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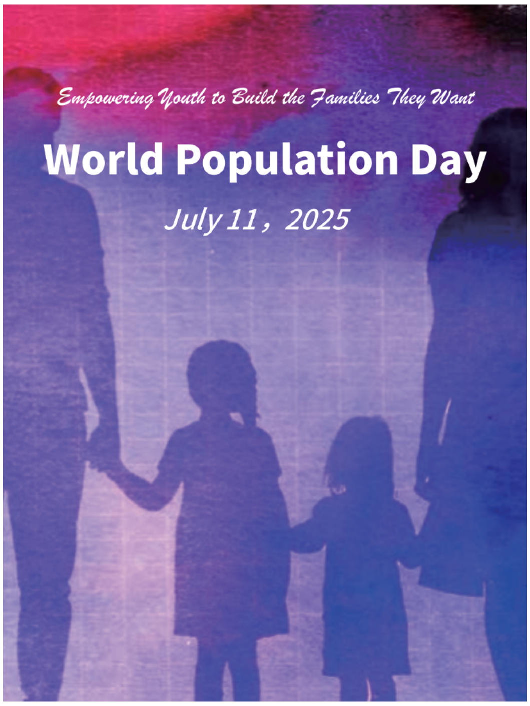

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Cover Image: adapted from the United Nations, https://www.un.org/en/observances/world-population-day.

Commentary

Empowering Youth to Build the Families They Want: Opportunities and Challenges

Danan Gu[1,#]

World Population Day, observed annually on July 11, focuses global attention on the intricate connections between population trends and sustainable development. Established by the United Nations Development Programme in 1989 and formally recognized by the UN General Assembly, its inaugural observance on July 11, 1990, spanned over 90 countries (*1–2*). This observance fosters dialogue on critical population issues, ranging from reproductive health and gender equality to the environmental sustainability.

For the 36th World Population Day in 2025, the United Nations Population Fund (UNFPA) has set the theme as "Empowering young people to create the families they want in a fair and hopeful world" (*3*), which underscores the pivotal role of youth in shaping demographic futures and affirms their fundamental right to reproductive autonomy. It serves as a call to action for governments, institutions, and societies to equip young people with the necessary tools, resources, and supportive environments, enabling them to make informed decisions about their lives and families.

While individuals aged 15–24 are defined as youth (*4*), persons between ages of 10 and 24 are usually considered young people (*5*). Comprising approximately 2 billion individuals, nearly a quarter of the global population, today's generation of young people is predominantly concentrated in low- and middle-income countries (*6*). These young people are transitioning into adulthood amidst profound economic, social, and environmental shifts. Their collective potential to drive national development and global progress, often termed the "demographic dividend," is contingent upon strategic investments in health, education, employment, and gender equality.

Despite this immense potential, many young people encounter significant obstacles in achieving their reproductive aspirations. Recent UNFPA research reveals that one in five individuals across 14 countries reports having fewer children than desired, attributing this to economic insecurity, job instability, housing unaffordability, gender inequality, and pervasive global uncertainties (*7*). The UN Secretary-General's 2025 message emphasizes that while youth possess vast potential, they frequently lack the conducive conditions required for them to flourish (*3*). True youth empowerment necessitates the dismantling of structural constraints that impede their ability to build the families they envision.

These barriers are not theoretical. Rather, they manifest in concrete, everyday realities that affect how young people live, grow, and plan for their futures. To better understand their needs, it is important to look more closely at the conditions that shape their choices and opportunities.

Access to youth-friendly sexual and reproductive health services remains a critical unmet need, especially for adolescent girls. Reproductive autonomy is fundamentally rooted in access to comprehensive sexual and reproductive health services. While adolescent birth rates have seen a substantial decline, from 73 to 38 births per 1,000 girls aged 15–19 since the 1990s, an estimated 12 million adolescent girls are still projected to give birth in 2025 (*5*). A significant number of these young individuals lack access to modern contraception, and tragically, maternal complications remain a leading cause of death among adolescent girls (*8*). Adolescent-responsive health systems to provide confidential counseling and respectful care are essential to reduce these risks and uphold reproductive autonomy.

Quality education is a powerful enabler of youth empowerment, yet many still lack access, particularly girls in low- and middle-income countries. Education helps delay early marriage and childbirth, enhances health outcomes, supports climate resilience, and promotes economic independence. Educated girls are more likely to make informed reproductive decisions and become active participants in public life. However, progress has stalled in many regions, leaving millions without the tools to build empowered futures (*9*).

Gender inequality continues to undermine young women's agency in family formation. Across many societies, girls are denied decision-making power regarding marriage, sexuality, and childbirth (*10*). Discriminatory laws and norms limit their leadership and economic participation. Achieving Sustainable

Development Goal 5 that focuses on gender equality and reproductive rights is essential to removing these barriers and enabling equitable opportunities for all (*11*).

Economic insecurity significantly hampers young people's ability to form families on their own terms. Precarious jobs, high living costs, and limited access to housing and childcare delay or derail family planning (*12*). Evidence shows that stable employment, entrepreneurship support, and robust social protections empower youth to pursue their desired family lives with confidence and security.

Digital inclusion and climate resilience are critical pillars of youth empowerment. However, millions of young people, especially in low-income, rural, or marginalized settings, lack access to the Internet, digital devices, and basic digital literacy, excluding them from vital educational and economic opportunities (*13*). At the same time, the worsening climate crisis threatens their health, livelihoods, and educational continuity. Equipping youth with digital access, green skills, and climate literacy, while aligning gender-responsive climate action with reproductive health and leadership programs, is essential to building more secure and equitable futures (*14*).

Achieving the ambitious 2025 vision necessitates coordinated, multi-sectoral efforts that empower young people to create the families they want and lead fulfilling lives in a fair and hopeful world. First, health and education systems must undergo comprehensive reform to be truly youth-responsive. Health services should be accessible, respectful, and confidential, with trained personnel and flexible hours to meet the diverse needs of adolescents and young adults. Simultaneously, education must extend beyond academic instruction to incorporate life skills, gender equality, and comprehensive sexual and reproductive health and rights (SRHR) education. Integrating SRHR into national curricula and delivering it effectively across all settings is essential for ensuring that young people are equipped to make informed choices.

Second, economic empowerment must be strengthened through labor market policies that promote youth employment and entrepreneurship by ensuring fair wages, skills development, and protections against exploitation. At the same time, comprehensive social protection systems, including childcare services, paid parental leave, and affordable housing, are vital to easing the financial and logistical burdens of parenthood, thereby making family formation more viable and appealing for young individuals. Special attention must be paid to marginalized groups, such as rural youth, girls, youth with disabilities, and those impacted by conflict or displacement, ensuring that investments and policies reach those most in need.

Third, digital inclusion must be prioritized to ensure that all young people can access and benefit from the opportunities offered by technology. Expanding digital infrastructure and ensuring access to affordable internet and devices can support youth engagement in education, health, employment, and civic life. However, this must be accompanied by targeted efforts to bridge persistent gender and rural-urban gaps in digital access and literacy, so that digital transformation is inclusive and equitable.

Fourth, legal and cultural environments must be transformed to uphold youth rights and agency. Restrictive laws and harmful social norms must be addressed through legal reform, public education campaigns, and strong youth-led advocacy. Enabling young people to participate meaningfully in policymaking processes not only upholds democratic principles but also improves the effectiveness and legitimacy of resulting policies.

Fifth, greater global solidarity is essential to ensure adequate resources for youth-centered development, especially in low- and middle-income countries. Donors, multilateral institutions, and international partners must scale up investments in reproductive health, education, climate resilience, and digital access. Crucially, all youth policies and programs must be rooted in a rights-based approach. As UNFPA emphasizes, the challenge is not declining fertility itself, but the erosion of reproductive choice (*7*). Efforts must focus on expanding options rather than applying pressure, ensuring that demographic targets never compromise individual autonomy or equity.

Finally, robust accountability mechanisms and sustained political commitment are needed to ensure progress. This includes investing in strong data systems with clear indicators such as adolescent birth rates, contraceptive coverage, gender parity in education, youth employment, digital access, and civic participation. Tools like the Young People's Empowerment Index (YPEI) can offer multidimensional insights (*15*). Youth must also be engaged in monitoring processes through national councils, digital feedback platforms, and community initiatives. Long-term government commitment to inclusive financing and global partnerships, such as South–South cooperation, will be key to scaling effective and innovative solutions.

In summary, the 2025 theme of the World Population Day presents a vital and timely opportunity: to unequivocally center youth in the global pursuit of reproductive rights, sustainable development, and overarching global equity. Empowering young people to create the families they desire is not merely an aspirational goal; it is an indispensable prerequisite for realizing demographic dividends, advancing fundamental human rights, and ultimately achieving a just, inclusive, and climate-resilient world. In alignment with this vision, the National Health Commission of China has set the theme of the 36th World Population Day in China as "Happy beginning with getting married and having children, love and support accompany each other" (*16*), highlighting marriage and childbirth support policies and service initiatives. This reflects a growing policy emphasis on supporting family formation through comprehensive, people-centered approaches. Taken together, the profound vision of the 2025 theme demands more than isolated sectoral reforms. It necessitates the establishment of inclusive systems that systematically dismantle barriers, unequivocally affirm agency, and strategically invest in futures shaped and led by youth. With unwavering political will, transformative cultural shifts, and concerted international cooperation, we possess the collective capacity to co-create a world where every young person, particularly girls, can shape their lives and families with unbridled freedom, inherent dignity, and enduring hope.

Disclaimer: Views expressed in this article are solely those of the author and do not necessarily reflect those of the United Nations.

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Vital Surveillances

Trends in the Incidence, Mortality and Lifetime Risks of Female Breast and Cervical Cancer — Guangdong Province, China, 2023

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ABSTRACT

Introduction: This study aims to report the epidemiological trends and provide updated estimates and lifetime risks for breast and cervical cancers among women in Guangdong province.

Methods: A Bayesian age-period-cohort model was applied to project incidence and mortality rates for 2023. The adjusted for multiple primaries (AMP) method was used to calculate the lifetime risks of developing and dying from breast and cervical cancer. Joinpoint analysis was employed to describe the temporal trends.

Results: The age-standardized incidence rate (ASIR) of female breast cancer increased from 2012 to 2019 in Guangdong province, with a particularly pronounced increase noted in the rural areas. The ASIR for cervical cancer among women aged over 55 increased in both urban and rural areas, whereas a declining trend was observed among women under the age of 55. The age-standardized mortality rates (ASMRs) for both breast cancer and cervical cancer demonstrated upward trends among women aged over 55, while no significant trend in ASMR was found for women under 55 years. In 2023, the estimated incidence rates of breast cancer and cervical cancer would be $50.81/10^5$ (ASIR would be $35.57/10^5$) and $15.31/10^5$ (ASIR would be $10.41/10^5$) respectively, with corresponding mortality rates of $10.78/10^5$ (ASMR would be $7.15/10^5$) and $6.11/10^5$ (ASMR would be $3.93/10^5$) for these cancers.

Conclusions: Breast cancer continues to pose a significant threat to women's health in both rural and urban areas of Guangdong, whereas cancer prevention and control programs for cervical cancer have shown positive impacts among the younger population. Greater emphasis should be placed on women aged over 55 to halt the rising mortality rates of both cancers within this population.

Breast cancer is the leading cancer diagnosis and cause of death in women worldwide, and cervical cancer ranks among the top five most common cancers in women (*1*). In China, the incidence rates of both cancers are increasing, while mortality rates show varying trends across different age groups and regions (*2*–*3*).

