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Gender and non-communicable diseases

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Gender and non-communicable diseases

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Editorial: A gendered approach for accelerating prevention and control of NCDs

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Editorial on the Research Topic
A gendered approach for accelerating prevention and control of NCDs

Gender is an important social determinant that shapes health behaviors, exposures, vulnerabilities, and influences health systems' responses (1). The first step in managing this is to acknowledge that women and men are not homogenous groups, and that their health opportunities and risks vary according to social, economic, environmental, and cultural influences (2).

Planning gender-responsive health promotion or preventive campaigns and interventions requires an understanding of the role of sex and gender in the burden of Non-Communicable Diseases (NCDs) and their behavioral risk factors. Current Research Topic on "*A gendered approach for accelerating prevention and control of NCDs*" has 15 articles which primarily focuses on the sex and gender differences with regard to morbidity and mortality of NCDs, its behavioral risk factors and access to care. This Research Topic is demographically and geographically diverse with studies among varying age groups from pre-school children to older citizens and from various countries across six continents.

The analysis of gender disaggregated data is the first step in mainstreaming gender in any health issue. Collecting and analyzing data disaggregated by sex is essential to identify differentials between women and men, whether related to sex or gender, in terms of disease magnitude and severity as well as its outcomes. Current Research Topic has four studies describing the gender disaggregated burden of NCDs. Study by Yue et al. revealed gender disparity and temporal trends of liver cancer in China from 1990 to 2019. Liver cancer incidence was three times higher in males than females and most of the cases occurred in males aged 50–54 years and females from 65 to 69 years. Felsinger et al. highlighted gender differences in the lung cancer epidemiology in Austria with the mean age of death of male lung cancer patients showing a consistent increase from 1992 to 2921, whereas women showed no significant change from 1992 to 2021 indicating that smoking behavior among adolescents girls should be tackled. Guzzinati et al. have done a retrospective population-based cohort study with 9,726 cutaneous malignant melanoma survivors and differentially assessed the risk of synchronous and metachronous

cancers stratified by sex. Both sexes demonstrated an excess risk for synchronous kidney/urinary tract malignancies. Women had an increased risk of synchronous breast cancer and males had an increased risk of metachronous thyroid and prostate malignancies. Migrants from West Africa, in Spain also showed marked gender-wise differences in morbidity between females and males for various NCDs and metabolic risk factors (MacKinnon et al.). Being female increased the risk of NCD and its risk factors, in addition to others such as living in Spain for >5 years, and being aged >50 years.

Using an economic model to quantify the impact of tobacco-related illnesses, Alcaraz et al. explored the differences in tobacco-attributable disease and economic burden between men and women in Argentina, Brazil, Chile, Colombia, Costa Rica, Ecuador, Mexico, and Peru. Risk factors for NCDs are strongly influenced by gender (1). There is a need to address the impact of gender norms and roles on the differential exposure to risk factors between men and women. Exploring magnitude and trends in exposure to risk factors will provide valuable insights into the prevention and control of non-communicable diseases. The current Research Topic has six articles in this regard. Mayer et al. analyzed data of 1,891 pre-school children from 224 early childhood education and care centers from Germany and provided gender disaggregated data and highlighted health inequalities among the children. A social gradient was observed with a higher BMI among children from lower socioeconomic groups families. Luo et al. looked at the gender differences in family meal frequency and the relationship between meal frequency and other health measures, among 159,904 California middle and high school students. Less than half (44.7%) students reported a high frequency of family meals and boys were more likely to have more frequent family meals compared to girls and those who identified their gender in another way. Being a girl was associated with a lower frequency of family meals and these differences started in middle school and persisted regardless of good family relationship. The findings were worse for those who did not identify as male or female.

