has achieved remarkable progress in improving screening rates through a comprehensive approach combining nationwide screening initiatives, public awareness campaigns, and technological advancements (*4*). This study demonstrates that these concerted efforts have yielded significant results. The screening coverage for women aged 35–64 years has increased substantially from approximately 36.8% in 2018 (*5*) to 51.5% in 2023–2024. More than half of women aged 30–49

TABLE 3. Multivariable logistic regression analysis of cervical cancer screening rates by sociodemographic factors among women aged 35–64 years in China, 2023–2024.

Characteristics	% (95% *CI*)	*OR* (95% *CI*)*	*P*
Geographic region			
Northern	43.4 (40.5, 46.3)	1.00(Ref)	0.002
Northeastern	33.8 (27.5, 40.2)	1.69(1.22, 2.36)	0.002
Eastern	58.8 (55.9, 61.6)	2.85 (2.05, 3.96)	<0.001
Central	58.1 (53.0, 63.1)	3.27 (2.26, 4.73)	<0.001
Southern	50.9 (44.1, 57.7)	2.36 (1.62, 3.44)	<0.001
Southwestern	49.8 (47.0, 52.6)	2.65 (1.90, 3.70)	<0.001
Northwestern	45.5 (40.5, 50.5)	1.87 (1.26, 2.77)	<0.001
Education			
Primary or less	40.2 (38.0, 42.3)	1.00（Ref）	
Middle	54.6 (52.4, 56.8)	1.87 (1.73, 2.01)	<0.0001
High	55.4 (52.6, 58.3)	1.87 (1.70, 2.07)	<0.0001
College or above	65.3 (61.8, 68.8)	2.46 (2.14, 2.84)	<0.0001
Household income per capita (CNY)			
Q1 (<7, 500)	44.6 (42.1, 47.1)	1.00（Ref）	
Q2 (7, 500–15, 999)	50.2 (47.9, 52.6)	1.22 (1.10, 1.35)	<0.0001
Q3 (16,000–29,999)	55.3 (52.6, 58.1)	1.37 (1.22, 1.53)	0.0009
Q4 (≥30,000)	58.8 (56.3, 61.2)	1.34 (1.20, 1.50)	<0.0001
Don't know or refused	46.3 (43.9, 48.6)	0.96 (0.86, 1.08)	0.496
Employment status			
Employed	53.8 (51.8, 55.8)	1.00 (Ref)	<0.0001
Housework	46.7 (44.3, 49.0)	1.57 (1.37, 1.78)	<0.0001
Retired	43.9 (39.3, 48.5)	1.47 (1.26, 1.72)	0.277
Unemployed	48.3 (44.3, 52.2)	1.12（0.91, 1.38）	
With health insurance coverage			
No	24.3 (20.4, 28.3)	1.00（Ref）	
Yes	52.1 (50.3, 53.8)	2.70 (2.15, 3.40)	<0.0001
Self-assessed health status			
Good	50.1 (48.1, 52.1)	1.00（Ref）	
Poor or fair	52.9 (51.1, 54.7)	1.21(1.11, 1.25)	<0.0001
Have health examination in past 3 years			
No	38.8 (36.9, 40.8)	1.00（Ref）	
Yes	61.8 (60.0, 63.6)	2.17 (2.03, 2.32)	<0.0001

Abbreviation: *OR*=odds ratio; *CI*=confidence interval.

**OR*, *CI*, and *P* were calculated using ever screened rates.

years have undergone at least one screening in their lifetime or within various screening intervals, exceeding the worldwide average screening rate reported in 2019 (*9*). However, a considerable disparity remains when compared to screening coverage in developed nations (e.g., 87% in the United States, 88% in Canada) (*9–10*). Although more than 57% of women aged 35–44 years have been screened at least once, this coverage still falls substantially short of both the national and WHO 2030 targets.

A particularly encouraging finding from this study is that half of the regions in Chinese mainland have already surpassed the 2025 screening rate target ahead of schedule. Five years ago, only 3 PLADs had achieved the 50% target, and screening rates in 12 PLADs were below 40% (*4*). This marked improvement underscores the effectiveness of implementing the free national screening program across diverse geographical regions.

This study was subject to at least two limitations. First, while the CAPI methodology reduced recall bias, it did not completely eliminate this potential source of error. Second, as this investigation was not specifically designed to assess cervical cancer screening, the questionnaire's limited scope precluded the inclusion of questions addressing practical barriers or individual reasons for non-participation in screening programs.

In summary, based on nationally and provincially representative survey data from 2023–2024, we present the most current estimates of cervical cancer screening rates across mainland China. Overall, 51.5%, 49.4%, 45.9%, and 34.0% of women aged 35–64 years have undergone screening at least once in their lifetime, and within the previous 5 years, 3 years, and 1 year, respectively. For the target population of women aged 35–64 years, the overall screening rate has reached the 2025 target, though this achievement is primarily driven by urban participation, with rural areas still showing a modest gap. To bridge the remaining disparities and meet both National and WHO targets for 2030, sustained policy and financial support for cervical cancer screening services is essential. Health education and outreach efforts should specifically target recommended age groups, while accessibility to health services requires strengthening in rural areas and northeastern regions.

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[#] Corresponding author: Jing Wu, wujing@ncncd.chinacdc.cn.

[1] Division of NCD and Risk Factor Surveillance, National Center for Chronic and Noncommunicable Disease Control and Prevention, Chinese Center for Disease Control and Prevention, Beijing, China; [2] National Center for Chronic and Noncommunicable Disease Control and Prevention, Chinese Center for Disease Control and Prevention, Beijing, China.

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Preplanned Studies

Association Between High-Risk Human Papillomavirus Infection and Cervical Cytology in Health Check-Up Women — 23 PLADs, China, 2023

Di Gao[1]; Gengli Zhao[1]; Xueyin Wang[1]; Juan Juan[1]; Yupeng Shi[2]; Taoye Xu[2]; Yue Wang[2]; Linhong Wang[3,#]; Xiaosong Zhang[1,#]

Summary

What is already known about this topic?

Previous studies have documented the prevalence and distribution of human papillomaviruses (HPV) infection. However, there is limited current nationwide data on HPV distribution across different cytological conditions in recent years.

What is added by this report?

This nationwide, cross-sectional study reveals that detection rates of HR-HPV infection and abnormal cytology among women undergoing health check-ups remain relatively high in China. Among women with abnormal cervical cytology, HPV-16 was the most prevalent HR-HPV genotype, followed by HPV-58 and HPV-52.

What are the implications for public health practice?

These findings, based on a large population sample across China, provide critical insights into current cervical cancer screening outcomes and can inform the development of HPV genotype-specific vaccination and screening strategies to reduce cervical cancer burden.

ABSTRACT

Introduction: Human papillomaviruses (HPV) testing and liquid-based cytology (LBC) are the primary screening methods for cervical cancer. However, recent nationwide data on HPV distribution across different cytological conditions in China remains limited.

Methods: This nationwide cross-sectional study analyzed health check-up data from the Dian laboratory network across China in 2023. The study included 238,807 women aged ≥20 years from 23 PLADs who underwent both HPV genotyping and LBC testing. The rates of abnormal cytology and HPV infection were weighted and standardized according to the Seventh National Population Census (2020).

Results: The overall weighted rates of HR-HPV infection and abnormal cytology were 12.30% and 9.25%, respectively. Among women with abnormal cervical cytology, HPV-16 was the most prevalent HR-HPV genotype, followed by HPV-58 and HPV-52.

Conclusions: The detection rates of HR-HPV and abnormal cytology remain relatively high in China. Both single and multiple HR-HPV infections were associated with increased risk of abnormal cervical cytology. These findings may inform the development of HPV genotype-specific vaccination and screening strategies to reduce cervical cancer burden.

Cervical cancer ranks as the fourth most common cancer globally in terms of both incidence and mortality among women, with a particularly high burden in low- and middle-income countries (*1*). Analysis of 700 population-based cancer registries in China revealed approximately 150,700 new cervical cancer cases and 55,700 deaths in 2022 (*2*). Human papillomaviruses (HPV) are sexually transmitted viruses that have been established as the primary etiological factor in cervical cancer development. While HPV testing and liquid-based cytology (LBC) remain the cornerstone methods for cervical cancer screening, current comprehensive data on high-risk HPV (HR-HPV) infection and LBC findings across China are limited. This nationwide, cross-sectional, population-based study conducted in 2023 aimed to characterize the detection rates of HR-HPV infection and abnormal cervical cytology among women undergoing health check-ups, and to analyze the associations between cytological abnormalities and HR-HPV infections. The study included 238,807 eligible women aged 20 years or older from 23 provincial-level administrative divisions (PLADs). Analysis revealed weighted detection rates of 12.30% for HR-HPV infection and 9.25% for abnormal cytology. Among women with abnormal cervical cytology, HPV-16 was the predominant HR-HPV genotype, followed by HPV-58 and HPV-52. These findings, derived from a large population-based sample in China, provide valuable insights into the current status of cervical cancer screening outcomes and may inform the development of HPV genotype-specific vaccination and screening strategies to reduce cervical cancer burden.

This nationwide, cross-sectional, population-based study utilized de-identified data from the Dian laboratory health check-ups database across China. From 248,913 women who underwent routine health check-ups or cervical cancer screening in 2023 across 1,638 submission units in 221 cities across 28 PLADs, 238,807 eligible women (95.9%) from 208 cities in 23 PLADs met the inclusion criteria: complete age and submission unit data, comprehensive testing data for 23 HPV genotypes and LBC outcomes, age ≥20 years, and a minimum of 1,000 individuals tested per PLAD. HPV specimens were collected by clinical physicians or nurses following standardized protocols. HPV detection and genotyping were performed using the Human Papillomavirus DNA Test Kit (Fluorescence Melting Curve Method) (Hangzhou DIAN Biotechnology Co., Ltd). The assay detected 14 HR-HPV genotypes: HPV-16, -18, -31, -33, -35, -39, -45, -51, -52, -56, -58, -59, -66, and -68. Single infection was defined as infection with one HPV genotype, while multiple infections were defined as infections with two or more genotypes. LBC was conducted following standard operating procedures, including Papanicolaou staining and liquid-based cytology sample preparation. LBC outcomes were classified according to The Bethesda System for Reporting Cervical Cytology (TBS) as: negative for intraepithelial lesion or malignancy (NILM), atypical squamous cells (ASC) including atypical squamous cells of undetermined significance (ASC-US) and atypical squamous cells-cannot exclude high-grade squamous intraepithelial lesion (ASC-H), low-grade squamous intraepithelial lesion (LSIL), high-grade squamous intraepithelial lesion (HSIL), squamous cell carcinoma (SCC), and atypical glandular cells (AGC). Due to low detection rates, ASC-H was combined with ASC-US into ASC for analysis, while AGC and SCC were excluded due to insufficient numbers for independent analysis.

Statistical analysis included descriptive statistics using frequencies and proportions, with group comparisons performed using Chi-square tests. Detection rates for abnormal cytology and HPV infection were weighted and standardized by 5-year age groups and provinces according to the female population distribution (aged ≥20 years) from the Seventh National Population Census in 2020. Multivariable logistic regression was employed to calculate odds ratios (*OR*) and 95% confidence intervals (*CI*), adjusting for age group, geographical region, and city-level random effects. Analyses were conducted using R software (version 4.4.2, R Core Team, Vienna, Austria), with statistical significance set at $P<0.05$ using two-tailed tests.

Among the 238,807 women aged 20 years and older (mean age 42.0±10.2 years), 17,271 individuals presented with cytological abnormalities. The weighted rates were 6.24% for ASC-US, 0.27% for ASC-H, 2.34% for LSIL, and 0.40% for HSIL (Table 1). Significant differences in LBC outcomes were observed across age groups ($P<0.001$), with total abnormality, LSIL, and HSIL rates increasing with age. Notable variations were also found across regions and HR-HPV infection groups, with the weighted rate of cytological abnormality exceeding 50% in the multiple infection group.

The overall weighted HR-HPV infection rate was 12.30%, comprising 10.55% single infections and 1.75% multiple infections. Figure 1 illustrates the distribution of HR-HPV genotypes across different LBC outcomes. HR-HPV infection rates varied significantly by cytological status: 7.78% in NILM, 52.34% in ASC, 69.82% in LSIL, and 94.74% in HSIL. HPV-16, HPV-52, and HPV-58 were the predominant genotypes across both single and multiple infections. While HPV-52 and HPV-58 showed the highest infection rates in NILM specimens, HPV-16 demonstrated increasing prevalence in more severe cytological abnormalities, reaching 9.77% for single infections and 2.66% for multiple infections in ASC. In HSIL specimens, HPV-16 single infection rates peaked at 42.27%, with multiple infections at 10.52%.

Table 2 presents the associations between HR-HPV infections and cervical cytological abnormalities. All 14 HR-HPV genotypes exhibited statistically significant positive associations with both ASC and LSIL, regardless of single or multiple infections, when compared to HPV-negative groups. Notably, for HSIL, significant associations were observed exclusively with multiple infection with any HR-HPV genotypes and single infections of HR-HPV types 16, 18, 31, 33, 35, 52, and 58.

TABLE 1. The weighted prevalence of cervical cytology outcomes among women in 23 PLADs, China, 2023.