China has devoted significant resources to cancer prevention efforts. In 2009, the country initiated a nationwide free screening program for breast and cervical cancers targeting rural women (*4*). The Healthy China Action Plan (2019–2030) further proposed measures, including improving screening coverage and promoting human papillomavirus (HPV) vaccination (*5*).

Regional epidemiological studies of these cancers are crucial for developing precise and effective local prevention and control strategies. The female population in Guangdong province represents 8.6% of China's total female population. Guangdong has a high fertility rate, high population density, and unbalanced regional development. The incidence and mortality rates of female breast cancer in Guangdong exceed the national average, while cervical cancer rates are slightly lower (*6*–*7*). Despite substantial investments in breast and cervical cancer prevention and control in Guangdong over recent decades, research on disease burden trends remains inadequate. Therefore, this study aims to elucidate the epidemiological trends and provide current estimates and lifetime risk assessments for breast and cervical cancers in Guangdong Province, China, which can inform targeted prevention and control policies and provide a reference for similar regions.

METHODS

Data Sources

In 2019, 40 population-based cancer registries in

Guangdong province provided high-quality cancer surveillance data, covering 38.08 million (38.37% of the total provincial population). Data quality control standards were based on the "Guideline for Chinese Cancer Registration" and the criteria of the International Agency for Research on Cancer/International Association of Cancer Registries (IARC/IACR). This analysis focused on female breast cancer (ICD10: C50) and cervical cancer (ICD10: C53). Temporal trends were analyzed using data from 7 registries with continuous, high-quality data available from 2012 to 2019, representing 14.29% of Guangdong's total population. Detailed information about the population-based cancer registration system in Guangdong province is available in previously published sources (*6*). Population and all-cause mortality data were obtained from the Guangdong Provincial Center for Disease Control and Prevention.

Statistical Analysis

A Bayesian age-period-cohort model was applied to project age-specific incidence and mortality rates for 2023, using aggregated female breast and cervical cancer data from 40 registries in 2019 and trends in age-specific rates from 7 registries between 2012 and 2019. Age-standardized incidence and mortality rates (ASIR/ASMR) were calculated based on Segi's world standard population. The lifetime risks of developing and dying from cancer were calculated using the "adjusted for multiple primaries (AMP)" method (*8*–*9*). Temporal trends were analyzed using Joinpoint software (version 4.9.1.0, Statistical Research and Applications Branch, National Cancer Institute, Bethesda, MD, USA), with results expressed as the average annual percentage change (AAPC). All findings were stratified by area (total, urban, and rural) and age group (all ages, <55 years, and ≥55 years). We used age 55 as the cutoff to distinguish between pre-menopausal and post-menopausal status to better understand disease burden and temporal trends in these different groups. Statistical analyses were performed using R software (version 4.2.2, R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

Trends in ASIR from 2012 to 2019

The ASIR of female breast cancer in Guangdong province showed a significant upward trend from 2012 to 2019 (AAPC: 3.4%), with a more pronounced increase in rural areas compared to urban areas. ASIRs increased across all age groups, with women aged 55 and older experiencing greater increases than those under 55. For cervical cancer, while there was no statistically significant change in overall ASIR, a decline was observed among women under 55 years (AAPC: −2.3%), particularly in rural areas (AAPC: −3.2%). Conversely, the ASIR for cervical cancer among women aged 55 and older showed an increasing trend in both urban and rural areas (Figure 1, Supplementary Table S1, available at https://weekly.chinacdc.cn/).

Trends in ASMR from 2012 to 2019

No statistically significant change was observed in the age-standardized mortality rate (ASMR) of female breast cancer in Guangdong province from 2012 to 2019. However, the ASMR in women aged 55 and older showed an upward trend (AAPC: 3.6%), primarily due to increases among urban women in this age group. Similarly, while no statistically significant trend was found in the overall ASMR for cervical cancer, there were significant increases in both urban (AAPC: 9.3%) and rural areas (AAPC: 7.5%) for women aged 55 and older. No significant trends were observed for women under 55 for either cancer (Figure 2, Supplementary Table S1).

Estimated Incidence and Lifetime Risks in 2023

In 2023, an estimated 25,444 new cases of female breast cancer were projected to occur in Guangdong province, corresponding to a crude incidence rate of $50.81/10^5$ and an ASIR of $35.57/10^5$. The lifetime risk of developing breast cancer was calculated to be 4.24%. For cervical cancer, the estimated number of new cases was 7,666, with a crude incidence rate of $15.31/10^5$ and an ASIR of $10.41/10^5$ (Table 1). The lifetime risk of being diagnosed with cervical cancer was 1.44%.

Estimated Mortality and Lifetime Risks in 2023

In 2023, breast cancer was estimated to cause 5,399 deaths among women in Guangdong province, with a crude mortality rate of $10.78/10^5$ and an ASMR of $7.15/10^5$. The lifetime risk of dying from breast cancer was 1.11%. For cervical cancer, an estimated 3,060 deaths were projected to occur, with a crude mortality rate of $6.11/10^5$ and an ASMR of $3.93/10^5$. The

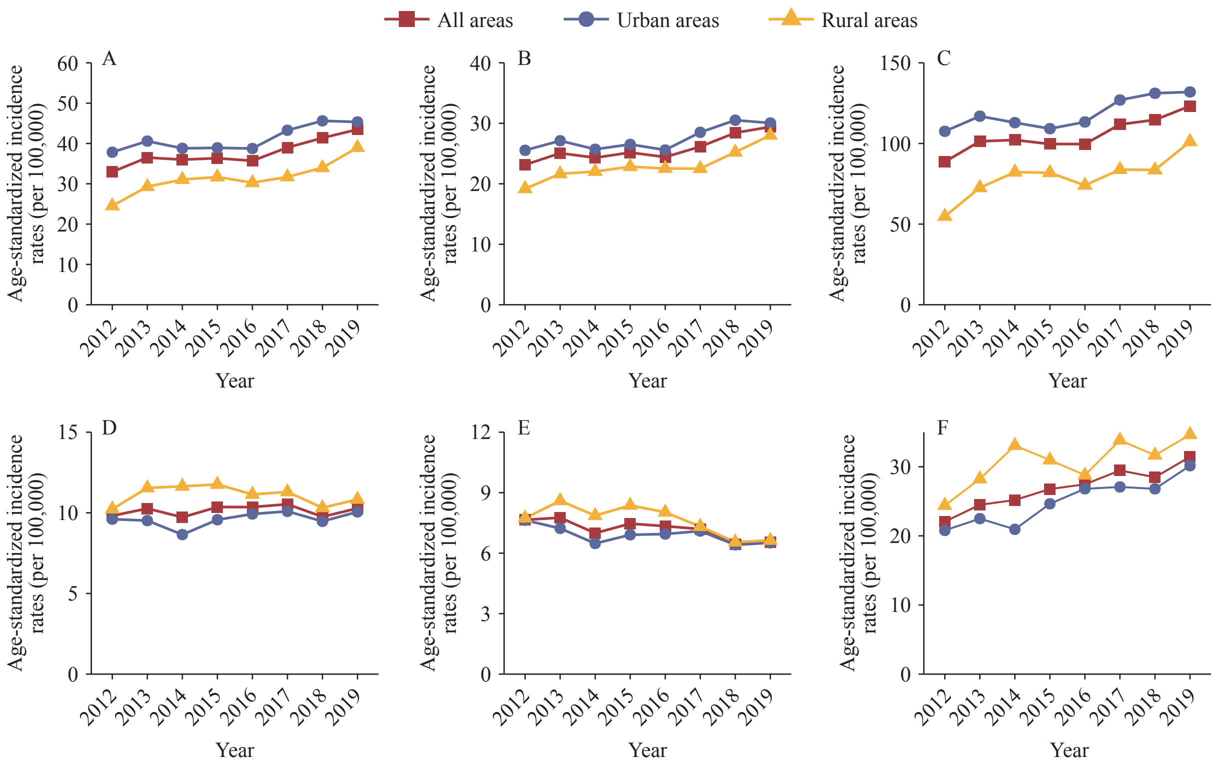

FIGURE 1. Trends in the incidence rates of breast and cervical cancers in Guangdong Province by area and age group, 2012–2019. (A) All ages for breast cancer; (B) <55 years for breast cancer; (C) ≥55 years for breast cancer; (D) All ages for cervical cancer; (E) <55 years for cervical cancer; (F) ≥55 years for cervical cancer.

lifetime risk of dying from cervical cancer was 0.67%. In contrast to incidence patterns, both the ASMR and lifetime mortality risk for cervical cancer were higher in rural areas than in urban areas (Table 1). The age-specific incidence and mortality rates and lifetime risks are illustrated in Figure 3 and Supplementary Figure S1 (available at https://weekly.chinacdc.cn/), respectively.

DISCUSSION

We estimated that the incidence rates of breast cancer and cervical cancer in Guangdong would be $50.81/10^5$ (ASIR would be $35.57/10^5$) and $15.31/10^5$ (ASIR would be $10.41/10^5$) respectively, with corresponding mortality rates of $10.78/10^5$ (ASMR would be $7.15/10^5$) and $6.11/10^5$ (ASMR would be $3.93/10^5$) for these cancers in 2023. Compared to the national estimates for 2022 in China (*10*), the ASIR and ASMR of breast cancer in Guangdong province remain higher than the national level, while the ASIR and ASMR of cervical cancer are lower than the national level. The lifetime risk of dying from cervical cancer among rural women was higher than that among urban women, while urban women faced higher lifetime risks of both developing and dying from breast cancer than rural women. The lifetime risks of developing and dying from breast cancer in Guangdong province are slightly higher than the national average in China, but both are lower than those in Japan and the United States (*11*). Conversely, the lifetime risks of developing and dying from cervical cancer in Guangdong province are slightly lower than the national average in China, but both are higher than those in Japan and the United States (*11*). The burden of breast cancer and cervical cancer in Guangdong accounts for a substantial proportion of the national burden, and breast cancer will remain the primary threat to women's health in Guangdong in both rural and urban areas for decades. Additionally, greater attention should be directed toward early detection and treatment of breast and cervical cancers for women over 55 years to halt the upward trends in mortality rates among this population.