Baj-Korpak et al. looked at the physical activity levels and kinesiophobia in medical students from Poland and Belarus during the COVID-19 pandemic. Male medical students in Poland had higher physical activity in-spite of restrictive conditions during COVID-19, whereas in Belarus with no restrictive conditions in force girls were more kinesiophobic. Yu Y. et al. explored the potential risk factors and gender differences for physical activity-related injuries (PARI) amongst 6,032 students in rehabilitation from 90 universities in China. Males had a higher cumulative frequency of injury and high levels of physical activity were associated with a greater risk of PARI. In addition high antisocial risk scores were also associated with elevated risk of PARI. In addition among girls, region wise differences were observed with girls from west China having a lower risk of PARI compared to East China. The study provides a basis for developing future injury prevention mechanisms with attention to differences between genders. In Kazhakhystan, Baspakova et al. provided an overview of the prevalence and associated behavioral risk factors for NCDs. Men showed higher rates of smoking and alcohol use, while women exhibited a greater prevalence of physical inactivity and obesity.

Health-seeking behavior in a gender/sex disaggregated manner could also give meaningful insights into the role of gender. Globally, women face significant barriers to access timely, adequate, or affordable health screening and care (3).

Yu H. et al. explored the experiences of older women with acute myocardial infarction (AMI), focusing on their perception, challenges, and coping strategies at the onset of chest pain in China. The study provides recommendations to reduce older women's delay in seeking care and highlighted the need for addressing gender related disparities among MI patients in accessing care. Targeted interventions to increase breast cancer screening attendance among women above 60 years has been suggested by Pedrós Barnils and Schüz who performed an intersectional analysis of inequalities in self-reported breast cancer screening in Spain. This often results in poor health outcomes and high rates of deaths among women in low-resource settings (3). Montesó-Curto et al. have qualitatively explored men's emotional experiences with fibromyalgia in clinics in Spain and the U.S., providing valuable insights into this area. The study highlighted the need for incorporating the emotional management into all treatment protocols for fibromyalgia, especially for men given the gender stigma. All the three studies will add to the evidence base and rationale to strengthen health systems responses to control NCDs.

Women face many gender-based challenges in relation to chronic diseases, especially in low- and middle-income countries (4). Nair et al. assessed the quality of life of postmenopausal women in India and described the risk of osteoporosis among them. The study underscored the complex interplay of demographic factors, menopausal experiences, and their impact on the participants' quality of life.

Violence against women is now recognized as a public health problem of epidemic proportions. A recent review explored link between violence and NCDs from a chronic stress framework and have found that survivors of repeated violence present an increased risk of NCDs (5). Debel et al. evaluated the prevalence and factors associated with gender based violence (GBV) among 6,085 female sex workers (FSW) in Ethiopia. The findings will have significant implications for program planning on prevention and response to mitigate the occurrence and impact of GBV among FSWs. The present Research Topic of articles primarily includes non-communicable diseases and its risk factors. Other than the conventional Non-communicable diseases (NCDs) such as cardiovascular diseases, cancers, mental health disorders, some rare chronic diseases such as fibromyalgia, violence have also been included. Violence is a non-communicable disease in the context of medicine and public health (6). The common risk factors for all non-communicable disease would appear to make the mitigation easier. However, several cross cutting factors such as gender, socioeconomic status make the mitigation difficult at the best of times. Understanding the interaction and complex contexts can be a first step toward mitigation. Several articles in this Research Topic give a varied view of the NCD's its risk factors among various age groups.

To summarize, the Research Topic reiterates that NCDs does not affect genders equally, as there are variations in prevalence, risk factors, and access to healthcare services among different gender

groups. It is essential to comprehend these differences in order to formulate targeted interventions and policies that cater to the specific requirements of each gender. Gender-responsive actions are needed to prevent, detect, manage and control NCDs and is crucial to ensure an equitable response in line with Universal Health Coverage and the Sustainable Development Goals.