Characteristics	*N* (%)	NILM (%, 95% *CI*)	ASC-US (%, 95% *CI*)	ASC-H (%, 95% *CI*)	LSIL (%, 95% *CI*)	HSIL (%, 95% *CI*)	*P*
Overall	238,807 (100.00)	90.75 (89.59, 91.97)	6.24 (5.87, 6.71)	0.27 (0.20, 0.49)	2.34 (2.11, 2.67)	0.40 (0.27, 0.67)	
Age groups (years)							<0.001
20−24	5,923 (2.48)	90.60 (87.01, 94.44)	7.04 (5.94, 8.44)	−	2.36 (1.82, 3.24)	−	
25−29	17,268 (7.23)	93.62 (91.47, 95.84)	4.51 (4.03, 5.08)	0.04 (0.02, 0.22)	1.77 (1.43, 2.22)	0.06 (0.02, 0.24)	
30−34	39,132 (16.39)	93.82 (92.30, 95.39)	4.41 (4.07, 4.81)	0.12 (0.08, 0.23)	1.54 (1.32, 1.81)	0.11 (0.05, 0.24)	
35−39	43,184 (18.08)	93.16 (91.70, 94.66)	4.66 (4.32, 5.03)	0.16 (0.09, 0.28)	1.85 (1.63, 2.12)	0.18 (0.13, 0.28)	
40−44	39,320 (16.47)	93.42 (91.86, 95.02)	4.71 (4.34, 5.12)	0.13 (0.07, 0.24)	1.54 (1.34, 1.80)	0.21 (0.12, 0.35)	
45−49	36,602 (15.33)	92.35 (90.61, 94.13)	5.22 (4.78, 5.71)	0.15 (0.08, 0.30)	2.11 (1.83, 2.45)	0.18 (0.11, 0.32)	
50−54	30,267 (12.67)	90.70 (88.84, 92.63)	6.49 (5.95, 7.09)	0.26 (0.15, 0.46)	2.22 (1.92, 2.59)	0.33 (0.22, 0.53)	
55−59	15,613 (6.54)	88.98 (86.38, 91.69)	7.48 (6.76, 8.32)	0.44 (0.26, 0.80)	2.79 (2.33, 3.39)	0.32 (0.16, 0.65)	
60−64	6,662 (2.79)	87.51 (83.45, 91.88)	7.66 (6.55, 9.11)	0.96 (0.49, 1.91)	3.30 (2.58, 4.40)	0.57 (0.29, 1.35)	
65−69	3,011 (1.26)	87.93 (81.55, 95.22)	7.14 (5.44, 10.00)	0.72 (0.31, 2.78)	3.60 (2.23, 6.28)	0.62 (0.22, 2.71)	
≥70	1,825 (0.76)	85.91 (78.74, 93.99)	9.30 (6.82, 12.89)	0.24 (0.01, 2.21)	3.00 (1.68, 5.57)	1.56 (0.63, 3.88)	
Geographical regions							<0.001
Eastern	98,582 (41.28)	91.68 (90.20, 93.23)	5.69 (5.26, 6.21)	0.23 (0.16, 0.45)	2.18 (1.94, 2.52)	0.24 (0.17, 0.45)	
Central	95,710 (40.08)	90.77 (88.96, 92.82)	6.10 (5.49, 7.03)	0.28 (0.14, 0.94)	2.29 (1.83, 3.12)	0.55 (0.34, 1.22)	
Western	44,515 (18.64)	88.94 (85.74, 92.49)	7.50 (6.44, 9.01)	0.35 (0.20, 1.23)	2.70 (2.19, 3.73)	0.51 (0.13, 1.62)	
HR-HPV infection							<0.001
Negative	212,808 (89.11)	95.47 (94.11, 97.18)	3.55 (3.25, 4.40)	0.07 (0.02, 0.96)	0.86 (0.74, 1.67)	0.05 (0.01, 0.95)	
Single	22,780 (9.54)	60.17 (57.41, 63.80)	24.72 (22.69, 27.72)	1.70 (1.29, 3.64)	10.81 (9.81, 12.98)	2.60 (1.62, 4.93)	
Multiple	3,219 (1.35)	47.64 (42.85, 53.80)	27.80 (24.35, 32.70)	1.51 (0.80, 4.52)	19.8 (16.54, 24.59)	3.26 (1.77, 6.81)	

Note: The weighted prevalence of cervical cytology outcomes was standardized by age groups and provinces according to the distribution of the female population aged 20 years and above from the Seventh National Population Census in 2020. "−" means the number of detected cases in this group is zero.

Abbreviation: PLADs=provincial-level administrative divisions; *CI*=confidence interval; NILM=negative for intraepithelial lesion or malignancy; ASC-US=atypical squamous cells of undetermined significance; ASC-H=atypical squamous cells-cannot exclude high-grade squamous intraepithelial lesion; LSIL=low-grade squamous intraepithelial lesion; HSIL=high-grade squamous intraepithelial lesion; HR-HPV=high-risk human papillomavirus.

DISCUSSION

This study revealed that the HR-HPV infection rate was 12.30%, with an abnormal cytology detection rate of 9.25%. The HR-HPV infection rate demonstrated a clear correlation with cervical cytological severity, increasing from 7.78% in NILM to 94.74% in HSIL. Both HR-HPV multiple infections and single infections showed significant associations with cytological abnormalities, with most HR-HPV single infections and all multiple infections conferring higher risks of ASC, LSIL, and HSIL. These findings underscore the critical role of multiple HR-HPV infections and single infections of highly carcinogenic types (particularly HPV-16) in driving cytological changes. Furthermore, these results highlight the essential value of combined LBC and HPV screening in risk assessment for precancerous lesions and the development of clinical management strategies.

The weighted detection rates of HR-HPV infection (12.30%) and abnormal cytology (≥ASC-US) (9.25%) observed in our study are comparable to previous research in China, which reported similar HR-HPV infection rates (12.1%) but lower rates of abnormal

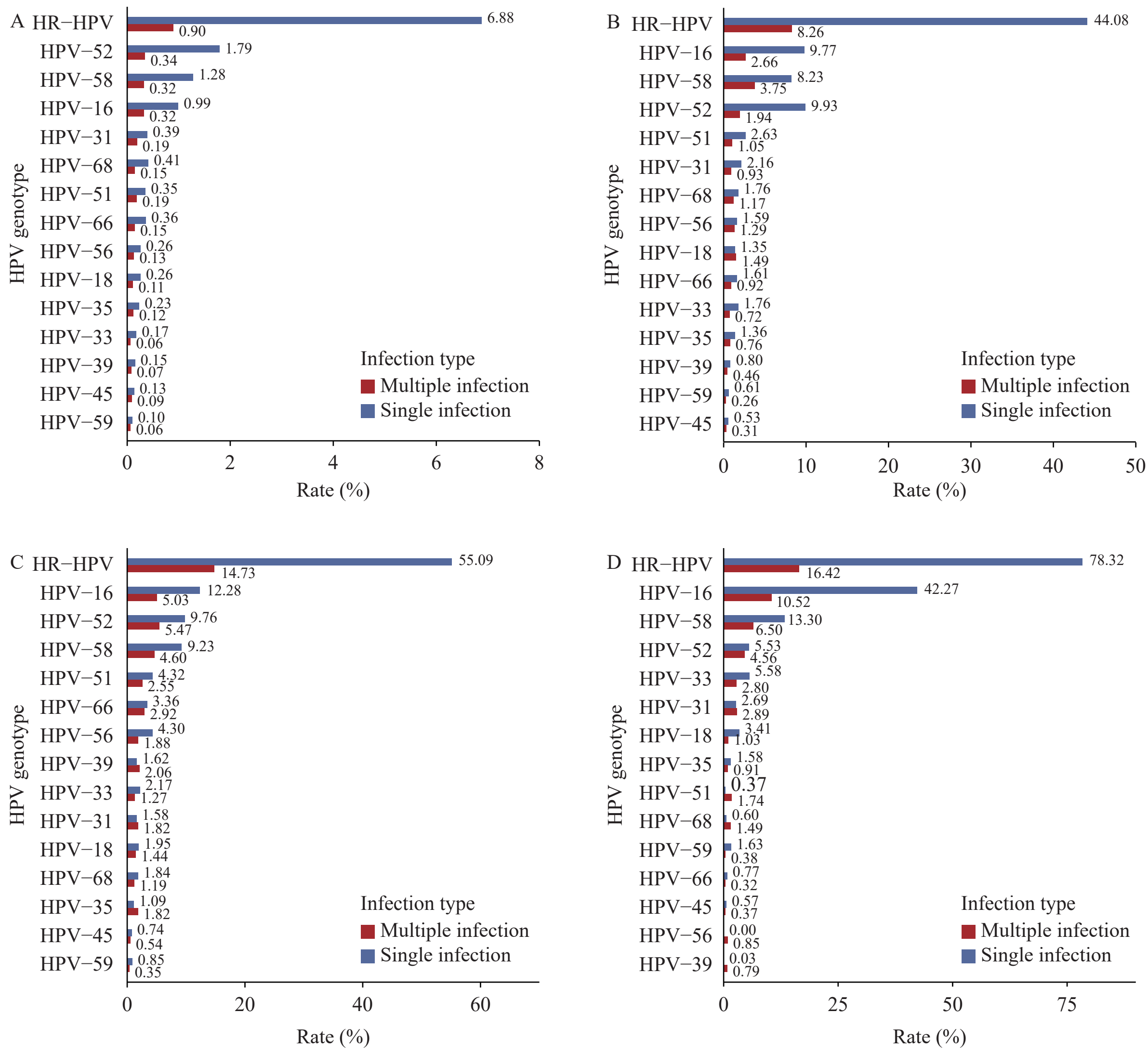

FIGURE 1. Distribution of HR-HPV single and multiple infections across cervical cytology outcomes among women in 23 PLADs, China, 2023. (A) NILM; (B) ASC; (C) LSIL; (D) HSIL.

Note: The weighted rates of HR-HPV single and multiple infections were standardized by age groups and provinces according to the female population aged 20 and above from the Seventh National Population Census in 2020.

Abbreviation: HR-HPV=high-risk human papillomavirus; PLADs=provincial-level administrative divisions; NILM=negative for intraepithelial lesion or malignancy; ASC=atypical squamous cells; LSIL=low-grade squamous intraepithelial lesion; HSIL=high-grade squamous intraepithelial lesion.

cytology (7.48%) (*3–4*) . Age-specific analysis revealed that cytological abnormalities predominantly manifested as ASC and LSIL in younger age groups, potentially reflecting transient or short-term HR-HPV infections. Conversely, HSIL detection rates increased with age, particularly among women aged 60 and above. This age-dependent increase in HSIL likely results from the cumulative effects of persistent HPV infections, immunological changes, and hormonal variations. These patterns emphasize the necessity for age-specific screening and management protocols, with particular attention to screening and follow-up in elderly populations. Current evidence has identified 13 HPV genotypes as carcinogenic for cervical cancer (*5*). Persistent infection with HR-HPV, especially those with high carcinogenic potential, is well-established as the primary etiological factor in the development of abnormal cervical cytology, precancerous lesions, and cervical cancer (*6*). Our findings demonstrated that HR-HPV multiple infection rates increased proportionally with cervical cytological severity. However, since cytological abnormalities do not invariably progress to precancerous lesions, further research is needed to determine whether HR-HPV

TABLE 2. Association between HR-HPV genotype infection and abnormal cervical cytology among women in 23 PLADs, China, 2023.