The ASIR of breast cancer increased more rapidly in rural areas compared to urban areas across all age subgroups, though the overall disease burden remained higher in urban areas. Several factors may contribute to the rising ASIR trend, including the implementation of

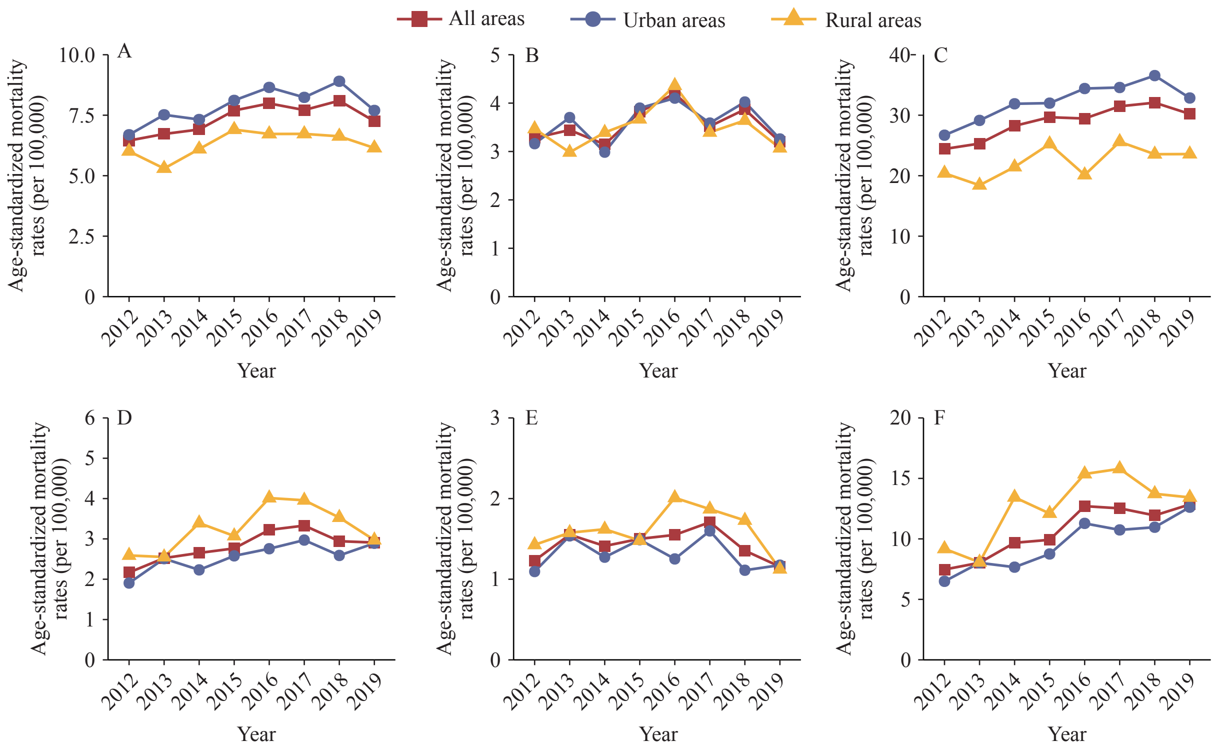

FIGURE 2. Trends in the mortality rates of breast and cervical cancers in Guangdong Province by area and age group, 2012-2019. (A) All ages for breast cancer; (B) <55 years for breast cancer; (C) ≥55 years for breast cancer; (D) All ages for cervical cancer; (E) <55 years for cervical cancer; (F) ≥55 years for cervical cancer.

free breast and cervical cancer screening programs in rural areas since 2009, which has increased detection rates while potentially decreasing mortality through early detection. The heavier disease burden in urban areas likely stems from greater exposure to risk factors such as work stress, obesity, physical inactivity, delayed childbearing, nulliparity, and reduced breastfeeding duration (*12–13*). For instance, women who did not breastfeed after childbirth had a 3.26-fold increased risk of breast cancer compared to those with a history of breastfeeding. Additionally, women with at least one live birth showed a significantly decreased risk compared to nulliparous women [odds ratio (*OR*)=0.09] (*12*). These findings underscore the importance of identifying key risk factors for implementing targeted interventions and screening measures in both rural and urban areas, for both younger and older women. The statistically significant rise in ASMR of breast cancer was observed only in women over 55 years, while no declining trend was evident in women under 55. These patterns suggest that screening benefits have yet to be fully realized in either region, and women over 55 in both rural and urban areas should remain a primary focus for breast cancer prevention and control efforts. Furthermore, considering the increasing ASIR and ASMR among older women, coupled with rising life expectancy and demographic shifts toward an aging population, reconsideration of screening guidelines may be warranted, particularly raising the upper age limit to better protect older women with elevated risk.

The incidence and mortality rates of cervical cancer for women under 55 in both urban and rural areas showed decreasing trends, indicating that cancer prevention and control measures for cervical cancer are beginning to show positive effects in younger age groups. HPV vaccination represents a key primary prevention measure, especially for young women. Research has shown that HPV-16/18 prevalence gradually increased among women aged 35-50 in Guangdong, with two infection peaks observed in women over 50 years (9.6%) and under 25 (8.2%) (*14*). In November 2021, Guangdong Province issued the Work Plan for Free HPV Vaccination of School-Age Girls (2022–2024), aiming to fully immunize 90% of girls under 15 against HPV by 2030. This initiative is estimated to benefit more than 750,000 individuals annually. The policy has not only increased HPV vaccine accessibility and vaccination rates but also raised public awareness of cervical cancer

TABLE 1. The estimated incidence, mortality, and lifetime risks of breast and cervical cancers in Guangdong province by area and age group, 2023.

Site	Area	Age group (years)	Incidence				Mortality			
			Cases	Crude rates (1/10^5)	ASIR (1/10^5)	Lifetime risks (%)	Deaths	Crude rates (1/10^5)	ASMR (1/10^5)	Lifetime risks (%)
Breast	Total	All ages	25,444	50.81	35.57	4.24	5,399	10.78	7.15	1.11
		<55	14,145	37.23	24.83	1.79	2,071	5.45	3.57	0.27
		≥55	11,299	93.52	96.42	2.45	3,328	27.55	27.42	0.84
	Urban areas	All ages	13,798	55.80	38.89	4.68	2,958	11.96	7.91	1.31
		<55	7,735	40.98	26.86	1.95	1,089	5.77	3.76	0.28
		≥55	6,063	103.63	107.10	2.73	1,869	31.94	31.44	1.03
	Rural areas	All ages	11,646	45.94	32.29	3.81	2,441	9.63	6.42	0.93
		<55	6,410	33.53	22.78	1.64	982	5.14	3.38	0.25
		≥55	5,236	84.03	86.14	2.17	1,459	23.42	23.61	0.68
Cervix	Total	All ages	7,666	15.31	10.41	1.44	3,060	6.11	3.93	0.67
		<55	3,276	8.62	5.69	0.42	729	1.92	1.23	0.09
		≥55	4,391	36.34	37.15	1.02	2,331	19.29	19.19	0.58
	Urban areas	All ages	3,924	15.87	10.88	1.45	1,313	5.31	3.51	0.57
		<55	1,748	9.26	6.03	0.44	359	1.90	1.21	0.09
		≥55	2,177	37.21	38.39	1.01	955	16.32	16.58	0.48
	Rural areas	All ages	3,742	14.76	9.96	1.42	1,747	6.89	4.32	0.77
		<55	1,528	7.99	5.36	0.39	370	1.94	1.26	0.10
		≥55	2,214	35.53	36.07	1.03	1,377	22.09	21.66	0.68

Abbreviation: ASIR=age-standardized incidence rate; ASMR=age-standardized mortality rate.

prevention, establishing a solid foundation for achieving the goal of cervical cancer elimination.

Although screening rates for both breast and cervical cancer in China have increased over time, they remain suboptimal (*15*–*16*). Guangdong province initiated a free breast and cervical cancer screening program for rural women in 2009 and expanded it to urban areas in 2020. According to China Chronic Disease and Risk Factor Surveillance (CCDRFS) data from Guangdong, screening coverage has improved substantially. Among women aged 35 years and older, cervical cancer screening rates increased from 19.4% in 2013 to 47.1% in recent years, while breast cancer screening rates rose from 18.6% to 45.0%. However, significant urban-rural disparities persist. Cervical cancer screening rates in urban areas increased from 23.2% to 50.2%, compared to 13.3% to 38.7% in rural areas. Similarly, breast cancer screening rates in urban areas rose from 24.1% to 48.8%, versus 9.7% to 34.5% in rural areas. Despite these improvements, both the ASIR and ASMR for cervical cancer continue to rise among women over 55 years of age in both urban and rural areas, with faster increases observed in the urban populations. These findings suggest that screening and tertiary prevention efforts for cervical cancer must be strengthened for women above 55 years in all regions. Furthermore, as the population ages, the recommended screening age range for cervical cancer should be extended to include older women, given the increasing incidence and mortality rates amongst this group.

This study has several strengths. Firstly, we conducted age and region subgroup analyses to identify high-risk populations. Secondly, the population-based surveillance data used are representative of the province. However, there are also limitations. Firstly, surveillance sites in rural areas were fewer than in urban areas, potentially contributing to fluctuations in trend analysis. Secondly, large cities in Guangdong have significant migrant populations, which may affect the precision of the cancer registry and vital surveillance data. Consequently, mortality figures may be slightly underestimated, necessitating careful interpretation of the data.

Conflicts of interest: No conflicts of interest.

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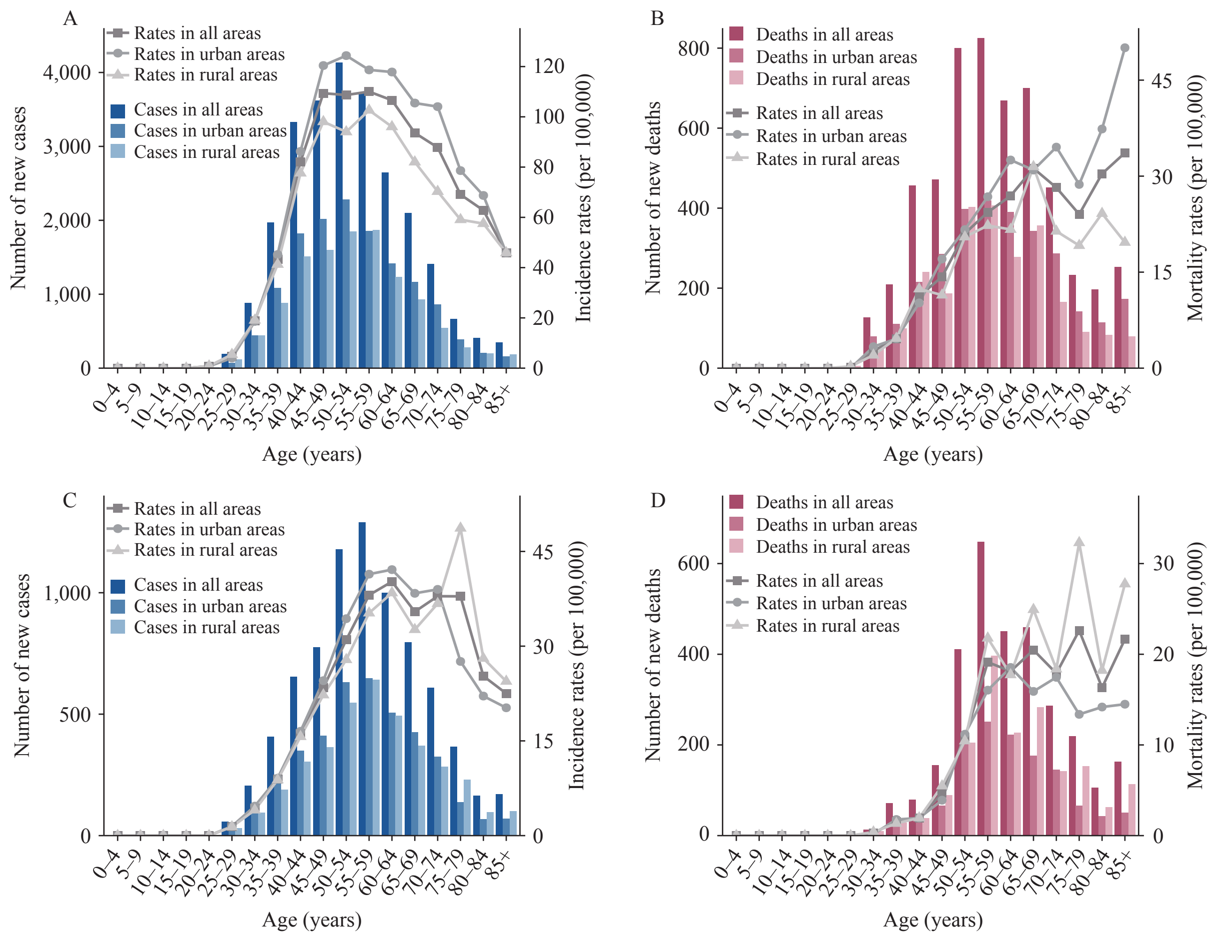

FIGURE 3. The cases/deaths and incidence/mortality rates of breast and cervical cancers in Guangdong Province by area and age group, 2023. (A) Cases and incidence rates for breast cancer; (B) Deaths and mortality rates for breast cancer; (C) Cases and incidence rates for cervical cancer; (D) Deaths and mortality rates for cervical cancer.