Author contributions

AS: Conceptualization, Investigation, Writing – original draft, Writing – review & editing. PR: Conceptualization, Writing – original draft, Writing – review & editing, Investigation. SP: Writing – original draft, Writing – review & editing, Conceptualization.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Gender disparity and temporal trend of liver cancer in China from 1990 to 2019 and predictions in a 25-year period

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Objective: This study aims to reveal epidemiological features and trends of liver cancer (LC) in China.

Methods: We retrieved data from the Global Burden of Disease database 2019. Joinpoint regression was used to examine the temporal trend of LC. Future trends of LC were estimated using the Nordpred.

Results: The incidence, mortality, and disability-standardized life year (DALY) rate of LC declined in China from 1990 to 2019. Among >210,000 LC cases in 2019, the LC incidences were nearly 3.15 times higher in males than in females. LC cases and LC-associated deaths were mostly found among patients aged 65 to 69 years. The proportion of LC attributable to hepatitis B decreased over time, whereas the proportions of LC attributable to hepatitis C, alcohol use, and non-alcoholic steatohepatitis increased modestly from 1990 to 2019. The majority of LC-associated deaths could be traced to four risk factors: smoking (20%), drug use (13.6%), alcohol use (11.7%), and high body mass index (10.1%). Based on the Nordpred prediction, there will be a steady decline in the incidence (39.0%) and mortality (38.3%) of liver cancer over a 25-year period from 2020 to 2044.

Conclusion: The disease burden of liver cancer in China has declined over the past 30 years. However, it remains important to control liver cancer among high-risk populations, especially elderly males with obesity, alcohol use, tobacco use, and/or drug abuse.

KEYWORDS

liver cancer, gender disparity, temporal trend, prediction, alcohol use, tobacco use

Introduction

Primary liver cancer (LC), the sixth most common cancer worldwide (1), is known for its insidious onset, complex etiology, extraordinarily heterogeneous, high degree of malignancy, and high recurrence and metastasis (2, 3). In 2019, a total of >534,000 new LC cases and >484,000 LC-associated deaths were estimated (4). By 2050, liver cancer probably affects more than 1 million patients annually (5). Liver cancer is associated with many risk factors, including chronic HBV or HCV infection, alcoholism, diabetes, non-alcoholic steatohepatitis, cirrhosis, aflatoxin, obesity, and tobacco use (6).

In China, LC is the second leading cause of cancer deaths, and the first leading cause is lung cancer (7). From 1990 to 2019, LC incidence and mortality declined in China (8), but the disease burden remains high due to the large population in China. In 2019, approximately 39.4% of global LC cases occurred in China (9). At least 60% of liver cancer is caused by HBV or HCV infection (10). China has implemented a series of strategies to control the spread of HBV and HCV, for instance, by introducing HBV vaccination in children (11, 12), blood transfusion screening of hepatitis viruses, and prevention of mother-to-child transmission (13, 14). Despite these enormous efforts, the absolute number of HBV- or HCV-infected patients remains high in China. According to the Global Burden of Disease (GBD) 2019, more than 23 million HBV infections occurred in China in 2019, and 0.6 million for HCV infections. Due to the dynamics of socioeconomic, dietary, lifestyle and living conditions, there is a growing concern for the impact of other LC-associated risk factors such as obesity, smoking, alcohol use, and non-alcoholic steatohepatitis (8, 15–17). Therefore, it remains important to evaluate the epidemic burden of LC from current and future perspectives.

Because China has the largest number of LC cases among all countries (8), this study aims to evaluate the disease burden of LC in China and estimate the future trend of liver cancer from 2019 to 2044 based on a multinational collaborative project from the GBD2019 (18, 19). This study will report epidemiological features of liver cancer and shed light on the management of liver cancer in China.

Abbreviations: DALY, Disability-standardized life year; ASDR, Age-standardized DALY rate; ASIR, Age-standardized incidence rate; ASMR, Age-standardized mortality rate; APC, Annual percentage change; BMI, body mass index; GBD the global burden of disease; LC, Liver cancer, CRA, Comparative Risk Assessment, DAAs, Direct-acting antiviral drugs.