HR-HPV genotype	NILM	ASC		LSIL		HSIL	
	n (%)	*n* (%)	a*OR* (95% *CI*)*	*n* (%)	a*OR* (95% *CI*)*	*n* (%)	a*OR* (95% *CI*)*
HPV-16							
Negative	219,049 (93.7)	11,120 (4.8)	1.00 (Ref)	3,466 (1.5)	1.00 (Ref)	205 (0.1)	1.00 (Ref)
Single infection	1,996 (51.5)	1,174 (30.3)	12.16 (11.26, 13.13)	500 (12.9)	16.51 (14.85, 18.37)	203 (5.2)	111.23 (90.57, 136.61)
Multiple infection	491 (44.9)	363 (33.2)	14.01 (12.18, 16.11)	185 (16.9)	23.63 (19.81, 28.20)	55 (5.0)	116.89 (84.65, 161.42)
HPV-18							
Negative	220,794 (92.9)	12,317 (5.2)	1.00 (Ref)	4,017 (1.7)	1.00 (Ref)	446 (0.2)	1.00 (Ref)
Single infection	539 (62.1)	245 (28.2)	7.82 (6.73, 9.10)	73 (8.4)	7.09 (5.56, 9.04)	11 (1.3)	9.26 (4.94, 17.33)
Multiple infection	203 (55.6)	95 (26.0)	8.44 (6.68, 10.65)	61 (16.7)	17.02 (12.85, 22.54)	6 (1.6)	13.71 (5.80, 32.42)
HPV-31							
Negative	220,367 (92.9)	12,299 (5.2)	1.00 (Ref)	3,990 (1.7)	1.00 (Ref)	442 (0.2)	1.00 (Ref)
Single infection	899 (73.0)	239 (19.4)	4.56 (3.94, 5.27)	82 (6.7)	4.79 (3.82, 6.00)	12 (1.0)	5.66 (3.14, 10.18)
Multiple infection	270 (56.6)	119 (24.9)	7.23 (5.86, 8.91)	79 (16.6)	15.32 (11.90, 19.73)	9 (1.9)	13.94 (7.00, 27.77)
HPV-33							
Negative	220,972 (92.9)	12,370 (5.2)	1.00 (Ref)	4,014 (1.7)	1.00 (Ref)	425 (0.2)	1.00 (Ref)
Single infection	420 (55.3)	214 (28.2)	8.25 (7.00, 9.72)	98 (12.9)	11.60 (9.27, 14.51)	28 (3.7)	29.09 (19.35, 43.73)
Multiple infection	144 (54.1)	73 (27.4)	8.39 (6.37, 11.04)	39 (14.7)	14.82 (10.36, 21.21)	10 (3.8)	30.77 (15.55, 60.89)
HPV-35							
Negative	220,833 (92.9)	12,385 (5.2)	1.00 (Ref)	4,025 (1.7)	1.00 (Ref)	451 (0.2)	1.00 (Ref)
Single infection	507 (69.1)	164 (22.3)	5.32 (4.48, 6.33)	55 (7.5)	5.66 (4.32, 7.40)	8 (1.1)	6.70 (3.27, 13.71)
Multiple infection	196 (51.7)	108 (28.5)	9.05 (7.25, 11.29)	71 (18.7)	19.77 (15.13, 25.85)	4 (1.1)	7.94 (2.86, 22.04)
HPV-39							
Negative	221,068 (92.9)	12,466 (5.2)	1.00 (Ref)	4,053 (1.7)	1.00 (Ref)	460 (0.2)	1.00 (Ref)
Single infection	333 (65.2)	127 (24.9)	6.88 (5.62, 8.43)	50 (9.8)	7.96 (5.92, 10.7)	1 (0.2)	1.43 (0.20, 10.50)
Multiple infection	135 (54.2)	64 (25.7)	8.49 (6.34, 11.37)	48 (19.3)	21.32 (15.38, 29.56)	2 (0.8)	6.58 (1.55, 27.88)
HPV-45							
Negative	221,121 (92.8)	12,547 (5.3)	1.00 (Ref)	4,098 (1.7)	1.00 (Ref)	458 (0.2)	1.00 (Ref)
Single infection	256 (72.7)	66 (18.8)	4.20 (3.22, 5.46)	29 (8.2)	5.64 (3.89, 8.19)	1 (0.3)	1.56 (0.31, 7.89)
Multiple infection	159 (68.8)	44 (19.0)	5.18 (3.74, 7.18)	24 (10.4)	8.65 (5.70, 13.11)	4 (1.7)	11.52 (4.40, 30.14)
HPV-51							
Negative	220,504 (93.0)	12,223 (5.2)	1.00 (Ref)	3,864 (1.6)	1.00 (Ref)	454 (0.2)	1.00 (Ref)
Single infection	746 (62.7)	273 (22.9)	6.57 (5.71, 7.55)	169 (14.2)	12.98 (10.93, 15.42)	2 (0.2)	1.29 (0.31, 5.29)
Multiple infection	286 (50.0)	161 (28.1)	9.50 (7.86, 11.49)	118 (20.6)	23.52 (18.87, 29.32)	7 (1.2)	10.48 (4.82, 22.77)
HPV-52							
Negative	217,250 (93.6)	11,069 (4.8)	1.00 (Ref)	3,479 (1.5)	1.00 (Ref)	414 (0.2)	1.00 (Ref)
Single infection	3,697 (67.9)	1,263 (23.2)	6.41 (6.00, 6.86)	454 (8.3)	7.31 (6.59, 8.12)	30 (0.6)	4.01 (2.76, 5.82)
Multiple infection	589 (51.2)	325 (28.2)	9.92 (8.64, 11.39)	218 (18.9)	21.79 (18.52, 25.63)	19 (1.7)	14.36 (8.90, 23.16)
HPV-56							
Negative	220,768 (93.0)	12,331 (5.2)	1.00 (Ref)	3,881 (1.6)	1.00 (Ref)	459 (0.2)	1.00 (Ref)
Single infection	538 (58.4)	200 (21.7)	6.51 (5.53, 7.65)	183 (19.9)	18.91 (15.86, 22.55)	0	–
Multiple infection	230 (51.5)	126 (28.2)	8.79 (7.11, 10.86)	87 (19.5)	19.57 (15.13, 25.29)	4 (0.9)	6.30 (2.43, 16.33)

Continued

HR-HPV genotype	NILM	ASC		LSIL		HSIL	
	n (%)	*n* (%)	a*OR* (95% *CI*)*	*n* (%)	a*OR* (95% *CI*)*	*n* (%)	a*OR* (95% *CI*)*
HPV-58							
Negative	218,443 (93.4)	11,416 (4.9)	1.00 (Ref)	3,549 (1.5)	1.00 (Ref)	373 (0.2)	1.00 (Ref)
Single infection	2,574 (64.8)	913 (23.0)	6.46 (5.97, 6.99)	425 (10.7)	9.64 (8.64, 10.75)	58 (1.5)	11.61 (8.71, 15.46)
Multiple infection	519 (49.1)	328 (31.1)	11.25 (9.78, 12.95)	177 (16.8)	20.64 (17.31, 24.60)	32 (3.0)	31.61 (21.47, 46.55)
HPV-59							
Negative	221,123 (92.8)	12,529 (5.3)	1.00 (Ref)	4,089 (1.7)	1.00 (Ref)	458 (0.2)	1.00 (Ref)
Single infection	285 (70.4)	83 (20.5)	5.13 (4.08, 6.44)	35 (8.6)	6.70 (4.82, 9.31)	2 (0.5)	3.56 (0.87, 14.59)
Multiple infection	128 (63.1)	45 (22.2)	6.15 (4.56, 8.30)	27 (13.3)	12.57 (8.66, 18.25)	3 (1.5)	9.40 (2.87, 30.86)
HPV-66							
Negative	220,451 (93.0)	12,325 (5.2)	1.00 (Ref)	3,890 (1.6)	1.00 (Ref)	456 (0.2)	1.00 (Ref)
Single infection	815 (69.4)	204 (17.4)	4.31 (3.69, 5.03)	154 (13.1)	10.39 (8.72, 12.38)	2 (0.2)	1.08 (0.29, 3.98)
Multiple infection	270 (52.9)	128 (25.1)	8.13 (6.60, 10.03)	107 (21.0)	22.33 (17.74, 28.11)	5 (1.0)	7.45 (3.10, 17.88)
HPV-68							
Negative	220,224 (92.9)	12,281 (5.2)	1.00 (Ref)	4,019 (1.7)	1.00 (Ref)	455 (0.2)	1.00 (Ref)
Single infection	1,021 (75.9)	251 (18.7)	4.19 (3.64, 4.81)	70 (5.2)	3.46 (2.73, 4.40)	3 (0.2)	1.35 (0.43, 4.27)
Multiple infection	291 (60.2)	125 (25.9)	7.26 (5.91, 8.91)	62 (12.8)	10.88 (8.31, 14.25)	5 (1.0)	7.00 (2.82, 17.36)

Note: "−" means the number of detected cases in this group is zero.

Abbreviation: HR-HPV=high-risk human papillomavirus; PLADs=provincial-level administrative divisions; NILM=negative for intraepithelial lesion or malignancy; ASC=atypical squamous cells; LSIL=low-grade squamous intraepithelial lesion; HSIL=high-grade squamous intraepithelial lesion; a*OR*=adjusted odds ratio; *CI*=confidence interval; Ref=reference.

* Adjusted for age group, geographical region, and the random effects at city level.

multiple infections increase the risk of cervical cancer progression.

In this study, the five most prevalent HR-HPV genotypes identified in the population with normal cytology were HPV-52, -58, -16, -68, and -31, aligning with previous global and Chinese research findings (*7*–*8*). Although HPV-52 and HPV-58 show relatively high prevalence in China, HPV-16 remained the predominant genotype among women with LSIL and HSIL. This finding underscores the exceptional carcinogenic potential of HPV-16, which accounts for over 60% of cervical squamous cell carcinomas, adenocarcinomas, and other anogenital and oropharyngeal cancers (*9*). A study examining HPV genotype-specific population attributable fractions (AFs) in invasive cervical cancer reveals that HPV-16, -18, -31, -33, -35, -45, -52, and -58 demonstrate the highest AFs, closely corresponding to the high-detection-rate HR-HPV genotypes in HSIL observed in our study. In China, the combined AF of HPV-16 and -18 reaches 75.6%, while the AF for HPV-16, -18, -31, -33, -45, -52, and -58 collectively accounts for 95.4% (*10*). Therefore, despite bivalent and quadrivalent HPV vaccines not including HPV-52 and HPV-58, expanding vaccination coverage remains crucial, regardless of vaccine type.

This study's primary strengths lie in its utilization of a large-scale, multi-center database from across China and standardized quality control procedures, enhancing data reliability and providing valuable insights for cervical cancer screening. However, several limitations warrant consideration. First, while based on comprehensive cervical cancer screening data, the study lacks colposcopy and histopathology results post-screening, which could have enabled further analysis of the causal relationship between HR-HPV genotype infection and invasive cervical cancer. Second, the cross-sectional design without longitudinal follow-up precludes investigation of persistent HR-HPV infection's impact on cervical cytological changes and precancerous lesions. Third, the database lacks crucial personal information, including residential area and HPV vaccination status. Nevertheless, this remains a significant population-based study in China, providing a foundation for future research.

In conclusion, this nationwide cross-sectional study revealed persistently high detection rates of HR-HPV infection and abnormal cytology based on a large-scale cervical cancer screening database in China. Among women with abnormal cervical cytology, HPV-16 emerged as the predominant HR-HPV genotype, followed by HPV-58 and HPV-52. These findings provide valuable insights that may inform the development of targeted HPV genotype-specific vaccination strategies and optimize screening protocols to reduce the burden of cervical cancer in China.

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[#] Corresponding authors: Xiaosong Zhang, zhangxiaosong@bjmu.edu.cn; Linhong Wang, linhong@chinawch.org.cn.

[1] Department of Obstetrics and Gynecology and Reproductive Medicine, Peking University First Hospital, Beijing, China; [2] Hangzhou Dian Medical Laboratory Center, Hangzhou City, Zhejiang Province, China; [3] National Center for Chronic and Non-Communicable Disease Control and Prevention, Chinese Center for Disease Control and Prevention, Beijing, China.

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Preplanned Studies

Prevalence and Severity of Menopausal Symptoms in Women of Different Ages — China, 2023–2024

Zhenghua Yong[1]; Yehuan Yang[2]; Yilin Yang[1]; Li Yang[2]; Yanxia Zhao[2]; Xiaomin Luo[2]; Mengke Yan[1]; Ruimin Zheng[2,#]

Summary

What is already known about this topic?

During menopause, women frequently experience a spectrum of physical, mental, and psychological symptoms due to declining ovarian function and fluctuating estrogen levels. There has been a notable absence of systematic, large-scale cross-sectional studies examining menopausal symptoms among Chinese women in recent years.

What is added by this report?

This study examines menopausal symptoms in Chinese women aged 40–60 years, documenting an overall prevalence of 46.3%. The three most commonly reported symptoms are insomnia (50.0%), fatigue (48.2%), and nervousness (46.9%). The prevalence of menopausal symptoms begins to increase in women over age 44, reaching its peak at age 52. Statistically significant differences in symptom severity exist between premenopausal and postmenopausal women within the 45–49 and 50–54 year age groups.

What are the implications for public health practice?

This study represents the first comprehensive large-scale investigation of menopausal symptoms in Chinese women. The findings demonstrate that symptom prevalence varies with age, providing an evidence base for developing targeted health management strategies and interventions specific to different age groups, ultimately enhancing the physical and mental well-being of women experiencing menopause.

ABSTRACT

Objective: To investigate the prevalence and severity of menopausal symptoms among Chinese women aged 40–60 years and provide evidence for developing personalized health management strategies.

Methods: Using a multi-stage stratified cluster sampling approach, we conducted a nationwide cross-sectional survey across representative provincial-level administrative divisions (PLADs) and prefecture-level cities, encompassing 26 district/county survey sites. The questionnaire collected information on demographic characteristics, menopausal status, and symptoms. Data analysis employed means and standard deviations ($\bar{X}$±*S*) or rates and proportion ratios to describe menopausal symptom occurrence, with group differences analyzed using Mann-Whitney or Kruskal-Wallis tests.

Results: The study included 42,304 women with a mean age of 49.9±5.7 years. The overall prevalence of menopausal symptoms was 46.3% [95% confidence interval (*CI*): 45.8%, 46.7%], predominantly mild to moderate in severity. The prevalence of mild to severe symptoms began increasing in women over age 44, peaking at age 52. Moderate to severe symptoms showed an uptick after age 46, also peaking at 52 years, while severe symptoms increased after age 48, reaching maximum prevalence at age 56. The most commonly reported symptoms were insomnia (50.0%, 95% *CI*: 49.5%, 50.5%), fatigue (48.2%, 95% *CI*: 47.7%, 48.7%), and nervousness (46.9%, 95% *CI*: 46.5%, 47.4%). Significant differences in symptom severity between premenopausal and postmenopausal women were observed in the 45–49 (P<0.001) and 50–54 (P=0.019 <0.05) age groups.