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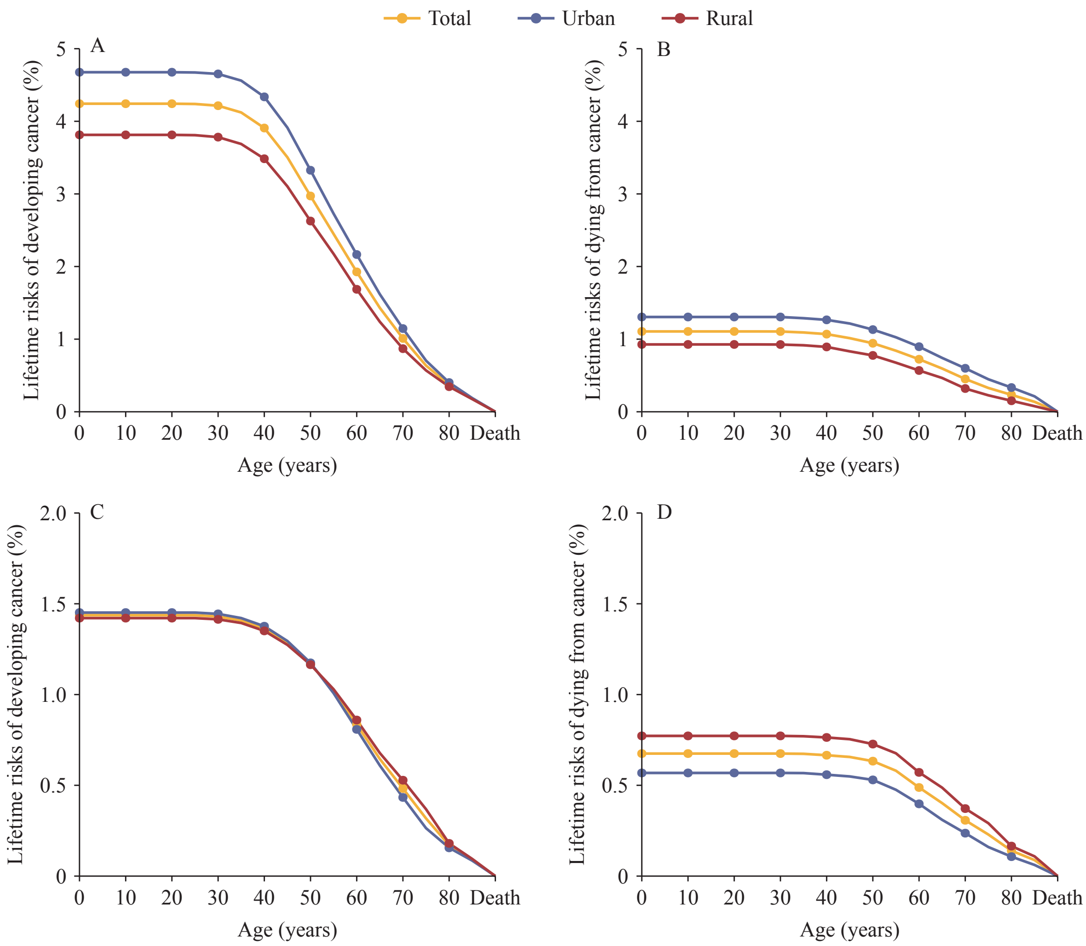
SUPPLEMENTARY MATERIAL

SUPPLEMENTARY TABLE S1. Trends for age-standardized incidence and mortality rates of breast and cervical cancers in Joinpoint analysis in Guangdong Province by area and age group, 2012–2019.

Site	Area	Age group (years)	Incidence		Mortality	
			AAPC (95% *CI*)	*P*	AAPC (95% *CI*)	*P*
Breast	Total	All	3.4 (1.8, 4.9)	0.002*	2.4 (−1.1, 5.9)	0.182
		<55	3.0 (1.5, 4.6)	0.003*	1.0 (−3.0, 5.2)	0.568
		≥55	3.9 (2.1, 5.7)	0.002*	3.6 (1.7, 5.5)	0.003*
	Urban areas	All	2.6 (0.9, 4.4)	0.009*	2.7 (−0.1, 5.5)	0.053
		<55	2.4 (0.7, 4.2)	0.015*	1.5 (−3.1, 6.2)	0.464
		≥55	2.9 (1.1, 4.7)	0.007*	3.5 (1.2, 5.9)	0.009*
	Rural areas	All	4.9 (2.4, 7.5)	0.003*	1.9 (−1.2, 5.0)	0.191
		<55	4.2 (2.3, 6.2)	0.002*	0.4 (−4.3, 5.3)	0.852
		≥55	6.1 (1.9, 10.5)	0.012*	3.1 (−0.7, 7.0)	0.093
Cervix	Total	All	0.4 (−0.9, 1.6)	0.496	3.5 (−0.2, 7.2)	0.061
		<55	−2.3 (−3.8, −0.8)	0.010*	−2.0 (−8.9, 5.4)	0.588
		≥55	4.5 (3.3, 5.8)	<0.001*	8.1 (4.2, 12.2)	<0.001*
	Urban areas	All	1.0 (−0.8, 2.8)	0.237	4.9 (1.2, 8.7)	0.017*
		<55	−1.7 (−3.4, 0.1)	0.060	−0.7 (−6.6, 5.4)	0.772
		≥55	5.3 (3.3, 7.3)	0.001*	9.3 (6.1, 12.6)	<0.001*
	Rural areas	All	−0.4 (−2.5, 1.8)	0.690	2.5 (−6.7, 12.5)	0.613
		<55	−3.2 (−5.6, −0.6)	0.023*	−2.4 (−11.2, 7.3)	0.615
		≥55	3.7 (0.5, 6.9)	0.029*	7.5 (0.6, 14.8)	0.038*

Abbreviation: AAPC=average annual percent change; *CI*=confidence interval.

* P<0.05.



SUPPLEMENTARY FIGURE S1. Lifetime risks of developing and dying from breast and cervical cancers within selected age intervals in Guangdong Province by area, 2023. (A) Risks of developing breast cancer; (B) Risks of dying from breast cancer; (C) Risks of developing cervical cancer; (D) Risks of dying from cervical cancer.

Preplanned Studies

Cost-Effectiveness of Increasing Outdoor Activity in Preventing Myopia in Children and Adolescents — China

Bonan Fan[1,&]; Xuanjing Li[2,&]; Yipeng Lyu[1]; Xiang Gao[1]; Shan Zhao[1]; Stella Wong[3]; Xinyi Liu[2,#]; Yan Li[1,4,#]

Summary

What is already known about this topic?

Myopia has emerged as a significant public health concern in China, particularly among children and adolescents. While evidence demonstrates the effectiveness of outdoor activity in preventing myopia, comprehensive economic analyses evaluating its role in reducing myopia-related diseases remain limited.

What is added by this report?

This study evaluates the cost-effectiveness of increasing outdoor activity across different educational stages in preventing myopia-related diseases among Chinese children and adolescents. The findings indicate that interventions implemented at all educational stages, with the exception of high school, are cost-effective strategies for reducing the myopia burden.

What are the implications for public health practice?

This research demonstrates the cost-effectiveness of increasing outdoor activity as a myopia prevention strategy among children and adolescents in China. It provides valuable insights for policymakers and healthcare planners to optimize resource allocation and develop targeted public health initiatives aimed at reducing the burden of myopia.

ABSTRACT

Introduction: Myopia has emerged as a major public health challenge affecting the visual health of children and adolescents in China. While evidence confirms the effectiveness of outdoor activity in preventing myopia, comprehensive economic analyses of its role in mitigating myopia-related diseases remain limited.

Methods: This study employed a microsimulation model to evaluate the cost-effectiveness of increasing outdoor activity across different educational stages — primary, middle, and high school — for myopia prevention in China. The model simulated myopia progression among individuals aged 6 to 18 years, with the intervention defined as an additional 40 minutes of daily outdoor activity. Outcomes measured included changes in myopia prevalence, quality-adjusted life years (QALYs), and associated medical costs.

Results: All intervention scenarios proved cost-effective, except for those targeting only the high school stage. Interventions focused on primary schools and combined primary–middle school stages not only improved health outcomes but also reduced medical costs. While the all-stages intervention yielded the greatest health benefits, its higher implementation costs make it more suitable for regions with greater resources.

Conclusion: These findings highlight the critical importance of early intervention in myopia prevention. Policymakers should prioritize outdoor activity programs at the primary school level and develop tailored prevention strategies based on local resource availability. This study provides empirical evidence for developing scientifically sound, cost-effective myopia prevention strategies for children and adolescents, with relevant implications for other developing countries facing a high myopia burden.

Myopia poses a significant public health challenge in China, with a prevalence of 51.9% among children and adolescents and 81.2% among high school students (*1*). If left uncontrolled, myopia can progress to severe visual impairments and impose substantial societal costs. While existing evidence demonstrates that outdoor activity is an effective intervention for preventing myopia, there remains a critical gap in economic analyses regarding its role in preventing myopia-related diseases. This study evaluates the cost-effectiveness of increasing outdoor activity across various educational stages in preventing myopia and its complications among children and adolescents in China. The results indicate that interventions implemented at all educational stages, with the exception of high school, are cost-effective strategies for reducing the burden of myopia.

This study developed a microsimulation model to simulate myopia progression among children and adolescents aged 6 to 18 years in China. The model was validated by comparing simulated myopia prevalence with data from the 2020 national survey (Table 1) (*2*). Specifically, the projected myopia prevalence rates closely aligned with those observed in the 2020 national survey, indicating reasonable model validity (Figure 1). Figure 2 shows the model schematic. Briefly, the model comprised five health states: "normal," "myopia," "high myopia," "pathological myopia," and "blindness." In each simulated year, individuals can remain in their current state, progress to a more severe state, or become blind. Interventions that reduce the risk of progression from one state to another could potentially alter the healthcare costs and quality-adjusted life years (QALYs).

This study estimated myopia prevalence from a 2022 government report (*1*). Age-specific transition probabilities between health states were derived from published literature, data from the National Health Commission of the People's Republic of China, and reports from the National Expert Advisory Committee on Vision Health Management for Children and Adolescents. In this study's model, it was assumed that simulated individuals had no other conditions affecting eyesight (e.g., glaucoma, diabetic retinopathy, and cataracts) and did not receive myopia treatment (e.g., surgery). The model tracked myopia onset, QALYs, and associated healthcare costs through age 18 under different intervention scenarios. This study developed the model using TreeAge Pro (version 2022, TreeAge Software, LLC, Williamstown, MA, USA), and the study was exempt from ethics approval as all data were publicly available.

The intervention in this study consisted of adding 40 minutes of outdoor activity each school day for

TABLE 1. Model validation against real-world data.

Educational stage	2018 input value (%)	2020 predictive value (%)	2020 true value (%)
6 years old	14.5	14.5	14.3
Lower grades of primary school	22.3	25.7	20.7
Upper grades of primary school	49.7	47.2	50.5
Middle school	71.6	70.2	71.1
High school	–	83.1	80.5

Note: "–" means that no input value was required for this stage.