Methods

Data sources

Data used in this study was extracted from the Global Burden of Disease 2019 (GBD2019) database (https://ghdx.healthdata.org/gbd-2019), which provides a comprehensive epidemiological database for 369 diseases and injuries (18, 19). We obtained complete data on the incidence, mortality, disability-standardized life year (DALY) rates, and risk factors of liver cancer by gender in China from 1990 to 2019 from GBD2019. The GBD2019 database included data from 204 countries and territories based on a variety of sources such as national surveys, censuses, vital statistics, and other health-related data sources. The data from these sources are used to estimate the incidences, mortality, and attributable risk based on the estimation method of the Bayesian meta-regression model DisMod-MR 2.1 (20). The LC data from China were mainly collected from the surveillance data of the China Disease Surveillance Point System and the registration data collected by the Chinese Center for Disease Control and Prevention (19, 20). The proportions of the five etiologies (HBV, HCV, alcohol use, non-alcoholic steatosis hepatitis, and other causes such as fluke and aflatoxin) from meta-analyses were used as inputs for the DisMod-MR 2.1 model which estimates the incidences, mortality, and proportions of liver cancer in the context of different etiologies (21). The GBD2019 estimation of attributable burden followed the general framework, the so-called Comparative Risk Assessment (CRA), which had been established for risk factors assessment (22). The protocol of the CRA method can be briefly summarized as follows. (i) The method includes risk-outcome pairs that meet the criteria with convincing evidence. (ii) It collects information on the relative risk by the level of exposure or by the cause of mortality/morbidity from pooled cohorts, meta-analyses of cohorts, and case-control data. Meta-analyses are used to estimate relative risks of mortality/morbidity for risk-outcome pairs. (iii) It uses DisMod-MR 2.1, spatiotemporal Gaussian process regression, or alternative methods to estimate the exposure levels of each age-sex-region-year. (iv) It collects theoretical minimum exposure levels from published trials or cohorts. (v) It calculates population attributable fractions and attributable burden. (vi) It estimates the disease burden attributable to various combinations of risk factors such as high body mass index (BMI) and high fasting blood glucose (22, 23).

Definitions

A high body-mass index (BMI) was defined as a value above 25 kg/m^2. The category of tobacco use included smoking, second-hand smoke, and smokeless tobacco use (e.g., chewing tobacco). Smoking was defined as the current/former use of any

smoked tobacco product (e.g., cigarettes, pipes, cigars, shisha, bidis, kreteks, and/or other local tobacco products) on a daily or occasional basis (24, 25). Secondhand smoke was defined for those non-smokers who lived with current daily smokers and had the average daily exposure to indoor air particulate matter (with an aerodynamic diameter <2.5μm) from second-hand smoke (26). Smokeless tobacco use was defined as the current use of any smokeless tobacco product (27). Alcohol use was defined as the average pure alcohol consumption ≥10 g/day in current drinkers who had consumed alcohol during the past 12 months (28). The consumption of pure alcohol (males: ≥60 g, females: ≥48 g) on a single occasion was defined as binge drinking (27). Drug use was defined as the regular use of opioids, cannabis, cocaine, amphetamines, or ever-injected drugs (26, 27).

Statistical analysis

To quantify the disease burden of LC in China, we used the age-standardized incidence rate (ASIR), age-standardized DALY rate (ASDR), and age-standardized mortality rate (ASMR) that take into account the age structure differences, as described previously (29). Joinpoint regression models (https://surveillance.cancer.gov/joinpoint/) were used to calculate annual percentage changes (APCs) and average annual percentage changes (average APCs). The grid search method and permutation tests were used to determine the joinpoint model and the optimal model, respectively.