Conclusions: The study revealed distinct patterns in the prevalence, severity, and manifestation of menopausal symptoms across different age groups in China. The age-related progression of symptoms provides a scientific foundation for developing targeted healthcare interventions for women at various stages of menopause.

Menopause represents a critical transitional phase in the female life cycle, characterized by the progressive decline of ovarian function from peak activity to complete cessation. This transition typically occurs between ages 40 and 60 years, encompassing the periods before, during, and after menopause (*1*).

During this transition, women may experience a diverse array of physical, mental, and psychological manifestations associated with decreased ovarian function and fluctuating estrogen levels. The severity and duration of symptoms exhibit considerable individual variation, generally persisting for 3 to 5 years (*2*). Both domestic and international research demonstrates a high prevalence of menopausal symptoms, albeit with notable population-specific variations (*3*–*5*). However, existing domestic research is limited by small sample sizes, inadequately defined age ranges, and regional specificity, which compromises the generalizability of findings (*6*–*7*).

This study derives from The Epidemiological Investigation of Menopause Status among Chinese Women (EIM-CW), a nationwide epidemiological survey conducted from August 2023 to February 2024. The study population comprised non-pregnant women aged 40–60 years who were either local residents or had maintained residence in the area for more than 6 months, excluding those with congenital absence of the uterus or history of premenopausal hysterectomy. The investigation employed a multi-stage stratified cluster sampling method to select representative provincial-level administrative divisions (PLADs) and prefecture-level cities nationwide. To ensure comprehensive representation across eastern, central, and western regions, the following locations were selected: Hebei Province (Tangshan City), Inner Mongolia Autonomous Region (Chifeng City), Liaoning Province (Shenyang and Dalian cities), Jiangsu Province (Wuxi City), Zhejiang Province (Ningbo City), Shandong Province (Jinan City), Henan Province (Luoyang City), Hubei Province (Xiangyang City), Guangxi Zhuang Autonomous Region (Liuzhou City), Sichuan Province (Meishan City), Shaanxi Province (Baoji City), and Gansu Province (Zhangye City). Sample allocation was proportional to provincial populations, with selected cities further stratified into urban and rural areas, yielding 26 district/county survey sites. From each site, two streets and two townships were randomly selected. Cluster sampling was then implemented to include all eligible female residents aged 40–60 years within the selected streets and townships.

Data collection was conducted through the custom-developed Chinese Women's Health Survey Platform, which incorporated a questionnaire covering demographic characteristics, menopausal status, and symptoms. The severity of menopausal symptoms was evaluated using a modified Kupperman scale, a validated tool widely used to assess menopausal symptoms. The scale utilized four severity levels: zero (normal, score=0), occasional (mild, score=1), persistent (moderate, score=2), and affecting life (severe, score=3). Symptom indices were weighted according to clinical significance: hot flushes and sweating received a score of 4; paresthesia, insomnia, nervousness, sexual complaints, and urinary tract infections received a score of 2; and melancholia, vertigo, fatigue, arthralgia/myalgia, headache, heart palpitations, and formication were assigned a score of 1. The total symptom score was calculated by multiplying the basic score by the severity score, yielding a possible range of 0 to 63 points. Based on the modified Kupperman scale, scores were categorized as follows: 6 or less indicated normal symptoms, 7 to 15 indicated mild symptoms, 16 to 30 indicated moderate symptoms, and scores exceeding 30 indicated severe symptoms, with higher total scores reflecting greater symptom severity.

Statistical analyses were performed using IBM SPSS (version 26.0, IBM Corp., New York, USA). Qualitative data were described using rates and proportion ratios, while quantitative data were reported as means and standard deviations ($\bar{X}\pm S$). Group differences were analyzed using Mann-Whitney and Kruskal-Wallis tests, with statistical significance set at α=0.05.

The study included 42,304 women with a mean age of 49.9±5.7 years, comprising 23,475 (55.5%) premenopausal and 18,829 (44.5%) postmenopausal women, with the latter group having a mean age of 49.4±3.3 years. A total of 19,570 women reported menopausal symptoms, yielding an overall prevalence rate of 46.3% [95% confidence interval (*CI*): 45.8%, 46.7%]. Mild symptoms were most common (31.0%), followed by moderate symptoms (14.3%), while severe symptoms were relatively rare (1.0%). Analysis of menopausal symptom severity across different sociodemographic characteristics revealed statistically significant differences (P<0.001) among women of varying age groups, ethnicities, occupations, regions, educational levels, and marital status (Table 1).

The analysis showed that 44.7% (10,496 of 23,475) of premenopausal women and 48.2% (9,074 of 18,829) of postmenopausal women experienced mild to severe menopausal symptoms. The Mann-Whitney test revealed significantly greater symptom severity among premenopausal women compared to postmenopausal women (P<0.001). Further analysis of symptom severity variations across age groups and

TABLE 1. Sociodemographic characteristics and severity of menopausal symptoms in 42,304 women.

Characteristic	Total n (%)	Severity of menopausal symptoms n (%)				H/U	P
		Normal 22,734 (53.7)	Mild 13,096 (31.0)	Moderate 6,053 (14.3)	Severe 421 (1.0)		
Age group (years)							
40–44	9,363 (22.1)	5,290 (56.5)	2,961 (31.6)	1,052 (11.2)	60 (0.6)	90.7*	<0.001
45–49	10,445 (24.7)	5,623 (53.8)	3,257 (31.2)	1,470 (14.1)	95 (0.9)		
50–54	11,951 (28.3)	6,172 (51.6)	3,675 (30.8)	1,962 (16.4)	142 (1.2)		
55–60	10,545 (24.9)	5,649 (53.6)	3,203 (30.4)	1,569 (14.9)	124 (1.2)		
Nation							
Han	39,441 (93.2)	20,997 (53.2)	12,297 (31.2)	5,754 (14.6)	393 (1.0)	$(51.8\times10^{6})^{\dagger}$	<0.001
Minority	2,863 (6.8)	1,737 (60.7)	799 (27.9)	299 (10.4)	28 (1.0)		
Occupation							
Farmer (forest, grazing, fishing)	10,963 (25.9)	6,860 (62.6)	2,779 (25.3)	1,242 (11.3)	82 (0.7)	1108.1*	<0.001
Worker	5,468 (12.9)	3,228 (59.0)	1,538 (28.1)	668 (12.2)	34 (0.6)		
Government/institutions	1,535 (3.6)	708 (46.1)	578 (37.7)	237 (15.4)	12 (0.8)		
Technical staff	1,533 (3.6)	749 (48.9)	534 (35.4)	221 (14.4)	20 (1.3)		
Business/service worker	2,753 (6.5)	1,511 (54.9)	899 (32.7)	333 (12.1)	10 (0.4)		
Individual/private business	2,340 (5.5)	1,355 (57.9)	672 (28.7)	293 (12.5)	20 (0.9)		
Teacher/soldier	1,324 (3.1)	516 (39.0)	510 (38.5)	271 (20.5)	27 (2.0)		
Medical worker	5,113 (12.1)	1,960 (38.3)	2,115 (41.4)	982 (19.2)	56 (1.1)		
Housewife	9,793 (23.1)	5,234 (53.4)	2,882 (29.4)	1,537 (15.7)	140 (1.4)		
Other	1,482 (3.5)	613 (41.4)	580 (39.1)	269 (18.2)	20 (1.3)		
Region							
Urban (District)	20,708 (49.0)	10,173 (49.1)	6,853 (33.1)	3,441 (16.6)	241 (1.2)	$(20.1\times10^{7})^{\dagger}$	<0.001
Rural (County)	21,596 (51.0)	12,561 (58.2)	6,243 (28.9)	2,612 (12.1)	180 (0.8)		
Education level							
Less than primary	6,990 (16.5)	3,865 (55.3)	1,863 (26.7)	1,145 (16.4)	117 (1.7)	879.6*	<0.001
Junior secondary	16,845 (39.8)	10,095 (59.9)	4,664 (27.7)	1,949 (11.6)	137 (0.8)		
Senior secondary	8,304 (19.6)	4,598 (55.4)	2,544 (30.6)	1,105 (13.3)	57 (0.7)		
University	9,833 (23.2)	4,024 (40.9)	3,892 (39.6)	1,809 (18.4)	108 (1.1)		
Master and above	332 (0.8)	152 (45.8)	133 (40.1)	45 (13.6)	2 (0.6)		
Marital status							
Married	40,393 (95.5)	21,981 (54.4)	12,376 (30.6)	5,661 (14.0)	375 (0.9)	$(32.2\times10^{6})^{\dagger}$	<0.001
Unmarried/divorced/widowed	1,911 (4.5)	753 (39.4)	720 (37.7)	392 (20.5)	46 (2.4)		

Note: Numbers outside parentheses represent frequencies; numbers inside parentheses represent percentages (%).
* Kruskal-Wallis H test.
† Mann-Whitney U test.

menopausal status demonstrated significant differences between premenopausal and postmenopausal women in the 45–49 (P<0.001) and 50–54 (P=0.019 <0.05) age groups (Figure 1).

Analysis by age group revealed that the prevalence of mild to severe menopausal symptoms began increasing in women over 44 years, reaching its peak at age 52 (49.8%, 95% *CI*: 47.9%, 51.8%). Moderate to severe symptoms showed an uptick in women over age 46, also peaking at 52 years (19.1%, 95% *CI*: 17.6%, 20.6%). Severe symptoms began increasing in women over age 48, with prevalence reaching its maximum at age 56 (1.6%, 95% *CI*: 1.0%, 2.1%; Figure 2A).

The most frequently reported menopausal symptoms were insomnia (50.0%, 95% *CI*: 49.5%, 50.5%), fatigue (48.2%, 95% *CI*: 47.7%, 48.7%), and

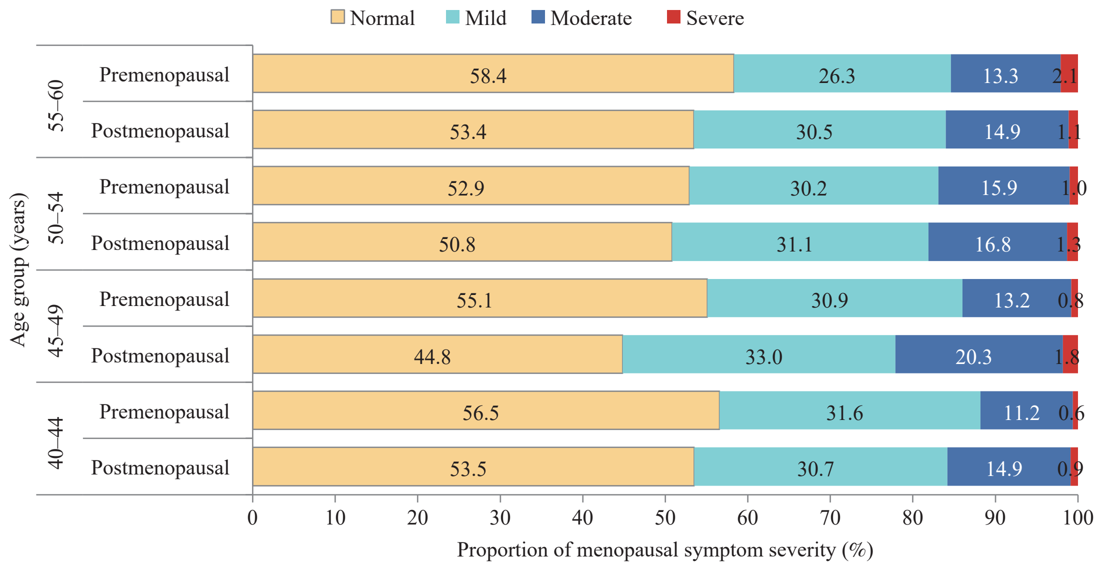

FIGURE 1. Severity of menopausal symptoms in women with different menopausal status across age groups.

nervousness (46.9%, 95% *CI*: 46.5%, 47.4%). Figure 2 illustrates the severity distribution of total menopausal symptoms and 13 specific symptoms across different age groups. Hot flushes and sweating affected 23.9% (95% *CI*: 23.5%, 24.3%) of women across all age groups, with prevalence increasing from age 40, peaking at age 52, and subsequently declining (Figure 2B). In contrast, the prevalence of nervousness, melancholia, and fatigue demonstrated an age-related decline (Figure 2E, 2F, and 2H). Notably, melancholia prevalence decreased from 29.2% at age 41 to 18.1% at age 60. Women under 50 exhibited higher rates of fatigue and neuropsychiatric symptoms, with fatigue exceeding 50% in women younger than 50 years and nervousness predominating in those under 47 years. Conversely, arthralgia/myalgia, sexual complaints, and urinary tract infections showed increasing prevalence with age, with sexual complaints demonstrating the most pronounced change, followed by arthralgia/myalgia (Figure 2I, 2M, and 2N).