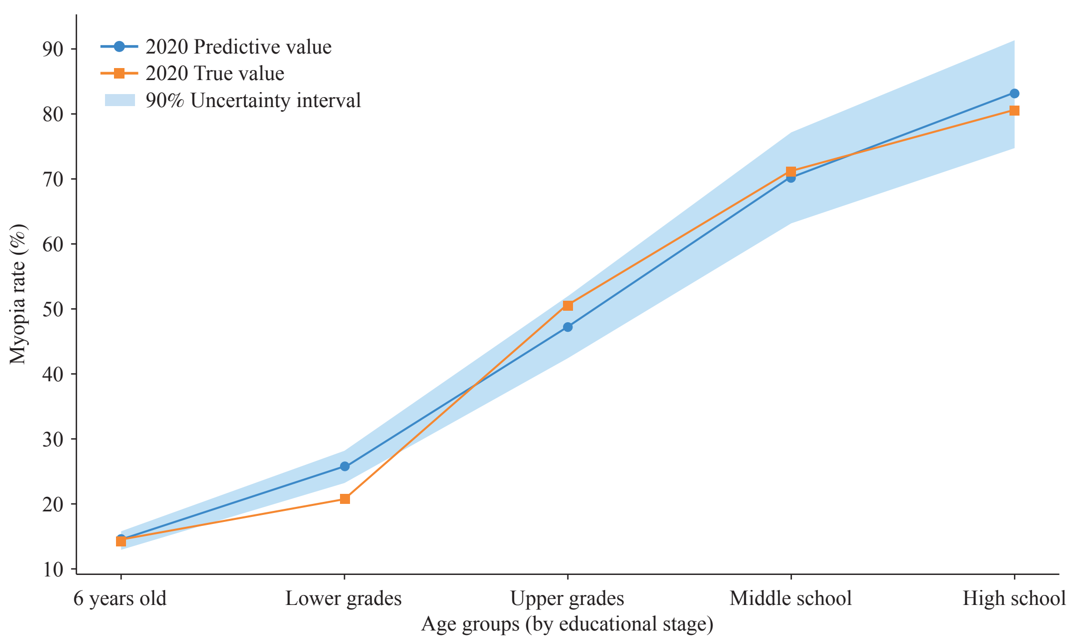


FIGURE 1. Model validation against real-world data.
Note: "Lower grades" and "Upper grades" means the lower and upper grades in primary school.

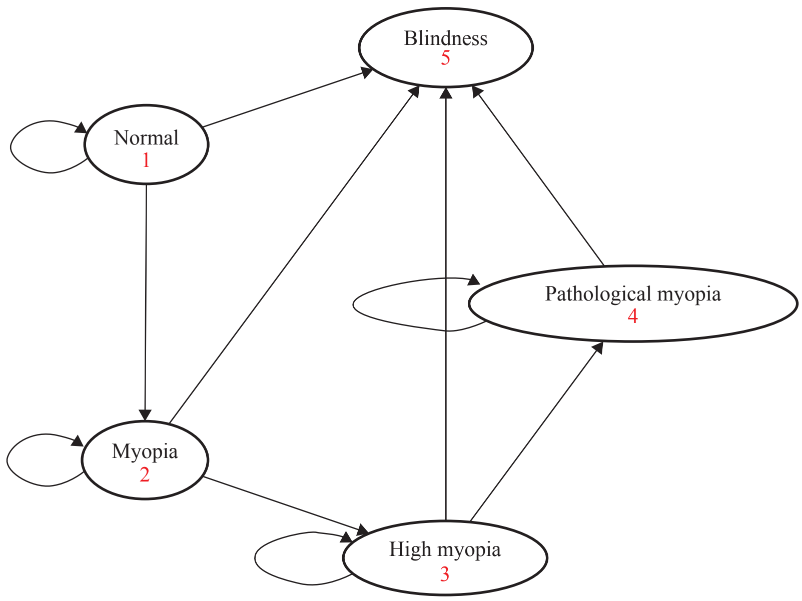


FIGURE 2. Model schematic.

three years. It based intervention effectiveness on a cluster randomized trial conducted in Guangzhou, China, which demonstrated a 30.4% cumulative incidence rate of myopia in the intervention group compared to 39.5% in the control group over three years (*3*). This study defined compliance rate as the proportion of children and adolescents who engaged in 40 minutes or more additional outdoor time following intervention implementation. The baseline analysis used an 83.5% compliance rate, as reported in this trial.

This study then modeled the impact of increasing outdoor activity across different educational stages: 1) primary school, 2) middle school, 3) high school, 4) primary and middle school, 5) middle and high school, and 6) all-stages (primary, middle, and high school). It compared these intervention strategies against a no-intervention scenario.

This study also collected cost data from a societal perspective, incorporating both direct and indirect costs, with estimates derived from previously published studies (*4*–*5*). Intervention and labor costs were estimated at 10.85 USD per person (*6*). Utility values for each health state were obtained from published literature (*7*), and QALYs were calculated by multiplying the duration spent in each health state by its corresponding utility value. Both costs and QALYs were discounted at 3.5% annually (*8*).

Table 2 presents the projected health and economic outcomes for 100,000 simulated children, comparing the status quo to the outdoor activity intervention. The primary school intervention was projected to increase QALYs by 0.069 years, while the middle school intervention was expected to increase QALYs by 0.011 years, and the high school intervention showed virtually no impact. The primary and middle school intervention was expected to increase QALYs by 0.083 years, while the middle and high school intervention showed an increase of 0.012 years. The all-stages intervention was projected to increase QALYs by 0.084 years. All interventions, except those limited to high school, were associated with reduced healthcare costs, with the largest savings observed in the all-stages intervention (168 USD), although it also incurred the highest implementation costs (130 USD per individual).

The incremental cost-effectiveness ratio (ICER) for the primary school, primary and middle school, and all-stages intervention was cost-saving. The middle school, middle and high school, and high school intervention had ICERs of 608 USD/QALY, 1,851 USD/QALY, and 28,902 USD/QALY, respectively. Compared to the status quo, all interventions except the high school-only intervention were cost-effective. Figure 3 presents the cost-effectiveness outcomes for all strategies, highlighting the "undominated strategies" — the primary school, primary and middle school, and all-stages interventions. These are considered optimal as they offer greater effectiveness at the same cost or lower costs for the same effectiveness. From a cost-effectiveness perspective, the primary school intervention is the favorable choice for scenarios

TABLE 2. Projected health and economic outcomes under different interventions.

Intervention strategy	Mean estimate				
	QALYs	Incremental QALYs	Costs (USD)	Incremental costs(USD)	ICER (USD/QALYs)
Status quo	9.279	–	1,228.95	–	–
Primary school	9.348	0.069	1,175.02	−53.93	Cost-saving
Middle school	9.290	0.011	1,235.70	6.75	608.03
High school	9.279	0	1,243.26	14.31	28,901.72
Primary & middle school	9.362	0.083	1,177.10	−51.84	Cost-saving
Middle & high school	9.290	0.012	1,249.86	20.91	1,787.32
All-stages	9.362	0.084	1,191.01	−37.94	Cost-saving

Note: "–" indicates not applicable; the status quo serves as the reference and thus has no incremental or ICER values. Incremental QALYs and Incremental costs are both compared to the status quo.
Abbreviation: QALYs=quality-adjusted life-years; USD=United States dollar; ICERs=incremental cost-effectiveness ratios.

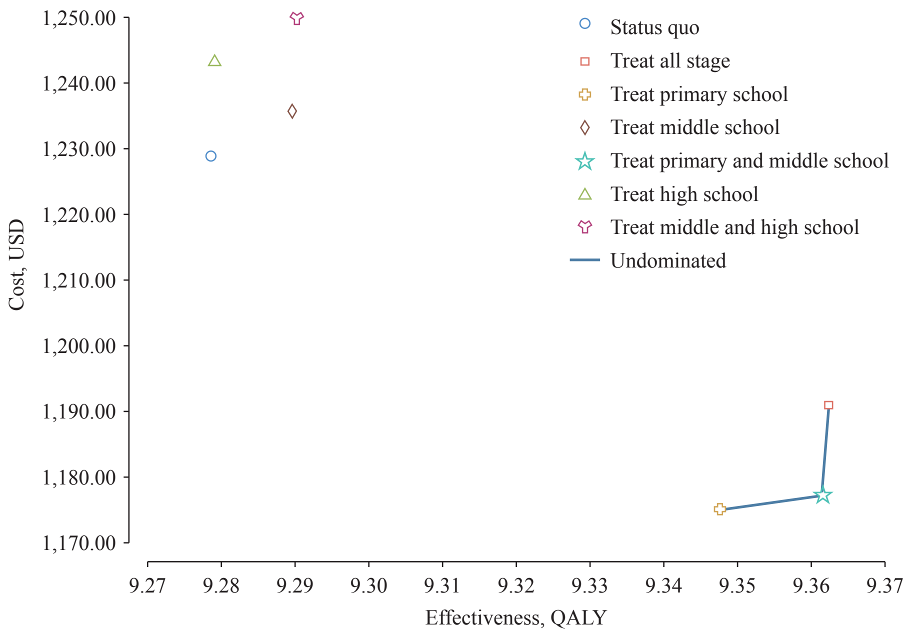


FIGURE 3. Cost-effectiveness analysis of different interventions.
Abbreviation: QALY=quality-adjusted life-years.

with limited budgets. Meanwhile, the primary and middle school or all-stages interventions are more suitable for achieving higher effectiveness when resources permit.

DISCUSSION

This study, utilizing a microsimulation model of myopia progression, provides valuable insights for guiding resource allocation in myopia prevention. To the best of this study's knowledge, it is the first health economic evaluation to assess the impact of increasing outdoor activity on preventing myopia among children and adolescents in China. The results demonstrate that outdoor activity interventions can substantially reduce the incidence of myopia-related diseases, with interventions in primary and middle school proving most cost-effective.

This study's findings emphasize that early intervention — particularly in primary school — yields the greatest benefits in preventing myopia. This supports previous research showing that myopia progression can be most effectively controlled when interventions are introduced early in life (*9*). Furthermore, while the all-stages intervention produces the largest reduction in healthcare costs, its higher implementation cost makes it less feasible for regions with limited economic resources. Interventions at the primary and middle school levels, though cost-saving, incur lower implementation costs and may be more appropriate for such regions.

The findings also underscore the importance of supportive public health policies tailored to the needs of different regions. Global initiatives, including those from the World Health Organization and the American Academy of Ophthalmology, have emphasized the importance of outdoor activity in myopia prevention (*10*). In China, national efforts, such as the "National Key Work Plan for Comprehensive Prevention of Myopia in Children and Adolescents," have recently been introduced to address myopia, including strategies to extend break times for students and promote outdoor activities. However, these policies often lack the specificity needed for effective implementation. For instance, they typically do not define the optimal duration of outdoor activity or outline structured intervention programs designed to maximize the benefits of outdoor exposure.

This study offers several strengths: it validated its microsimulation model of myopia progression against real-world data on the prevalence and incidence of myopia in Chinese children and adolescents, which enhances the reliability of the resultant cost-effectiveness results. Additionally, by simulating various intervention strategies, it provides robust evidence that can inform the development of practical, cost-effective myopia prevention policies. Furthermore, this study demonstrates how interventions should be tailored to accommodate the economic and healthcare constraints of different regions.