We used the age-period-cohort model and the power-link function in the R Nordpred package to project the future trend of incidence and mortality of LC in China, taking into account the impact of population structure. As an R package, Nordpred was built based on the age-period-cohort model, a well-established estimation method for cancer incidence and/or mortality prediction (30, 31). The measured variable of incidence or mortality was modeled using input variables such as age, calendar period, and birth cohort. The model can be briefly expressed as $R_{\alpha p} = (A_\alpha + D \cdot p + P_p + C_c)^5$, where $R_{\alpha p}$ indicates the incidence or mortality numbers from the age group α during the period p; A_α indicates the age component for the age group α; D represents the common drift parameter that summarizes the linear component of the trend; P_p denotes a non-linear period component during the period p; and C_c indicates the non-linear cohort component of the cohort c (32). The performance of Nordpred-based predictions has been validated and optimized by many studies (33–35). In our study, we analyzed the incidence and mortality data of liver cancer in China for a five-year period (1990 to 1994, 1995 to 1999, ..., 2015 to 2019) and the 5 years old age groups except those under 14 years old (<15y, 15y to 19y, 20y to 24y, ... ≥95y). The prediction of liver-cancer incidence/mortality was conducted in the 5-year period (2020 to 2024, 2025 to 2029, 2030 to 2034, 2035 to 2039, 2040 to 2044). The estimated population of China and standard population structure were collected from the United Nations World Population Prospects 2019 Revision (https://population.un.org/wpp/) and the WHO standard population structure (https://seer.cancer.gov/stdpopulations/world.who.html).

Statistical analysis was performed using R (version 4.1.0), Joinpoint Regression Program (version 4.9.0.0), and GraphPad Prism (version 8.0.1). *P*-value<0.05 was considered statistically significant. All rates are reported per 100 000 person-years.

Results

Temporal trend of liver cancer (LC) in China

In 2019, approximately 210,462 LC cases and 187,699 LC-associated deaths were reported in China (Table 1). The majority of LC cases were males, and the number of male cases was 3.15 times higher than that of female cases. Compared with the data in 1990, the total number of LC cases and LC-associated deaths in 2019 decreased by 11.1 and 19.3%, respectively (Figure 1). The decrease in females was more dramatic than that in males, with a significant decrease in LC cases (females: 24.0%, males: 6.1%) and LC-associated deaths (females: 27.9%, males: 15.7%). The DALY rate showed a similar downward trend over years (Supplementary Figure S1).

The highest number of LC cases and LC-associated deaths were observed among patients aged between 65 and 69 years (Supplementary Figures S2A,S2B). Most LC cases occurred in males aged from 50 to 54 years and females aged from 65 to 69 years (Supplementary Figures S2C,S2E). LC deaths in both males and females mostly occurred in patients aged from 65 to 69 years (Supplementary Figures S2D,S2F). From 1990 to 2019, the overall trends of ASIR and ASMR decreased over time. The ASIR dropped dramatically from 2001 to 2005, with a decreased $APC_{2001\text{-}2005}$ of −17.30% in males and −15.43% in females (Table 2). The most significant decrease in ASMR occurred between 2000 and 2004, with a decreased $APC_{2000-2004}$ of −17.5% in males and −15.56% in females (Table 2). Since 2012, both ASIR and ASMR in males shared a slightly increasing trend ($APC_{2010-2019}$ of ASIR, 1.6% [1.4 to 1.7%]; $APC_{2012\text{-}2019}$ of ASMR, 1.6% [1.2 to 2.1%]), whereas the ASIR and ASMR in females remained stable (Table 2).

Risk factors of liver cancer in China

We analyzed the proportion of liver cancer caused by five specific etiologies (alcohol use, hepatitis B, hepatitis C, non-alcoholic steatosis hepatitis, and other causes) in Chinese patients with liver cancer. Our results showed that nearly 80%

TABLE 1 Incidences, mortality, and DALY rates of liver cancer in China in 1990 and 2019.