DISCUSSION

This study represents the first comprehensive cross-sectional investigation of menopausal symptoms among community-dwelling women in China. We provide robust evidence regarding the prevalence and severity of menopausal symptoms in Chinese women aged 40–60 years. Our findings reveal significant variations in the prevalence, severity, and manifestation of menopausal symptoms across different age groups in the Chinese population. Previous research has documented that the prevalence of moderate to severe menopausal symptoms reaches 29.8% among perimenopausal women in Greece (*3*), while a study in Shanghai Municipality reported a prevalence of 73.8% among women aged 40–60 years (*4*). Our observed prevalence was lower than that reported in Shanghai, and the occurrence of moderate to severe symptoms was less frequent than in Greek women. The elevated prevalence in Shanghai may be attributed to the city's intense urban lifestyle and occupational stress, which could adversely affect women's physical and mental well-being. Additionally, genetic variations among populations likely play a crucial role in symptom manifestation, while methodological differences in sampling, data collection, and analysis may contribute to the observed disparities across studies. Understanding age-specific symptom patterns enables the development of targeted early prevention strategies and more effective health education initiatives, facilitating the implementation of age-appropriate public health interventions.

The study reveals distinct patterns in menopause symptoms between premenopausal and postmenopausal women, with a notably higher prevalence in the latter group (48.2%). Our analysis of how menopausal status influences symptom severity across age groups revealed particularly significant differences among women aged 45–49 years and 50–54 years — periods approaching natural menopause — further substantiating the relationship between menopausal status and symptom intensity. Research indicates that women experiencing premature

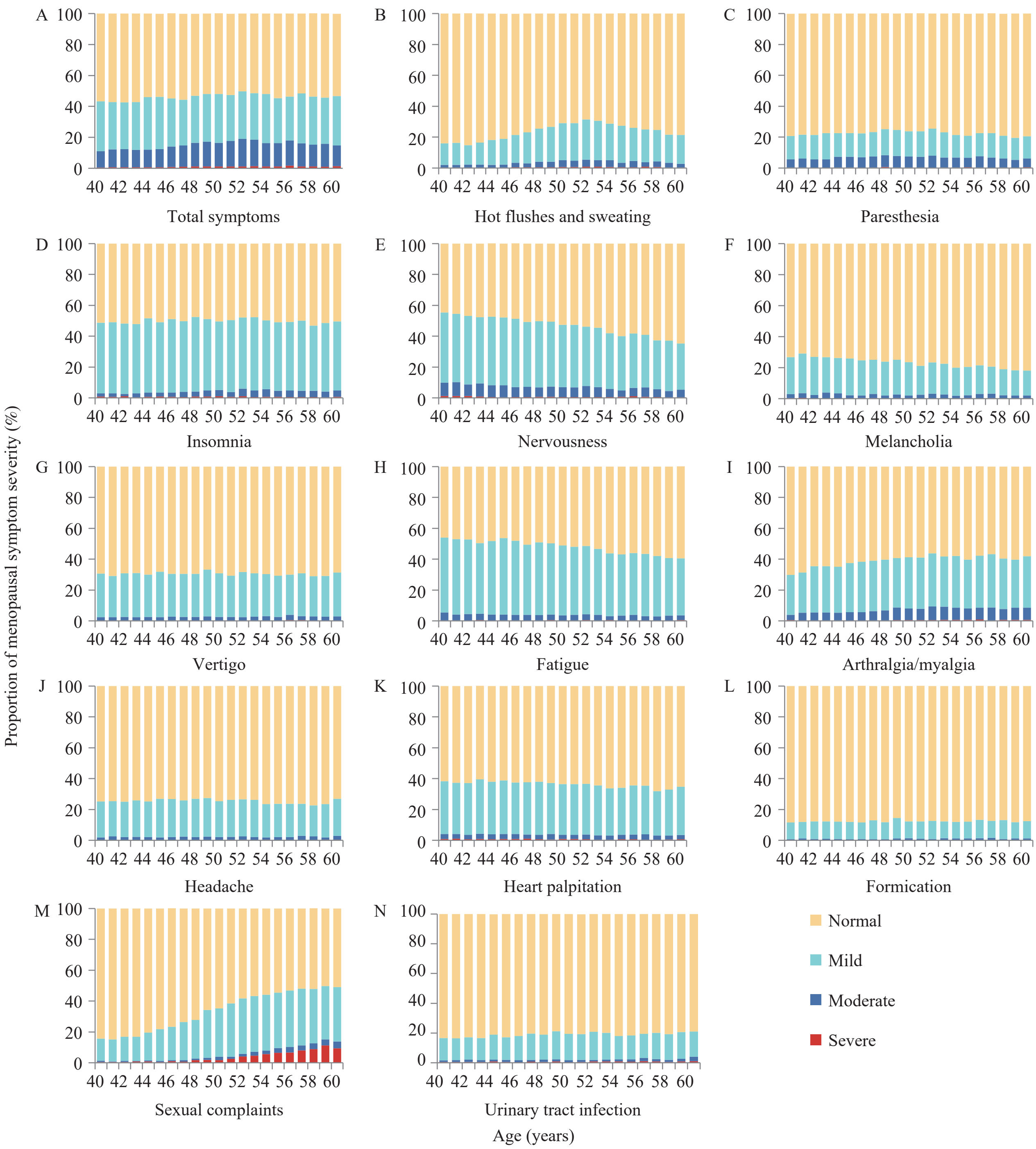

FIGURE 2. Severity of total and 13 menopausal symptoms in women of different age groups. (A) Total symptoms; (B) Hot flushes and sweating; (C) Paresthesia; (D) Insomnia; (E) Nervousness; (F) Melancholia; (G) Vertigo; (H) Fatigue; (I) Arthralgia/myalgia; (J) Headache; (K) Heart palpitation; (L) Formication; (M) Sexual complaints; (N) Urinary tract infection.

ovarian failure report both a higher prevalence and greater severity of symptoms compared to those undergoing natural menopause (*8*).

Our findings reveal that the severity of menopausal symptoms exhibits distinct age-related patterns among women aged 40–60 years. A notable inflection point occurs at age 44, marking a significant increase in mild to severe symptoms. This timing likely corresponds to critical physiological changes, particularly an accelerated decline in ovarian function that leads to substantial hormonal fluctuations affecting endometrial integrity, bone metabolism, and cardiovascular function. The prevalence of moderate and severe climacteric symptoms reaches its peak at age

52, while severe symptoms demonstrate maximum prevalence at age 56. This temporal pattern may be attributed to the increasing prevalence of comorbid chronic conditions such as hypertension, diabetes, and cardiovascular disease with advancing age (*9*), which potentially exacerbate symptom severity during the 52–56 year age range. These findings suggest that enhanced clinical screening and therapeutic interventions should be targeted toward women in this age group.

Our analysis identified insomnia, fatigue, and nervousness as the predominant menopausal symptoms among women aged 40–60 years. This symptom profile differs from findings in other populations, such as the southwestern United States, where fatigue, musculoskeletal pain, and headaches were most prevalent among women aged 40–65 years (*5*). Similarly, surveys in Beijing reported bone and joint muscle pain, fatigue, and insomnia as primary symptoms (*6*), while Guangzhou residents predominantly experienced insomnia, fatigue, and headaches (*7*). These regional variations likely reflect the influence of cultural factors, lifestyle differences, and disparities in healthcare resource accessibility. Notably, fatigue consistently emerges as a leading symptom across multiple studies, potentially reflecting the fundamental alterations in energy metabolism and physiological function that characterize the menopausal transition.

Hot flushes and sweating, the primary manifestations of vasomotor symptoms in menopausal women, typically peak within 6 months after menstruation cessation and generally resolve within 1–2 years post-menopause. This study found that 23.9% of surveyed women reported experiencing hot flushes and sweating, a notably lower prevalence compared to other countries. For instance, moderate to severe vasomotor symptoms affect 40% of Greek women(*3*). The prevalence of vasomotor symptoms varies considerably across European countries, ranging from 31% in France to 52% in Italy (*10*). These differences may be attributed to genetic variations across ethnic groups affecting hormonal sensitivity during menopause. Notably, these symptoms peak among 52-year-old Chinese women, approximately 2–3 years post-menopause, suggesting this period warrants targeted interventions and medical management as needed.

This study has two primary limitations. First, the modified Kupperman score, being a self-report measure, may be subject to varying interpretations among menopausal women participating in the survey. Second, the cross-sectional design inherently limits the establishment of causal relationships between menopausal symptoms and their potential contributing factors. Future research should incorporate longitudinal cohort studies to analyze the factors influencing menopausal symptoms across different age groups and explore effective intervention strategies.

In conclusion, this nationally representative cross-sectional survey reveals a significant prevalence of menopausal symptoms among Chinese women, with notable variations in both severity and prevalence across different age groups. The comprehensive findings provide a robust scientific foundation for developing targeted healthcare strategies tailored to women at various stages of menopause. These insights hold substantial public health implications for alleviating menopausal symptoms and promoting the holistic well-being of women during their menopausal transition.

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[#] Corresponding author: Ruimin Zheng, zhengruimin@ncwchnhc.org.cn.

[1] Chinese Center for Disease Control and Prevention, Beijing, China; [2] National Center for Women and Children's Health, National Helath Commission of the People's Republic of China, Beijing, China.

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Preplanned Studies

Female Breast Cancer Incidence and Association with Socioeconomic Status in a Population-Based Cohort — China, 2018–2024

Heling Bao[1,&]; Liwen Fang[2,&]; Shu Cong[2]; Xiaolei Guo[3]; Zhentao Fu[3]; Xiaoli Liu[4]; Weiwei Shi[4]; Hongjian Liu[5]; Hui Liu[1,#]; Xuening Duan[6,#]; Linhong Wang[2,#]

Summary

What is already known about this topic?

Breast cancer has emerged as the most prevalent cancer among women globally and is increasingly affecting younger populations. However, the relationship between individual socioeconomic status (SES) and breast cancer risk remains incompletely understood.

What is added by this report?

This population-based cohort study revealed a breast cancer incidence rate of 48.9 per 100,000 person-years. Women with high SES demonstrated a significantly elevated risk of breast cancer compared to those with low SES [hazard ratio (*HR*)=1.42, 95% confidence interval (*CI*): 1.05, 1.92]. Self-perceived SES appeared to moderate this association, with an increased breast cancer risk particularly evident among women who had both low objectively assessed and self-perceived SES.

What are the implications for public health practice?

These findings underscore the need for tailored breast cancer screening programs and targeted health education initiatives that account for differences across SES groups.

ABSTRACT

Introduction: Breast cancer has emerged as the most prevalent cancer among women globally. However, the relationship between individual socioeconomic status (SES) and breast cancer risk remains incompletely understood.

Methods: This population-based cohort study recruited women aged 30–70 years from Shandong, Hebei, and Jiangsu provinces in China during 2008 and 2018. We developed a composite SES measure through latent class analysis incorporating household income, education level, and health insurance type, stratifying participants into low and high SES groups. Self-perceived SES was evaluated using a Likert scale. We employed Cox proportional hazards regression to estimate hazard ratios (*HRs*) and 95% confidence intervals (*CIs*) for the association between SES and breast cancer incidence.

Results: Among 62,350 participants followed for an average of 6.1 person-years, we identified 300 incident breast cancer cases. The overall incidence rate was 48.9 per 100,000 person-years. Women with high SES demonstrated significantly elevated breast cancer risk compared to those with low SES (*HR*=1.42, 95% *CI*: 1.05–1.92). Self-perceived SES appeared to modify this relationship, with increased breast cancer risk observed among women categorized as both objectively and subjectively low SES.

Conclusions: These findings underscore the need for SES-specific approaches to breast cancer screening programs and targeted health education initiatives.

Breast cancer has emerged as the predominant cancer affecting women worldwide and in China (*1*). While several established risk factors exist (including alcohol consumption, reproductive history, family history, and age at menarche and menopause), the relationship between socioeconomic status (SES) and breast cancer risk remains complex. Recent evidence suggests that women with high SES may face an increased risk of breast cancer, potentially due to delayed childbearing, having fewer children, and shorter breastfeeding duration (*2*). However, other studies have demonstrated an inverse association, highlighting the intricate interplay of lifestyle factors, environmental conditions, and healthcare accessibility in determining disease patterns (*3*–*4*). In China, cohort studies examining this relationship are limited. Our previous research revealed low health literacy and screening rates among women with low SES, underscoring the uncertainty surrounding this issue (*5*–*6*). Understanding these relationships is crucial for developing targeted interventions to reduce breast cancer incidence in high-risk populations.

This population-based cohort study, encompassing 62,350 participants with 300 incident breast cancer cases during a mean follow-up of 6.1 person-years, revealed that women with high SES demonstrated an elevated risk of developing breast cancer compared to those with low SES. The relationship appeared to be moderated by self-perceived SES, with the effect primarily driven by an increased breast cancer risk among women who were classified as having both low objectively assessed and self-perceived SES compared to their counterparts. These findings emphasize the importance of implementing tailored screening programs and health education strategies across different SES groups.