Despite these strengths, this study has several limitations. First, it focuses exclusively on the health and economic outcomes of myopia-related diseases, potentially overlooking the broader benefits of outdoor activity. Second, it assumes that outdoor activity only influences the transition from "normal" to "myopia" due to insufficient evidence regarding the effect of outdoor activity on myopia progression after onset. Future research should investigate the effects of outdoor activity on individuals with more severe myopia-related diseases and examine the optimal duration and timing of interventions.

In conclusion, this study is the first to assess the health and economic impacts of increasing outdoor activity for myopia prevention among children and adolescents in China. The results provide valuable evidence for policymakers developing cost-effective myopia prevention strategies. Furthermore, these findings can serve as a reference for other developing countries facing a high burden of myopia.

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Preplanned Studies

Establishment and Validation of a Risk Prediction Model for Non-Suicidal Self-Injury Among Adolescents Based on Machine Learning Methods — Jiangsu Province, China, 2023

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Summary

What is already known about this topic?

Non-suicidal self-injury (NSSI) has become increasingly common among adolescents, posing a significant public health concern that impacts both physical and mental well-being.

What is added by this report?

A total of 12.72% of adolescents aged 10–18 had engaged in NSSI in Jiangsu Province, China. A well-calibrated risk prediction model [AUC=0.800, 95% confidence interval (*CI*): 0.776, 0.823] identified 8 key predictors of NSSI: insomnia, emotional symptoms, cohesion of family environment, history of drinking alcohol, gender, conflict of family environment, conduct problems, and academic level.

What are the implications for public health practice?

This study underscores the importance of personalized prevention strategies for NSSI and highlights the necessity of implementing comprehensive behavioral interventions, such as providing mental health support, enhancing sleep quality, and cultivating supportive family environments.

ABSTRACT

Introduction: Non-suicidal self-injury (NSSI) has become increasingly prevalent among adolescents, representing a significant public health concern with profound impacts on both physical and mental well-being. This study aims to determine the prevalence of NSSI among adolescents in Jiangsu Province and develop a prediction model to facilitate early identification and intervention.

Methods: This study is based on the "School-based Evaluation and Response to Child Health (SEARCH)" project. A cross-sectional survey was conducted among students from 11 schools in Jiangsu Province, China in 2023. Following data cleaning, 11,427 students were included in the analysis. Machine learning methods were employed to establish a risk prediction model for NSSI among adolescents.

Results: The prevalence of NSSI among adolescents aged 10–18 was 12.72%. Eight key predictors of NSSI were identified: insomnia, emotional symptoms, cohesion of family environment, history of drinking alcohol, gender, conflict of family environment, conduct problems, and academic level. The XGBoost model demonstrated an area under the curve (AUC) of 0.800 [95% confidence interval (*CI*): 0.776, 0.823] and an accuracy (ACC) of 0.886 in the testing set.

Conclusions: This study underscores the importance of personalized prevention strategies for NSSI and highlights the necessity of implementing comprehensive behavioral interventions, including mental health support, sleep quality enhancement, and cultivation of supportive family environments.

Non-suicidal self-injury (NSSI) refers to deliberate and repeated self-harm without suicidal intent that is not socially sanctioned (excluding practices such as tattoos and body piercings). Common methods include cutting, burning, hitting, and scratching. In recent years, NSSI has become increasingly prevalent among adolescents, raising significant public health concerns due to its adverse impacts on both physical and mental well-being. NSSI is a key risk factor for suicidal behavior (*1*) and may increase the risk of subsequent psychopathological symptoms, repeated self-harm, and substance abuse issues (*2*). A systematic review reported that the prevalence rates of non-suicidal self-harm among youth in low- and middle-income countries ranged from 15.5% to 33.3% (*3*), with prevalence in China varying from 5.4% to 33.8% due to differences in research designs and evaluation metrics (*4*). The onset of NSSI typically occurs in early adolescence (ages 11 to 14), peaks during mid-adolescence (ages 15 to 16), and then declines in late adolescence or early adulthood. Therefore, conducting epidemiological studies within community populations, particularly among student groups, is essential for investigating NSSI behavioral patterns and facilitating early detection and intervention for high-risk individuals. This study employs machine learning methods to develop and validate a risk prediction model for NSSI in adolescents, providing robust scientific evidence for early identification and prevention initiatives.

This study was based on the baseline cross-sectional data from the longitudinal cohort study "School-based Evaluation and Response to Child Health (SEARCH)," which was conducted in Jiangsu Province, China. A digital platform was used to assess the mental health status of students. Participants were recruited using a stratified cluster randomized sampling method from Hailing District (Taizhou City), Yixing (Wuxi City), and Sheyang Counties (Yancheng City) in Jiangsu Province at baseline from September 2022 to February 2023. A total of 11,427 adolescents participated in this study, with a response rate of 98.2%. Data collection involved three cities in Jiangsu Province, including three primary schools, five junior high schools, and three senior high schools. The process of data collection, model establishment and validation is illustrated in the flowchart presented in Supplementary Figure S1 (available at https://weekly.chinacdc.cn/).

The questionnaire comprised two sections. The first section collected sociodemographic information, including gender, academic level, regional economic level, family structure, parental marriage status, the frequency of parental quarrels, and students' academic performance ranking. The second section assessed NSSI using the Chinese version of Ottawa Self-Injury Inventory (OSI). Additional assessments included the Strengths and Difficulties Questionnaire (SDQ) for emotional and behavioral issues, the Chinese version of Family Environment Scale (FES-CV) for family environment, and Insomnia Severity Index (ISI) for insomnia status. The Cronbach's alpha for OSI, SDQ, FES-CV and ISI were 0.72, 0.78, 0.78, and 0.89, respectively, indicating substantial internal validity. Health-related variables, such as alcohol and cigarette use, were recorded as binary outcomes (yes/no). A priori evaluations of potential factors associated with NSSI were conducted based on established scientific knowledge, public health relevance, and predictors highlighted in previous research findings. The presence or absence of NSSI was used as the outcome variable, with a total of 21 variables employed as predictors. Categorical variables were compared between students with and without NSSI using chi-square tests. Shapley Additive exPlanation (SHAP) and extreme gradient boosting (XGBoost) were used to filter predictors and establish a risk prediction model for NSSI among adolescents (*5*). To refine the prediction model, a 5-fold cross-validation and manual fine-tuning process was utilized to identify the optimal parameters. Participants were randomly divided into a training set (1,034 students with NSSI) and a testing set (419 with NSSI) in a 7∶3 ratio. Variable importance and SHAP beeswarm plots were generated to visualize the results. Receiver operating characteristic (ROC) curves, area under the curve (AUC), accuracy (ACC), and calibration plots were used to evaluate the prediction accuracy of the model. All statistical analyses were conducted using R Statistical Software (version 4.3.3, R Development Core Team, Vienna, Austria). A P value below 0.05 was considered statistically significant.

A total of 11,427 students aged 10 to 18 participated in the survey, comprising 6,083 (53.2%) boys and 5,344 (46.8%) girls, with a mean age of 14.0±2.4 years. Among these participants, 12.72% reported engaging in NSSI (Table 1). Using the XGBoost algorithm, this study evaluated the importance of 21 predictive factors and identified optimal parameters through 5-fold cross-validation. The variable importance plot (Figure 1) reveals that the eight most influential variables in the optimal model are insomnia, emotional symptoms, cohesion of family environment, history of drinking alcohol, gender, conflict of family environment, conduct problems, and academic level. The SHAP beeswarm plot (Supplementary Figure S2, available at https://weekly.chinacdc.cn/) illustrates the predictive contribution of each factor to NSSI risk. The AUC and ACC values of the XGBoost model were 0.817 [95% confidence interval (*CI*): 0.803–0.831] and 0.882 in the training set, and 0.800 (95% *CI*: 0.776–0.823) and 0.886 in the testing set, respectively. The ROC curves are presented in Figure 2. The calibration curve for the XGBoost model shows dots closely aligned with the 45° diagonal line (Supplementary Figure S3, available at https://weekly.chinacdc.cn/), indicating strong concordance between predicted and observed values.

TABLE 1. Comparisons of characteristics between Non-NSSI students and NSSI students [*N* (%)].

Variables	Non-NSSI students (*N*=9,974)	NSSI students (*N*=1,453)	Total (*N*=11,427)	$χ^2$
Gender				
Male	5,417 (54.3)	666 (45.8)	6,083 (53.2)	36.59*
Female	4,557 (45.7)	787 (54.2)	5,344 (46.8)	
Academic level				
Primary school	2,939 (29.5)	270 (18.6)	3,209 (28.1)	78.19*
Middle school	3,697 (37.1)	656 (45.1)	4,353 (38.1)	
High school	3,338 (33.5)	527 (36.3)	3,865 (33.8)	
Regional economic level				
Low	3,257 (32.7)	543 (37.4)	3,800 (33.3)	151.73*
Middle	2,865 (28.7)	582 (40.1)	3,447 (30.2)	
High	3,852 (38.6)	328 (22.6)	4,180 (36.6)	
Family structure				
Core family	4,599 (46.1)	586 (40.3)	5,185 (45.4)	17.09*
Non-core family	5,375 (53.9)	867 (59.7)	6,242 (54.6)	
Parental marriage status				
Married	7,890 (79.1)	1,058 (72.8)	8,948 (78.3)	29.57*
Others	636 (6.4)	122 (8.4)	758 (6.6)	
Unknown	1,448 (14.5)	273 (18.8)	1,721 (15.1)	
Frequency of parental quarrels				
Never	4,230 (42.4)	335 (23.1)	4,565 (39.9)	371.87*
Sometimes	5,438 (54.5)	948 (65.2)	6,386 (55.9)	
Often	306 (3.1)	170 (11.7)	476 (4.2)	
Academic performance ranking				
Top 25%	3,406 (34.1)	463 (31.9)	3,869 (33.9)	97.70*
26%–50%	1,809 (18.1)	294 (20.2)	2,103 (18.4)	
51%–75%	1,118 (11.2)	205 (14.1)	1,323 (11.6)	
Bottom 25%	885 (8.9)	216 (14.9)	1,101 (9.6)	
Not disclosed	2,756 (27.6)	275 (18.9)	3,031 (26.5)	
SDQ_emotional symptoms				
Normal	9,369 (93.9)	965 (66.4)	10,334 (90.4)	1,183.43*
Marginal	284 (2.8)	146 (10.0)	430 (3.8)	
Abnormal	321 (3.2)	342 (23.5)	663 (5.8)	
SDQ_conduct problems				
Normal	8,358 (83.8)	853 (58.7)	9,211 (80.6)	598.39*
Marginal	974 (9.8)	267 (18.4)	1,241 (10.9)	
Abnormal	642 (6.4)	333 (22.9)	975 (8.5)	
SDQ_hyperactivity				
Normal	8,859 (88.8)	877 (60.4)	9,736 (85.2)	896.61*
Marginal	588 (5.9)	210 (14.5)	798 (7.0)	
Abnormal	527 (5.3)	366 (25.2)	893 (7.8)	
SDQ_peer problems				
Normal	6,848 (68.7)	733 (50.4)	7,581 (66.3)	280.98*
Marginal	2,653 (26.6)	518 (35.7)	3,171 (27.8)	