The participants were recruited from the Breast Cancer Cohort in Chinese Women (BCCS-CW) (*5*). We enrolled 63,219 women aged 30–70 years from 8 counties and 6 districts across Shandong, Hebei, and Jiangsu provinces in 2008 and 2018. Follow-up occurred in two phases: Phase I (2018–2020) comprised clinician-based examinations and household surveys for the 2008 cohort, while Phase II (2020–2024) linked both recruitment waves to cancer and death registries. Participants were followed until breast cancer diagnosis, death, loss to follow-up, or November 2024.

SES assessment incorporated three dimensions: household income per capita, individual education level, and health insurance type. Each dimension was categorized as low, medium, or high based on self-reported data and sample distribution. Following *Pan* et al. (*7*), we derived a composite SES measure using latent class analysis, which identified two distinct classes: low and high. Additionally, we assessed self-perceived SES using a 5-point Likert scale question: "How would you describe yourself economically in this community?" Responses were categorized as low, medium, or high. This study collected comprehensive covariate data through questionnaires, including demographic characteristics, physical examination findings, reproductive history, alcohol consumption, family history, and hormone exposure.

The study calculated overall breast cancer incidence rates stratified by SES and covariates, with χ^2 tests evaluating between-group differences. A Cox proportional hazards regression model was employed to calculate hazard ratio (*HR*) and 95% confidence interval (*CI*) for breast cancer risk by objectively assessed and self-perceived SES, adjusting for covariates. The marginaleffect package in R software was used to calculate the change in breast cancer risk per one-unit increase in independent variables. Missing data were handled using Markov chain Monte Carlo algorithm for continuous variables and mode imputation for categorical variables. All analyses were conducted using SAS (version 9.4; SAS Institute, Cary, USA) and R software (version 4.4.1; R Foundation for Statistical Computing, Vienna, Austria).

Among the 62,350 participants included in the analysis, with a total follow-up of 612,972.8 person-years (median 6 person-years), the demographic distribution showed that 35% were aged <40 years, 35% were between 40–49 years, and 15% were aged ≥ 60 years. Additionally, 9% were unmarried or divorced, 18% were unemployed, and 5% experienced menopause after age 55. Latent class analysis categorized 16,869 participants (27%) into the high SES group and 45,481 (73%) into the low SES group. Regarding self-perceived SES, 3,751 participants identified as low, 47,821 as middle, and 10,778 as high.

The overall breast cancer incidence rate was 48.9 per 100,000 person-years (Table 1). The highest incidence rate of 68.1 per 100,000 person-years was observed among women aged 40–49 years, with a significantly elevated risk compared to those aged <40 years (*HR*=1.80, 95% *CI*: 1.35, 2.40). Women who experienced menopause after age 55 demonstrated an incidence rate of 65.5 per 100,000 person-years, higher than their counterparts (*HR*=1.34, 95% *CI*: 0.85, 2.12). A notably elevated incidence rate of 125.1 per 100,000 person-years was observed among women with a family history of breast or ovarian cancer, corresponding to a significantly increased risk (*HR*=2.42, 95% *CI*: 1.28, 4.55) compared to those without such history.

Analysis by SES revealed an incidence rate of 47.5 per 100,000 person-years in the low SES group compared to 53.7 per 100,000 person-years in the high SES group, yielding an adjusted *HR* of 1.42 (95% *CI*: 1.05, 1.92). Conversely, breast cancer incidence showed an inverse relationship with self-perceived SES. The highest incidence rate of 75 per 100,000 person-years was observed among participants with low self-perceived SES, while those with moderate self-perceived SES showed an incidence rate of 48.5 per 100,000 person-years (*HR*=0.67, 95% *CI*: 0.46, 0.99). The lowest incidence rate of 39.7 per 100,000 person-

TABLE 1. Baseline characteristics of women in the cohort.

Characteristics	Participants	Case	Person-years	Incident rate per 100,000	Hazards ratios (95% *CI*)	
					Age adjusted¶	Full adjusted**
All	62,350	300	612,972.8	48.9	NA	NA
Age group						
<40	16,889	76	197,710.1	38.1	1	1
40–49	18,983	126	184,919.2	68.1	1.91 (1.43, 2.54)	1.80 (1.35, 2.40)
50–59	17,703	73	154,841.7	47.1	1.37 (0.99, 1.89)	1.26 (0.90, 1.78)
≥60	8,775	25	73,501.8	34.0	0.99 (0.63, 1.56)	0.92 (0.57, 1.50)
Marital status						
Married	56,375	273	547,530.7	49.9	1	1
Others*	5,975	27	65,442.1	41.3	0.82 (0.55, 1.24)	0.78 (0.52, 1.18)
Occupation						
No work	17,773	102	190,484.4	53.5	1.13 (0.87, 1.46)	1.16 (0.90, 1.51）
Farmer	30,419	136	295,673.1	46.0	1	1
Other work	14,158	62	126,815.4	48.9	1.11 (0.82, 1.50)	1.08 (0.77, 1.52）
BMI						
Normal or thin	22,710	99	223,896.4	44.2	1	1
Overweight†	39,640	201	389,076.4	51.7	1.13 (0.89, 1.44)	1.12 (0.88, 1.43)
Menopause after 55						
No	59,530	279	580,920.9	48.0	1	1
Yes	2,820	21	32,052.0	65.5	1.32 (0.84, 2.09)	1.34 (0.85, 2.12)
Family history§						
No	61,511	290	604,978.2	47.9	1	1
Yes	839	10	7,994.6	125.1	2.68 (1.43, 5.03)	2.42 (1.28, 4.55)
MET						
Low	31,098	152	302,281.0	50.3	1	1
High	31,252	148	310,691.8	47.6	0.93 (0.74, 1.17)	0.93 (0.74, 1.17)
SES						
Low	45,481	223	469,514.8	47.5	1	1
High	16,869	77	143,458.0	53.7	1.25 (0.96, 1.63)	1.42 (1.05, 1.92)
Self-perceived SES						
Low	3,751	31	41,319.7	75.0	1	1
Moderate	47,821	232	478,538.8	48.5	0.67 (0.46, 0.98)	0.67 (0.46, 0.99)
High	10,778	37	93,114.4	39.7	0.58 (0.36, 0.94)	0.55 (0.33, 0.90)

Abbreviation: *CI*=confidence interval; SES=socioeconomic status; BMI=body mass index; MET=metabolic equivalent of task; NA=not applicable.

* Others included single, separated, divorced, and widowed;

† Overweight included overweight and obese categories;

§ Family history of cancer refers to second-degree relatives;

¶ Models are adjusted for age only;

** Models are adjusted for age, marital status, race, occupation, BMI, physical exercise, red meat consumption, drinking, smoking, family history, radiation therapy to chest, menarche, menopause, and self-perceived SES.

years was found among participants with high self-perceived SES (*HR*=0.55, 95% *CI*: 0.33, 0.90).

Subgroup analyses (Table 2) revealed that the positive association between high SES and breast cancer incidence was more pronounced among several demographic groups: women aged 40–49 years compared to those under 40, married women versus other marital statuses, unemployed women versus

TABLE 2. Associations between socioeconomic status and breast cancer risk by subgroup analysis in the cohort.

Characteristics	Low SES		High SES		Adjusted HRs (95% *CI*)	
	Person-years	Incident rate per 100,000	Person-years	Incident rate per 100,000	High *vs*. Low¶	*P*
Age group, years						
<40	131,645.7	45.6	68,064.4	23.5	0.72 (0.40, 1.28)	0.27
40–49	136,848.0	59.2	48,071.2	93.6	2.09 (1.41, 3.08)	**<0.001**
50–59	132,166.0	46.2	22,675.7	52.9	1.39 (0.72, 2.70)	0.33
≥60	68,855.1	30.5	4,646.7	86.1	2.52 (0.83, 7.68)	0.10
Marital status						
Married	412,481.9	48.2	135,048.8	54.8	1.56 (1.16, 2.08)	**0.003**
Others*	57,032.9	42.1	8,409.2	35.7	0.61 (0.17, 2.28)	0.47
Occupation						
No work	159,430.1	47.0	31,054.2	86.9	2.05 (1.27, 3.29)	**0.003**
Farmer	258,864.9	47.5	36,808.2	35.3	0.90 (0.50, 1.64)	0.74
Other work	51,219.9	48.8	75,595.5	48.9	1.52 (0.88, 2.63)	0.14
BMI						
Normal or thin	161,317.2	43.4	62,579.3	46.3	1.39 (0.86, 2.25)	0.17
Overweight†	308,197.7	49.6	80,878.7	59.3	1.51 (1.07, 2.15)	**0.02**
Menopause after 55						
No	27,787.1	57.6	4,264.9	117.2	2.44 (0.80, 7.42)	0.12
Yes	441,727.7	46.9	139,193.1	51.7	1.40 (1.20, 1.92)	**0.04**
Family history§						
No	464,835.9	46.7	140,142.4	52.1	1.39 (1.02, 1.90)	**0.04**
Yes	4,678.9	128.2	3,315.6	120.6	1.24 (0.28, 5.50)	0.78
MET						
Low	227,134.6	48.9	75,146.4	54.6	1.41 (0.92, 2.17)	0.11
High	242,380.3	46.2	68,311.5	52.7	1.53 (0.99, 2.38)	0.06
Self-perceived SES						
Low	39,037.9	76.8	2,281.8	43.8	0.45 (0.06, 3.50)	0.45
Moderate	380,150.1	45.8	98,388.7	58.9	1.50 (1.06, 2.12)	**0.02**
High	50,326.8	37.8	42,787.5	42.7	1.67 (0.80, 3.48)	0.17

Note: The bold texts represets *P*<0.05.

Abbreviation: *HR*=hazard ratio; *CI*=confidence interval; SES=socioeconomic status; BMI, body mass index; MET=metabolic equivalent of task.

* Others included single, separated, divorced, and widowed;

† Overweight included overweight and obese;

§ Family history of cancer in second-degree relatives;

¶ Models adjusted for all covariates except the stratification variable.

farmers, overweight or obese women versus those of normal weight, women without a family history of breast cancer versus those with such history, and women with relatively high self-perceived SES versus those with low self-perceived SES. Notably, an inverse association emerged between high SES and breast cancer incidence among women with low self-perceived SES, yielding a HR of 0.45 (95% *CI*: 0.06, 3.50).

Figure 1 illustrates the incremental change in breast cancer risk associated with unit increases in age, BMI, physical exercise, and self-perceived SES, stratified by SES groups. The analysis demonstrated consistently elevated breast cancer risk among women in the high SES group compared to those with low SES across all examined parameters.

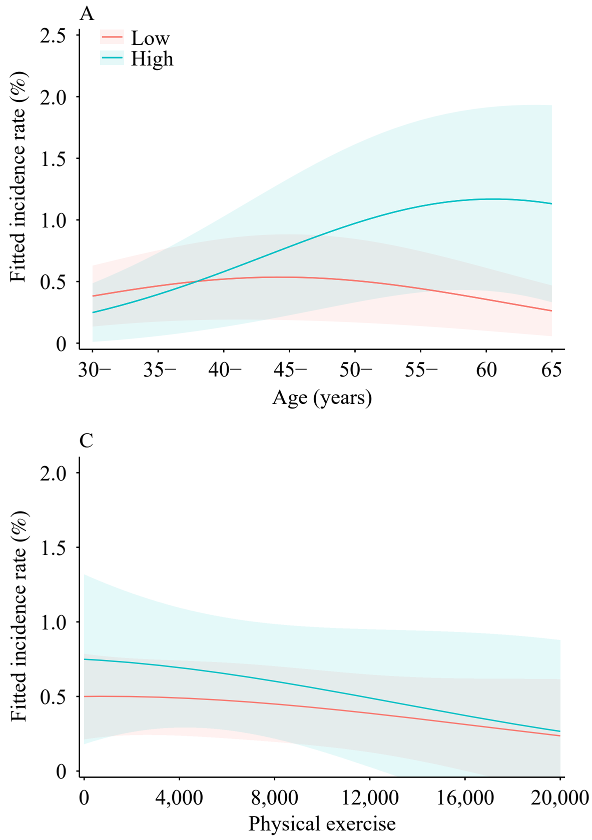

FIGURE 1. Differences in breast cancer incidence by socioeconomic status subgroups among women in the cohort. (A) Age-stratified predictions; (B) BMI-stratified predictions; (C) Physical activity level (MET) predictions; (D) Self-perceived socioeconomic status predictions.
Abbreviation: SES=socioeconomic status; BMI=body measurement index; MET=metabolic equivalent of task.

DISCUSSION

In this cohort study of over 60,000 participants followed for a median of 6 person-years, we observed a cumulative breast cancer incidence of 48.9 per 100,000 person-years. Using latent class analysis of individual education level, household income, and health insurance status, we identified two distinct SES groups. Women in the high SES group demonstrated significantly higher breast cancer incidence compared to those in the low SES group. Notably, this pattern was inversed when examining self-perceived SES, where women who perceived themselves as having low SES exhibited significantly higher breast cancer incidence than those with higher self-perceived SES.

The breast cancer incidence rate observed in this study was modestly lower than rates reported in both the national cancer registry and previous Chinese cohort studies (*8–9*). This discrepancy likely stems from our stringent case definition criteria, which excluded cases diagnosed within one year of enrollment to distinguish incident from prevalent cases and account for diagnostic delays. Additionally, our baseline survey incorporated clinician-based breast examinations, which enhanced early detection of breast abnormalities and potential early-stage cancers. Consequently, our cohort represents a screened population with inherently lower breast cancer risk compared to the general population.

This study revealed that women with high SES demonstrated a higher breast cancer incidence compared to those with low SES, aligning with recent systematic review findings (*2*). While some studies attribute this increased risk among high-SES women to enhanced healthcare access, earlier detection capabilities, and specific lifestyle factors including dietary patterns and physical activity levels (*10*), this pattern should not diminish attention to low-SES populations. Delayed diagnosis among low-SES groups often results in more advanced-stage breast cancer presentations and elevated mortality rates. European research (*4*) has documented pronounced socioeconomic disparities in cancer survival, with breast cancer patients from low-SES backgrounds experiencing significantly shorter survival times.

Beyond objectively assessed SES, this investigation examined the relationship between self-perceived SES and breast cancer incidence, revealing an inverse association. Subgroup analyses identified that this pattern was primarily driven by elevated breast cancer risk among women who were classified as low SES and also perceived themselves as having low socioeconomic status. This phenomenon may be explained by the documented impact of low self-perceived SES on mental health outcomes, particularly depression and anxiety, which are established independent risk factors for female breast cancer (*11*). Further research is warranted to elucidate the underlying mechanistic pathways of this association.

This study has several limitations. The relatively short follow-up period limited statistical power for many subgroup analyses. Additionally, potential residual confounding factors, particularly detailed lifestyle variables, warrant further investigation regarding their role in mediating the SES-breast cancer relationship. Furthermore, the cohort may not fully represent Chinese women from western and central regions, potentially limiting generalizability.

In conclusion, this population-based cohort study demonstrated that women with high SES had an elevated risk of breast cancer compared to those with low SES, with self-perceived SES potentially moderating this association. These findings suggest the need for tailored screening programs and targeted health education strategies across different SES groups to optimize breast cancer prevention and early detection efforts.

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Corresponding authors: Hui Liu, liuhui@pumc.edu.cn; Xuening Duan, duanxuening@pku.edu.cn; Linhong Wang, linhong@ncwchnhc.org.cn.

[1] Institute of Medical Information, Chinese Academy of Medical Sciences & Peking Union Medical College, Beijing, China; [2] National Center for Chronic and Non-communicable Disease Control and Prevention, Chinese Center for Disease Control and Prevention, Beijing, China; [3] Shandong Center for Disease Control and Prevention, Jinan City, Shandong Province, China; [4] Hebei Center for Disease Control and Prevention, Shijiazhuang City, Hebei Province, China; [5] Taixing Center for Disease Control and Prevention, Taixing City, Jiangsu Province, China; [6] Peking University First Hospital, Beijing, China.

& Joint first authors.

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Preplanned Studies

Detection and BI-RADS Classification of Breast Nodules in Urban Women — China, 2021

Xiaoxi Liu[1,&]; Yaxin Xing[2,&]; Yining Zu[3,&]; Heling Bao[1]; Xue Ding[1]; Yongchao Chen[1]; Canqing Yu[4,5,6,7]; Jun Lyu[4,5,6,7]; Linhong Wang[8]; Bo Wang[3,4,7]; Sailimai Man[3,4,5,6,#]; Liming Li[4,5,6,7,#]; Hui Liu[1,#]

Summary

What is already known about this topic?

Female breast nodules represent the most frequently detected lesions during breast ultrasound screening. Notably, nodules classified as Breast Imaging Reporting and Data System (BI-RADS) 4 or 5 indicate an elevated risk of breast cancer. Nevertheless, the detection rate and BI-RADS classification of female breast nodules in China remain largely undocumented.

What is added by this report?

In 2021, breast nodules were detected in 27.9% of urban women in China. Among women with breast nodules marked with BI-RADS classification information, 95.9% were categorized as BI-RADS 2–3, while 4.0% were classified as BI-RADS 4–5. Age, geographic location, per capita gross domestic product (GDP), body mass index (BMI), high triglyceride (TG), high low-density lipoprotein cholesterol (LDL-C), and diabetes were identified as risk factors for BI-RADS 4–5.

What are the implications for public health practice?

This study highlights the importance of managing high-risk women with breast nodules through BI-RADS classification. Women with older age, high TG, high LDL-C, or diabetes demonstrate higher detection rates of BI-RADS 4–5, underscoring the need for targeted health interventions for high-risk populations while accounting for regional and socioeconomic disparities.

ABSTRACT

Introduction: Female breast nodules represent the most frequently detected lesions during breast ultrasound screening. Notably, nodules classified as BI-RADS 4 or 5 indicate an elevated risk of breast cancer. Nevertheless, the detection rate and BI-RADS classification of female breast nodules across China remain largely undocumented.

Methods: This study analyzed health examination data from 6,412,893 urban women across 31 provincial-level administrative divisions (PLADs). We calculated detection rates of breast nodules and their various BI-RADS classifications. Chi-square (χ^2) tests were performed to compare differences between groups. Multivariable logistic regression models were constructed to explore associations between breast nodules and BI-RADS 4–5 with demographic, socioeconomic, and metabolic indicators.

Results: The overall detection rate of breast nodules in Chinese urban women was 27.9%, with provincial rates ranging from 11.6% to 37.0%. Among women with breast nodules marked with BI-RADS classification information, 95.9% were categorized as BI-RADS 2–3, while 4.0% were classified as BI-RADS 4–5. Further analyses revealed that age, geographic region, per capita gross domestic product (GDP), body mass index (BMI), high triglyceride (TG), high low-density lipoprotein cholesterol (LDL-C), and diabetes were significant risk factors for BI-RADS 4–5 classification.

Conclusions: This study highlights the importance of managing high-risk women with breast nodules through BI-RADS classification, underscoring the need for targeted health interventions while considering regional and socioeconomic disparities.

Breast cancer is the most prevalent cancer among women, with a significant rise in incidence observed in China (*1–2*). Breast ultrasound plays a central role in the early detection of female breast cancer or lesions predisposing to female breast cancer, particularly nodules, which are the most commonly encountered abnormalities (*3*). The Breast Imaging Reporting and Data System (BI-RADS) provides a standardized framework for assessing and reporting the malignancy risk associated with breast nodules. Notably, nodules classified as BI-RADS 4 or 5 indicate an elevated risk of breast cancer (*4–5*). This distinction is critical for risk stratification and subsequent clinical decision-making. However, there is a significant gap in nationwide research regarding the detection rate of female breast nodules in China, as well as the prevalence of nodules with malignancy risk. This paucity of data may impede timely intervention and prevention for breast cancer. Therefore, this study analyzed the health examination data of 6,412,893 urban women from 31 provincial-level administrative divisions (PLADs) across the country, aiming to comprehensively investigate the detection rate and BI-RADS classification of breast nodules in Chinese urban women, and identify factors potentially associated with the malignancy risk. Our findings demonstrated that the overall detection rate of breast nodules in Chinese urban women was 27.9%, with provincial rates ranging from 11.6% to 37.0% across 31 PLADs. Among women with breast nodules marked with BI-RADS classification information, 95.9% were categorized as BI-RADS 2–3, while 4.0% were classified as BI-RADS 4–5. Further analyses revealed that age, geographic region, per capita gross domestic product (GDP), body mass index (BMI), high triglyceride (TG), high low-density lipoprotein cholesterol (LDL-C), and diabetes were risk factors of BI-RADS 4–5. The findings of this study provide valuable evidence to guide breast cancer prevention strategies in China.

This study utilized data from the Meinian Healthcare Group system, the largest health examination chain in China, with coverage across 231 prefecture-level cities spanning 31 PLADs. The Meinian Healthcare Group implements a comprehensive quality control system encompassing standardized operational protocols, unified staff training programs, and regular quality assessments for imaging and laboratory testing. Study participants primarily comprised employees and urban residents who underwent physical examinations, laboratory tests, and imaging assessments, as detailed in a previous publication (*6*). From January 1, 2021, to December 31, 2021, a total of 6,412,893 women were included in the analysis. Exclusion criteria encompassed: male sex; age under 18 years; pregnancy; absence of breast ultrasound information; and history of bilateral breast cancer surgery.

The detection rate of breast nodules was defined as the proportion of women with clearly documented breast nodules in their ultrasound examination reports relative to the total number of women examined. In accordance with the BI-RADS guidelines, breast nodules were stratified into three categories: BI-RADS 0–1 (lesions requiring further imaging or negative findings), BI-RADS 2–3 (benign lesions), and BI-RADS 4–5 (malignant lesions). The detection rate for each BI-RADS classification group was calculated as the proportion of samples assigned to that particular classification relative to the total number of samples labeled with any BI-RADS classification. Explanatory variables included age, geographic region (east, central, west, and northeast), city-level per capita GDP, BMI (kg/m^2), high TG (defined as TG≥1.7 mmol/L), high LDL-C (defined as LDL-C≥3.4 mmol/L), and diabetes (defined as fasting glucose ≥7.0 mmol/L).

We calculated the detection rate of female breast nodules and various BI-RADS classifications, along with their 95% confidence intervals (*CI*s). Chi-square (χ^2) tests were performed to compare differences between groups. Multivariable logistic regression models were constructed to examine the associations between female breast nodules and BI-RADS 4–5 with demographic, socioeconomic, and metabolic indicators, adjusting for all explanatory variables. Statistical analyses were conducted using SAS software (version 9.4, SAS Institute Inc., Cary, NC, USA). A two-tailed $P<0.05$ was considered statistically significant.

Among the 6,412,893 eligible women, 30.1% were aged 30–39 years, 47.9% resided in eastern China, and 28.2% were overweight. Overall, 27.9% (95% *CI*: 27.8%, 27.9%) of urban women in China were detected with breast nodules. The detection rate varied significantly by age, region, and per capita GDP, with the highest rates observed among women aged 40–49 years (37.0%, 95% *CI*: 36.9%, 37.1%), those residing in northeastern China (31.2%, 95% *CI*: 31.1%, 31.3%), and those living in areas with the highest per capita GDP (29.8%, 95% *CI*: 29.7%, 29.9%). Multivariable logistic regression analysis revealed that women aged 40–49 years demonstrated the highest risk of having breast nodules [odds ratio (*OR*)=2.10, 95% *CI*: 2.09, 2.11]. Women living in areas with the lowest per capita GDP had the lowest risk of breast nodules. Regarding BMI, underweight women were more susceptible to developing breast nodules (Table 1).

Women residing in western China demonstrated a significantly lower risk of breast nodules compared to their counterparts in eastern regions (*OR*=0.68, 95% *CI*: 0.68, 0.68). Figure 1 further illustrates the regional disparity in the detection rate of female breast nodules. Overall, PLADs in the eastern and northeastern regions

TABLE 1. Detection rate and associated factors of breast nodules in urban women in China, 2021.

Variables	Number (*n*, %)	Nodules (%, 95% *CI*)	Nodules	
			OR (95% *CI*)	*P*
Overall	6,412,893 (100.0)	27.9 (27.8, 27.9)	−	−
Age group (years)				
18–29	984,606 (15.3)	22.9 (22.8, 23.0)	Reference	−
30–39	1,930,638 (30.1)	28.2 (28.2, 28.3)	1.34 (1.33, 1.35)	<0.0001
40–49	1,443,857 (22.5)	37.0 (36.9, 37.1)	2.10 (2.09, 2.11)	<0.0001
50–59	1,369,632 (21.4)	27.1 (27.0, 27.1)	1.37 (1.36, 1.38)	<0.0001
60–69	526,369 (8.2)	17.2 (17.1, 17.3)	0.76 (0.75, 0.76)	<0.0001
70+	157,791 (2.5)	13.7 (13.6, 13.9)*	0.59 (0.58, 0.60)	<0.0001
Geographic region				
Eastern	3,074,829 (47.9)	29.8 (29.8, 29.9)	Reference	−
Central	1,499,099 (23.4)	27.1 (27.0, 27.2)	0.89 (0.88, 0.89)	<0.0001
Western	1,222,489 (19.1)	22.3 (22.2, 22.3)	0.68 (0.68, 0.68)	<0.0001
Northeastern	616,476 (9.6)	31.2 (31.1, 31.3)*	1.12 (1.11, 1.13)	<0.0001
Per capita GDP				
Lowest	1,625,373 (25.3)	25.8 (25.7, 25.9)	Reference	−
Up to median	1,613,646 (25.2)	26.8 (26.8, 26.9)	1.08 (1.08, 1.09)	<0.0001
Above median	1,514,973 (23.6)	29.1 (29.0, 29.1)	1.12 (1.12, 1.13)	<0.0001
Highest	1,658,901 (25.9)	29.8 (29.7, 29.9)*	1.11 (1.10, 1.11)	<0.0001
BMI				
Underweight	340,926 (5.3)	27.9 (27.8, 28.1)	1.04 (1.03, 1.04)	<0.0001
Normal	3,650,339 (56.9)	29.5 (29.4, 29.5)	Reference	−
Overweight	1,808,859 (28.2)	26.5 (26.4, 26.5)	0.86 (0.86, 0.87)	<0.0001
Obesity	612,769 (9.6)	22.6 (22.5, 22.7)*	0.72 (0.71, 0.72)	<0.0001
High TG				
No	5,220,433 (81.4)	28.4 (28.4, 28.4)	Reference	−
Yes	1,192,460 (18.6)	25.6 (25.5, 25.6)*	0.98 (0.98, 0.99)	<0.0001
High LDL-C				
No	5,144,749 (80.2)	28.2 (28.2, 28.2)	Reference	−
Yes	1,268,144 (19.8)	26.6 (26.5, 26.6)*	0.99 (0.98, 0.99)	<0.0001
Diabetes				
No	6,195,661 (96.6)	28.1 (28.0, 28.1)	Reference	−
Yes	217,232 (3.4)	22.7 (22.6, 22.9)*	0.96 (0.95, 0.97)	<0.0001

Note: "−" means that data are not applicable.
Abbreviation: *OR*=odds ratio; *CI*=confidential interval; GDP=gross domestic product; LDL-C=low-density lipoprotein cholesterol.
* P<0.05.

exhibited higher detection rates of breast nodules, while relatively lower rates were observed in the western region. At the provincial level, the detection rates of female breast nodules ranged from 11.6% to 37.0%, with the lowest detection rates observed in Xizang, Guizhou, and Chongqing, and the highest in Zhejiang, Liaoning, and Tianjin PLADs.