Continued

Variables	Non-NSSI students (*N*=9,974)	NSSI students (*N*=1,453)	Total (*N*=11,427)	χ^2
Abnormal	473 (4.7)	202 (13.9)	675 (5.9)	
SDQ_prosocial behavior				
Normal	7,910 (79.3)	1,049 (72.2)	8,959 (78.4)	38.28*
Marginal	1,049 (10.5)	199 (13.7)	1,248 (10.9)	
Abnormal	1,015 (10.2)	205 (14.1)	1,220 (10.7)	
FES_cohesion				
Low	1,030 (10.3)	530 (36.5)	1,560 (13.7)	897.37*
Medium	3,809 (38.2)	624 (42.9)	4,433 (38.8)	
High	5,135 (51.5)	299 (20.6)	5,434 (47.6)	
FES_conflict				
Low	4,891 (49.0)	310 (21.3)	5,201 (45.5)	859.38*
Medium	4,369 (43.8)	713 (49.1)	5,082 (44.5)	
High	714 (7.2)	430 (29.6)	1,144 (10.0)	
FES_achievement				
Low	4,116 (41.3)	671 (46.2)	4,787 (41.9)	12.63*
Medium	5,533 (55.5)	737 (50.7)	6,270 (54.9)	
High	325 (3.3)	45 (3.1)	370 (3.2)	
FES_intellectual-cultural				
Low	3,103 (31.1)	672 (46.2)	3,775 (33.0)	159.05*
Medium	5,572 (55.9)	699 (48.1)	6,271 (54.9)	
High	1,299 (13.0)	82 (5.6)	1,381 (12.1)	
FES_active recreational				
Low	2,012 (20.2)	578 (39.8)	2,590 (22.7)	354.57*
Medium	3,571 (35.8)	544 (37.4)	4,115 (36.0)	
High	4,391 (44.0)	331 (22.8)	4,722 (41.3)	
FES_organization				
Low	2,645 (26.5)	754 (51.9)	3,399 (29.7)	408.23*
Medium	5,935 (59.5)	619 (42.6)	6,554 (57.4)	
High	1,394 (14.0)	80 (5.5)	1,474 (12.9)	
FES_control				
Low	4,115 (41.3)	599 (41.2)	4,714 (41.3)	5.90
Medium	4,509 (45.2)	625 (43.0)	5,134 (44.9)	
High	1,350 (13.5)	229 (15.8)	1,579 (13.8)	
Insomnia				
No	8,019 (80.4)	609 (41.9)	8,628 (75.5)	1,015.67*
Yes	1,955 (19.6)	844 (58.1)	2,799 (24.5)	
Smoking history				
No	9,417 (94.4)	1,209 (83.2)	10,626 (93.0)	244.43*
Yes	557 (5.6)	244 (16.8)	801 (7.0)	
Drinking history				
No	8,405 (84.3)	905 (62.3)	9,310 (81.5)	406.09*
Yes	1,569 (15.7)	548 (37.7)	2,117 (18.5)	

Abbreviation: *N*=number; NSSI=non-suicidal self-injury; SDQ=Strengths and Difficulties Questionnaire; FES=family environment scale.
* *P*<0.01.

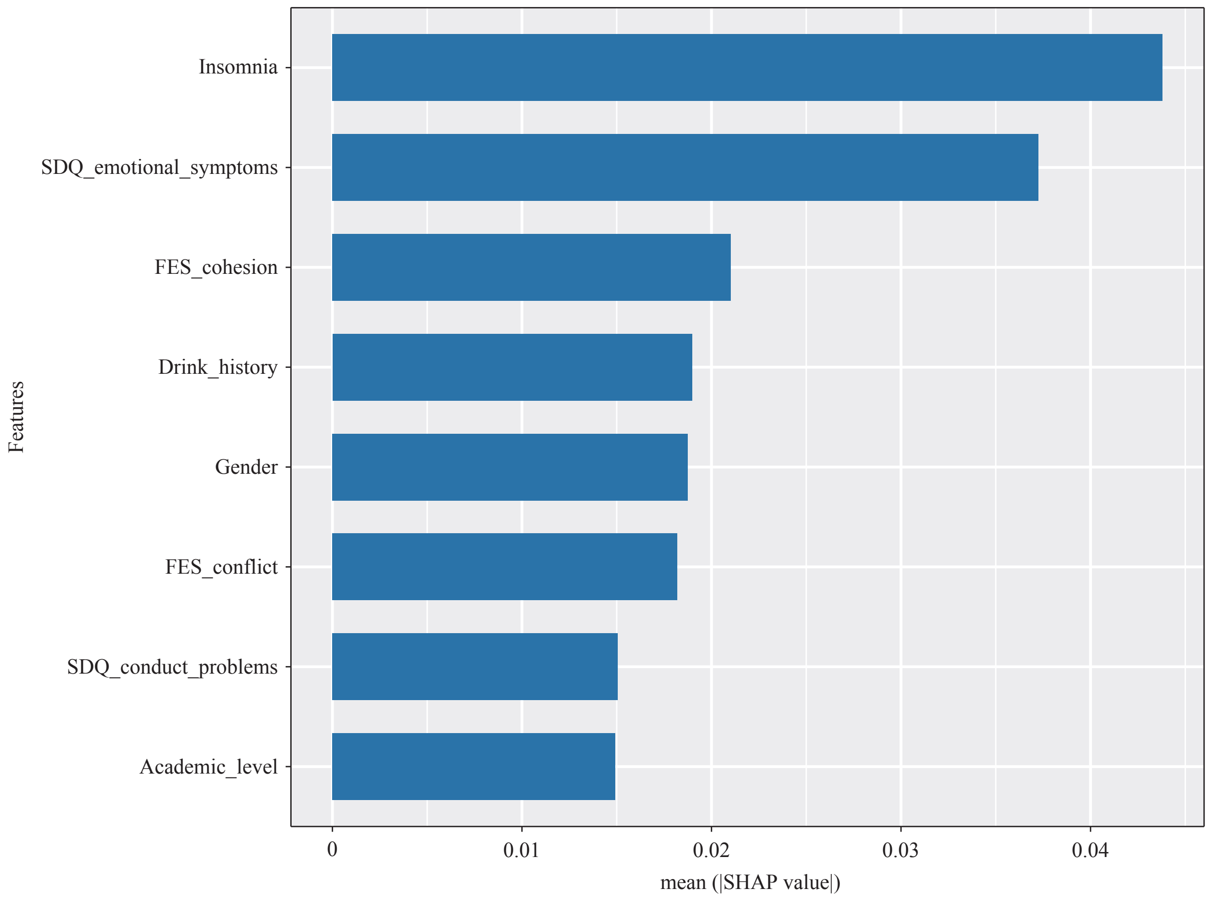

FIGURE 1. The SHAP value importance of features.
Abbreviation: SDQ=strengths and difficulties questionnaire; FES=family environment scale; SHAP=Shapley Additive exPlanations.

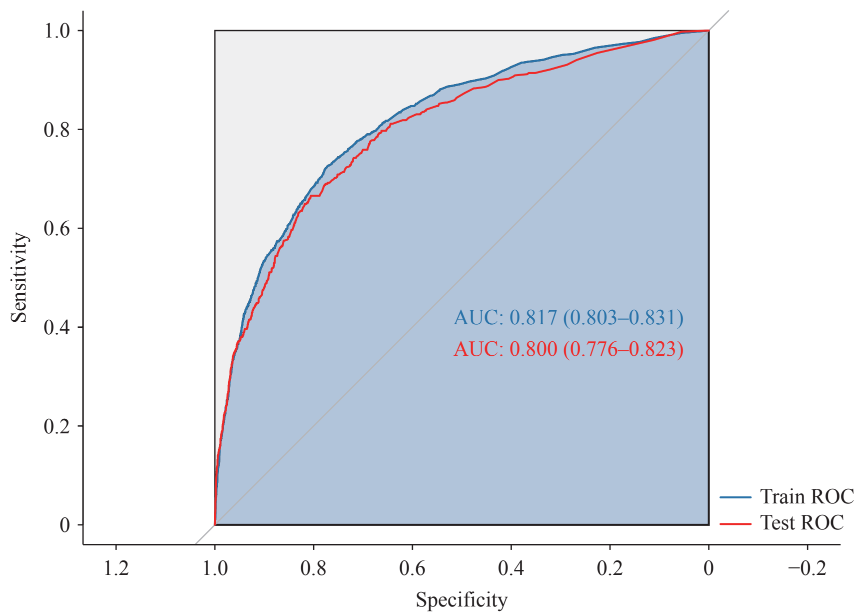

FIGURE 2. The ROC curves of training set and testing set.
Abbreviation: ROC=receiver operating characteristic; AUC=area under curve.

DISCUSSION

The prevalence of NSSI among adolescents aged 10 to 18 in Jiangsu Province is 12.72%, which is notably higher than the 4.64% reported among the same age group in Sichuan Province (*5*), yet lower than the 30.2% observed in Anhui Province (*6*). This study is the first to apply the XGBoost algorithm to develop a risk prediction model for adolescent NSSI in Jiangsu, China. Using data from 11,427 school-aged adolescents, this study's authors built a risk prediction model by filtering variables based on SHAP value importance. The model demonstrated good predictive performance, identifying insomnia, emotional symptoms, family environment cohesion, history of drinking alcohol, gender, family conflict, conduct problems, and academic level as key predictors for NSSI. Current research on NSSI prediction across various populations faces several limitations. Notably, there is a lack of studies focusing on predictive models specifically for adolescents, and existing models often include a limited range of independent variables. Additionally, few studies have explored the potential of XGBoost in NSSI prediction. This approach offers several advantages, including flexibility in data type handling, efficient training, and strong predictive performance. This study's final results confirm that the model has high predictive accuracy and a well-calibrated curve fit.

Zhou et al. (*7*) constructed a random forest model to predict NSSI among junior and senior high school students, identifying key predictors including adolescent depression, insomnia, family conflict, and gender. Similarly, Jiang et al. (*8*) reported that family environment cohesion and conflict were significant contributors to NSSI, which aligns with this study's findings. Marti-Puig et al. (*9*), using machine learning models with leave-one-subject-out (LOSO) cross-validation, demonstrated that recent adverse emotional experiences can trigger NSSI in adolescents. Consistent with these studies, this study research identified emotional symptoms and insomnia as significant predictors of NSSI (*10*). Additionally, within China's cultural and educational context, adolescence represents a transition from junior to senior high school characterized by increasing academic pressure. Consequently, academic level emerged as a predictor in this study's model. Furthermore, this study's model included drinking history and conduct problems as predictive factors, supplementing previous literature.

This study has several limitations. First, its cross-sectional design precludes causal inferences; therefore, results should be interpreted cautiously. Future longitudinal studies are needed to better quantify the influence of independent variables on NSSI. This study's "SEARCH" project is currently conducting subsequent cohort studies to address this limitation. Second, as this research was conducted in Jiangsu Province, the findings may not be generalizable to other regions or populations. External validation through multi-center or nationwide cohort studies will be essential in future research. Third, this study employed self-assessment questionnaires, particularly concerning sensitive topics such as NSSI, which may be susceptible to recall bias or underreporting. These limitations should be considered when interpreting the findings.

Currently, only a few countries have established comprehensive self-injury monitoring systems. Given that most individuals who self-injure do not seek medical attention or assistance, and considering the significant social stigma associated with self-injury behavior, medical systems can only capture a small fraction of the broader self-injury population. Most existing studies are limited to hospitalized patients or clinical cohorts. Therefore, epidemiological studies within community populations, particularly among students, are essential for understanding the behavioral characteristics of adolescent NSSI and enabling early identification and intervention for high-risk groups. Establishing a risk prediction model for NSSI among adolescents allows for more targeted interventions, ensuring that those most vulnerable receive personalized support. This study's findings highlight the necessity for personalized anti-NSSI strategies that effectively address specific behaviors and practical needs. Implementing comprehensive behavioral interventions, such as providing mental health support, improving sleep quality, and creating a harmonious family atmosphere, may help reduce NSSI among adolescents.