Among women with breast nodules marked with BI-RADS classification information, 95.9% (95% *CI*: 95.9%, 96.0%) were classified as BI-RADS 2–3, and 4.0% (95% *CI*: 4.0%, 4.0%) were classified as BI-RADS 4–5. The highest detection rate of BI-RADS 4–5 was observed in women aged over 70 years (11.6%, 95% *CI*: 10.8%, 12.3%). Multivariable

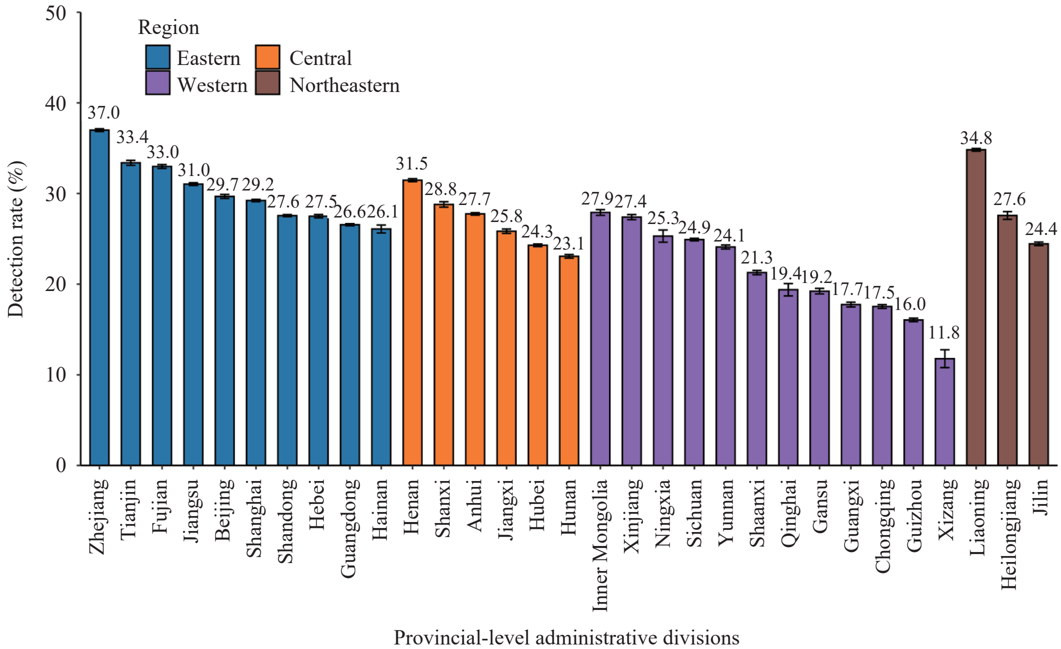

FIGURE 1. Regional disparities in the detection rate of breast nodules in Chinese urban women, 2021.

logistic regression revealed that the risk of BI-RADS 4–5 increased with age, with women aged 50 and above exhibiting odds ratios exceeding 2. Notably, women aged 70 or older demonstrated the highest risk (*OR*=5.41, 95% *CI*: 4.97, 5.90). Unlike the pattern observed for breast nodules, women in western regions had the highest risk of BI-RADS 4–5, and overweight or obese women exhibited a higher risk of BI-RADS 4–5. Women with metabolic abnormalities, including high TG, high LDL-C, and diabetes, faced an elevated risk of BI-RADS 4–5. Additionally, women residing in areas with higher per capita GDP demonstrated a higher risk of BI-RADS 4–5 (Table 2).

DISCUSSION

The World Health Organization emphasizes that early identification of individuals with subtle symptoms, signs, or both of possible breast malignancies is fundamentally important for breast cancer prevention and control (*7*). Breast nodules represent the most common lesions detected during breast ultrasound screening. Identifying women with breast nodules and assessing their malignancy risk according to BI-RADS classification constitutes an effective strategy to promote early detection and diagnosis of breast cancer. For improved policy formulation and implementation, comprehensive data are essential to understand the epidemiological profile of female breast nodules and their associated malignancy risk in China.

This study represents the first nationwide analysis of the detection rate and BI-RADS classification of breast nodules in Chinese urban women using comprehensive health examination data. We found that 27.9% of eligible women presented with breast nodules. Compared with previous studies that relied on smaller samples or focused on specific PLADs or medical institutions, our detection rate falls within a moderate range (*8*–*11*). Given that our sample encompassed 31 PLADs and all adult age groups in China, these findings likely provide a more accurate reflection of the overall prevalence of breast nodules among Chinese urban women. Furthermore, this study determined that the detection rate of BI-RADS 4–5 was 4.0%, with this proportion increasing progressively with age, consistent with findings from previous research.

Our analysis revealed that women aged 40–49 years exhibited the highest risk of breast nodules, consistent with findings from previous studies (*9*–*10*). Notably, our novel findings demonstrated that women aged ≥70 years and those aged 50–69 years presented significantly higher risks of BI-RADS 4–5 classification. Given China's rapidly aging population and increasing life expectancy, the elevated malignancy risk observed among elderly women warrants particular attention. These findings collectively emphasize that women aged ≥40 years face an increased risk for both breast nodules and BI-RADS 4–5 classifications, with

TABLE 2. Detection rates of various BI-RADS classifications and associated factors of BI-RADS 4–5 in urban women, China, 2021.

Variables	Number (*n*, %)	BI-RADS (%, 95% *CI*)		BI-RADS 4–5	
		2–3	4–5	*OR* (95% *CI*)	*P*
Overall	788,367 (100.0)	95.9 (95.9, 96.0)	4.0 (4.0, 4.0)	–	–
Age group, years					
18–29	112,893 (14.3)	97.8 (97.7, 97.9)	2.2 (2.1, 2.3)	Reference	–
30–39	243,082 (30.8)	97.3 (97.2, 97.4)	2.7 (2.6, 2.7)	1.22 (1.16, 1.28)	<0.0001
40–49	231,893 (29.4)	95.8 (95.8, 95.9)	4.1 (4.0, 4.2)	1.86 (1.77, 1.94)	<0.0001
50–59	158,946 (20.2)	94.1 (94.0, 94.2)	5.9 (5.8, 6.0)	2.62 (2.50, 2.75)	<0.0001
60–69	34,294 (4.4)	91.4 (91.1, 91.7)	8.6 (8.3, 8.9)	3.95 (3.73, 4.19)	<0.0001
70+	7,259 (0.9)	88.3 (87.6, 89.1)*	11.6 (10.8, 12.3)*	5.41 (4.97, 5.90)	<0.0001
Geographic region					
Eastern	425,123 (53.9)	96.6 (96.6, 96.7)	3.3 (3.3, 3.4)	Reference	–
Central	161,651 (20.5)	96.1 (96.0, 96.2)	3.9 (3.8, 4.0)	1.12 (1.08, 1.15)	<0.0001
Western	133,538 (16.9)	93.8 (93.7, 94.0)	6.0 (5.9, 6.2)	1.89 (1.83, 1.95)	<0.0001
Northeastern	68,055 (8.7)	95.4 (95.3, 95.6)*	4.6 (4.4, 4.7)*	1.19 (1.14, 1.25)	<0.0001
Per capita GDP					
Lowest	196,744 (25.0)	95.6 (95.5, 95.7)	4.4 (4.3, 4.5)	Reference	–
Up to median	230,338 (29.2)	95.5 (95.4, 95.6)	4.5 (4.4, 4.6)	1.05 (1.02, 1.08)	0.0012
Above median	181,244 (23.0)	96.0 (96.0, 96.1)	3.9 (3.8, 4.0)	1.13 (1.09, 1.17)	<0.0001
Highest	180,041 (22.8)	96.9 (96.8, 96.9)*	3.1 (3.0, 3.2)*	1.08 (1.03, 1.12)	0.0004
BMI					
Underweight	47,256 (6.0)	97.3 (97.2, 97.5)	2.6 (2.5, 2.7)	0.93 (0.87, 0.98)	0.0108
Normal	487,221 (61.8)	96.3 (96.2, 96.3)	3.7 (3.6, 3.7)	Reference	–
Overweight	200,719 (25.5)	95.1 (95.0, 95.2)	4.8 (4.7, 4.9)	1.06 (1.03, 1.09)	<0.0001
Obesity	53,171 (6.7)	94.9 (94.7, 95.0)*	5.1 (4.9, 5.3)*	1.07 (1.02, 1.11)	0.0034
High TG					
No	658,122 (83.5)	96.2 (96.2, 96.3)	3.7 (3.7, 3.8)	Reference	–
Yes	130,245 (16.5)	94.5 (94.4, 94.6)*	5.4 (5.3, 5.6)*	1.06 (1.03, 1.10)	<0.0001
High LDL-C					
No	637,905 (80.9)	96.2 (96.2, 96.3)	3.7 (3.7, 3.8)	Reference	–
Yes	150,462 (19.1)	94.7 (94.6, 94.8)*	5.3 (5.1, 5.4)*	1.09 (1.06, 1.13)	<0.0001
Diabetes					
No	768,214 (97.4)	96.0 (96.0, 96.1)	3.9 (3.9, 4.0)	Reference	–
Yes	120,153 (2.6)	93.2 (93.0, 93.6)*	6.7 (6.4, 7.1)*	1.08 (1.01, 1.14)	0.0149

Note: Due to the extremely small sample size, the detection rate of BI-RADS 0–1 is 0.0%; therefore, these data are not displayed in the table. "-" means that data are not applicable.

Abbreviation: *OR*=odds ratio; BMI=body mass index; *CI*=confidence interval; GDP=gross domestic product; LDL-C=low-density lipoprotein cholesterol.

* *P*<0.05.

special vigilance required for potentially malignant breast disease in women aged ≥70 years.

BI-RADS 4–5 classification indicates a high risk of breast cancer. Our geographic distribution analysis revealed that the highest risk of BI-RADS 4–5 was observed in western regions of China. Regarding socioeconomic indicators, regions with higher per capita GDP demonstrated a significant positive correlation with increased risk of BI-RADS 4–5 classification. Additionally, this study identified several metabolic and anthropometric risk factors associated with BI-RADS 4–5, including BMI and various metabolic indicators. These findings underscore the importance of developing tailored prevention strategies for populations with these high-risk factors, while simultaneously accounting for regional and socioeconomic disparities.

This study has several limitations. First, as the data were derived exclusively from health examination centers in urban areas, rural populations may be inadequately represented. Further research incorporating rural residents is necessary to provide a more comprehensive epidemiological profile of breast nodules across China. Second, the cross-sectional design inherently limits our ability to establish definitive causal relationships between breast nodules, BI-RADS 4–5 classification, and the associated factors identified. Finally, since our detection rates were based solely on ultrasound examination results — while breast nodule detection methods also include physical examination and mammography — there exists a potential risk of underestimation in our reported prevalence.

This study represents the first nationwide, big data-based analysis of the detection rate and BI-RADS classification of breast nodules in Chinese urban women, alongside an exploration of factors associated with BI-RADS 4–5. The findings underscore the pressing need for greater attention to female breast nodules and provide valuable foundational data for optimizing high-risk management in China's urban female population.

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Corresponding authors: Hui Liu, liuhui@pumc.edu.cn; Sailimai Man, sailimai.man@meinianresearch.com; Liming Li, lmlee@bjmu.edu.cn.

[1] Institute of Medical Information, Chinese Academy of Medical Sciences, Beijing, China; [2] Peking Union Medical College, Beijing, China; [3] Meinian Institute of Health, Beijing, China; [4] Peking University Health Science Center Meinian Public Health Institute, Beijing, China; [5] Department of Epidemiology and Biostatistics, School of Public Health, Peking University, Beijing, China; [6] Key Laboratory of Epidemiology of Major Diseases (Peking University), Ministry of Education, Beijing, China; [7] Peking University Center for Public Health and Epidemic Preparedness & Response, Beijing, China; [8] National Center for Chronic and Non-communicable Disease Control and Prevention, Chinese Center for Disease Control and Prevention, Beijing, China.
[&] Joint first authors.

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