Conflicts of interest: No conflicts of interest.

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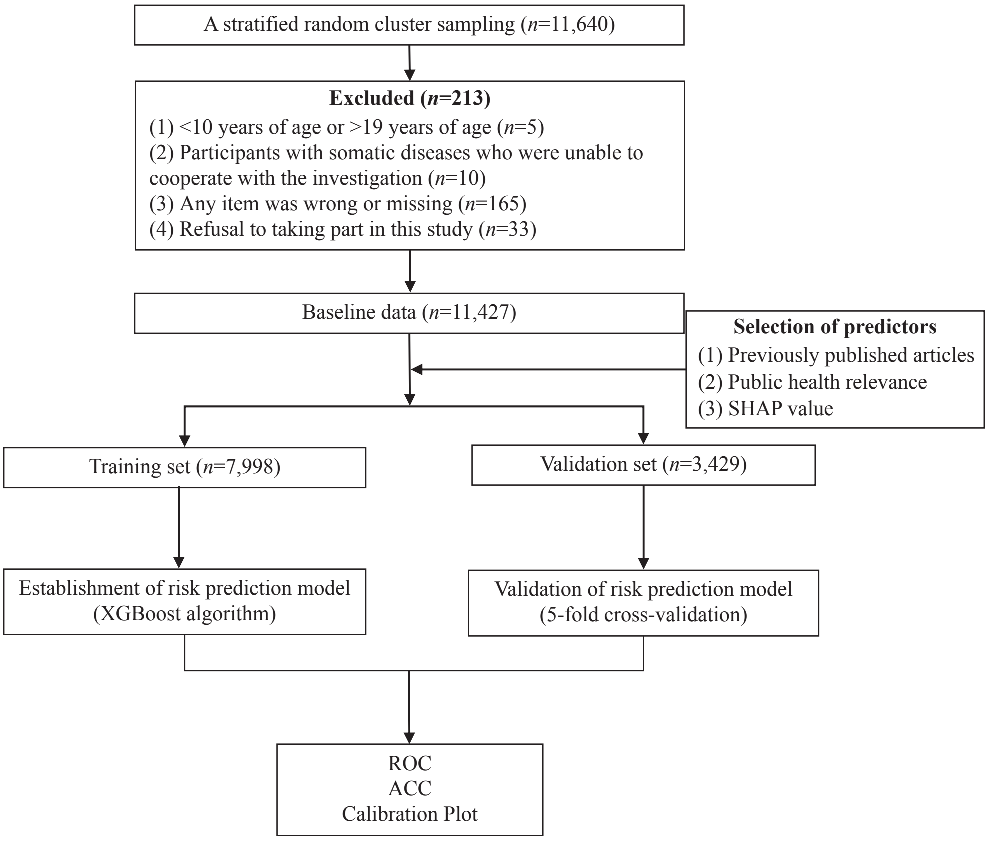
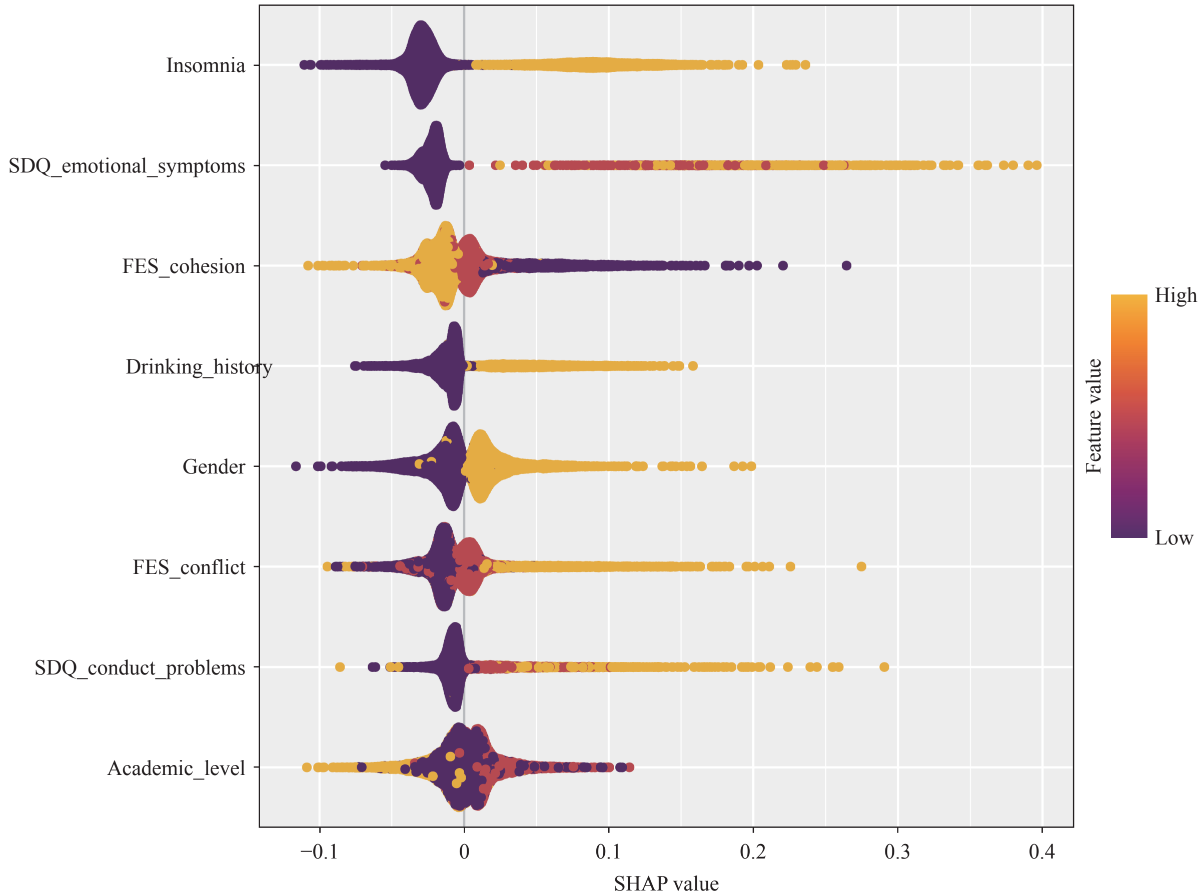
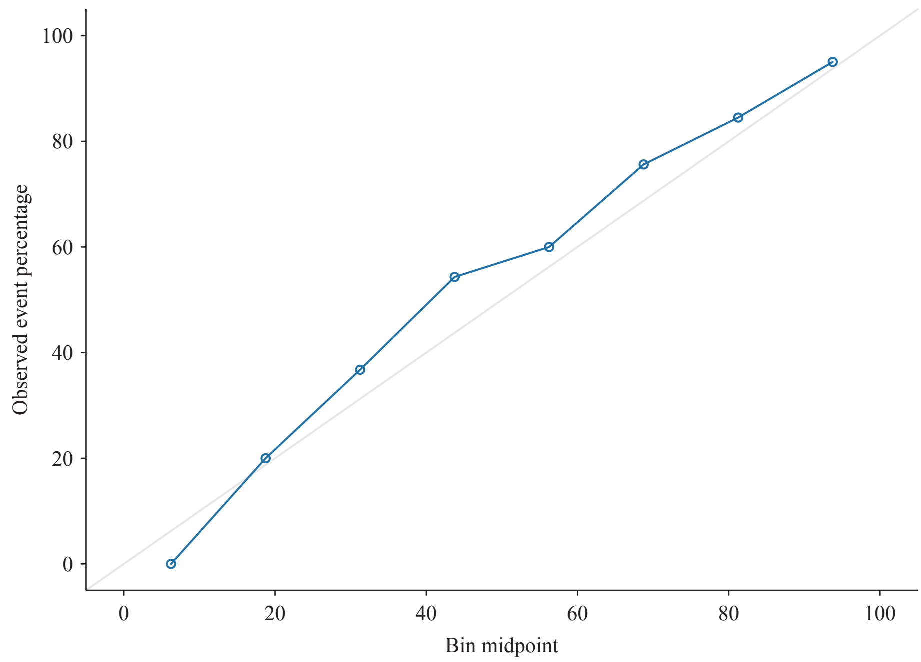
SUPPLEMENTARY MATERIAL



SUPPLEMENTARY FIGURE S1. The flowchart of data collection, model establishment and validation.
Abbreviation: SHAP=Shapley Additive exPlanations; ROC=receiver operating characteristic; ACC=accuracy.



SUPPLEMENTARY FIGURE S2. The SHAP beeswarm plot.
Abbreviation: SDQ=strengths and difficulties questionnaire; FES=family environment scale; SHAP=Shapley Additive exPlanations.



SUPPLEMENTARY FIGURE S3. The calibration curve for XGBoost model.

Notifiable Infectious Diseases Reports

Reported Cases and Deaths of National Notifiable Infectious Diseases — China, May 2025*

Diseases	Cases	Deaths
Plague	0	0
Cholera	2	0
SARS-CoV	0	0
Acquired immune deficiency syndrome†	4,240	1,573
Hepatitis	130,327	208
Hepatitis A	1,862	0
Hepatitis B	108,245	32
Hepatitis C	16,525	176
Hepatitis D	20	0
Hepatitis E	3,089	0
Other hepatitis	586	0
Poliomyelitis	0	0
Human infection with H5N1 virus	0	0
Measles	200	0
Epidemic hemorrhagic fever	268	0
Rabies	19	18
Japanese encephalitis	1	0
Dengue	126	0
Anthrax	23	0
Dysentery	2,978	0
Tuberculosis	55,165	228
Typhoid fever and paratyphoid fever	459	0
Meningococcal meningitis	14	1
Pertussis	4,260	0
Diphtheria	0	0
Neonatal tetanus	1	0
Scarlet fever	7,844	0
Brucellosis	6,982	0
Gonorrhea	9,533	0
Syphilis	54,898	6
Leptospirosis	12	0
Schistosomiasis	1	0
Malaria	343	1
Human infection with H7N9 virus	0	0
COVID-19	440,662	7
Monkey pox§	112	0
Influenza	115,573	0

Continued

Diseases	Cases	Deaths
Mumps	8,962	0
Rubella	66	0
Acute hemorrhagic conjunctivitis	2,659	0
Leprosy	31	0
Typhus	218	0
Kala azar	35	0
Echinococcosis	292	0
Filariasis	0	0
Infectious diarrhea[¶]	179,418	1
Hand, foot and mouth disease	52,036	0
Total	1,077,760	2,043

* According to the National Bureau of Disease Control and Prevention.

[†] The number of deaths of Acquired immune deficiency syndrome (AIDS) is the number of all-cause deaths reported in the month by cumulative reported AIDS patients.

[§] Since September 20, 2023, Monkey pox was included in the management of Class B infectious diseases.

[¶] Infectious diarrhea excludes cholera, dysentery, typhoid fever and paratyphoid fever.

The number of cases and cause-specific deaths refer to data recorded in National Notifiable Disease Reporting System in China, which includes both clinically-diagnosed cases and laboratory-confirmed cases. Only reported cases of the 31 provincial-level administrative divisions in the Chinese mainland are included in the table, whereas data of Hong Kong Special Administrative Region, Macau Special Administrative Region, and Taiwan, China are not included. Monthly statistics are calculated without annual verification, which were usually conducted in February of the next year for de-duplication and verification of reported cases in annual statistics. Therefore, 12-month cases could not be added together directly to calculate the cumulative cases because the individual information might be verified via National Notifiable Disease Reporting System according to information verification or field investigations by local CDCs.

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