	Patient number in 1990	Patient number in 2019	Change (%)	ASR in 1990 (Per 100,000)	ASR in 2019 (Per 100,000)	Change (%)
Incidence						
Total	236,825	210,462	−11.1	25.7	10.5	−58.8
Females	66,709	50,675	−24.0	15.0	4.9	−67.3
Males	170,115	159,787	−6.1	36.4	16.4	−54.9
<25 years	5,285	1,395	−73.6	2.4	1.1	−54.2
25 to 49 years	65,258	43,508	−33.3	16.0	7.7	−51.9
50 to 74 years	144,013	130,842	−9.1	83.3	31.4	−62.3
≥75 years	22,269	34,717	55.9	114.8	57.8	−49.7
Mortality						
Total	232,449	187,699	−19.3	26.0	9.4	−63.8
Females	67,543	48,674	−27.9	15.6	4.8	−69.2
Males	164,905	139,025	−15.7	36.7	14.6	−60.2
<25 years	4,273	881	−79.4	1.8	0.6	−64.6
25 to 49 years	59,579	33,222	−44.2	14.6	5.9	−59.5
50 to 74 years	141,337	11,542	−18.3	81.7	27.7	−66.1
≥75 years	27,260	38,144	39.9	140.5	63.5	−54.8
DALY						
Total	7,577,768	5,325,460	−29.7	769	264	−65.7
Females	1,987,369	1,179,666	−40.6	420	116	−72.4
Males	5,590,399	4,145,795	−25.8	1,103	415	−62.4
<25 years	322,471	65,931	−79.6	129.5	45.9	−64.6
25 to 49 years	2,855,373	1,563,215	−45.3	697.8	277.3	−60.3
50 to 74 years	4,033,010	3,214,174	−20.3	1,233.5	409.1	−66.8
≥75 years	366,914	482,141	31.4	1,339.4	533.5	−60.2

DALY, Disability-adjusted life years; ASR, Age-standardized rate.

of liver cancer cases in China were attributable to HBV or HCV infection, especially among male patients. HBV/HCV infections remained the leading cause of liver cancer, although the proportion of other causes had increased slightly. Among female patients, the proportion of HBV- and HCV-induced LC was similar, but the proportion of HBV-induced LC was significantly higher than that of HCV-induced LC in male patients (Figure 2). As for the risk factors associated with the deaths, the majority of LC-associated deaths in 2019 can be attributed to smoking (20%), followed by drug use (13.6%), alcohol use (11.7%), and high BMI (10.1%). High BMI also caused a modest increase in LC-associated deaths from 1990 (4.4%) to 2019 (10.1%) (Figure 3).

Prediction of LC incidence and mortality in China

Based on the accumulated data from 1990 to 2019, we projected the LC incidence and mortality in China from 2020 to 2044. Based on the prediction from the Nordpred software (see Methods), the age-standardized incidence of LC will decrease steadily from 10.7 (per 100,000 population) in 2019 to 6.9 (per 100,000 population) by 2044. The LC incidence will be still higher in males (10.8 per 100,000) than in females (3.3 per 100,000) in 2044 (Figure 4A). In the evaluation of age-standardized mortality rates, similar findings were found in the prediction of LC incidence (Figure 4B). In 2019, the mortality rate for LC was 9.7 per 100,000, with 14.7 per 100,000 in male patients and 4.87 per 100,000 in female patients. By 2044, the mortality rate for LC is expected to drop to 5.9 per 100,000, 9.0 per 100,000 for men, and 2.4 per 100,000 for women.

Discussion

The disease burden and risk factors of liver cancer in China have not been fully reported to date. Previous studies only predicted the incidences of liver cancer in China based on the limited data from 1983 to 2007 and from 2000 to 2014 (36, 37). Here, this study reveals the disease burden of liver cancer in China from 1990 to 2019 and the future trend of incidence and

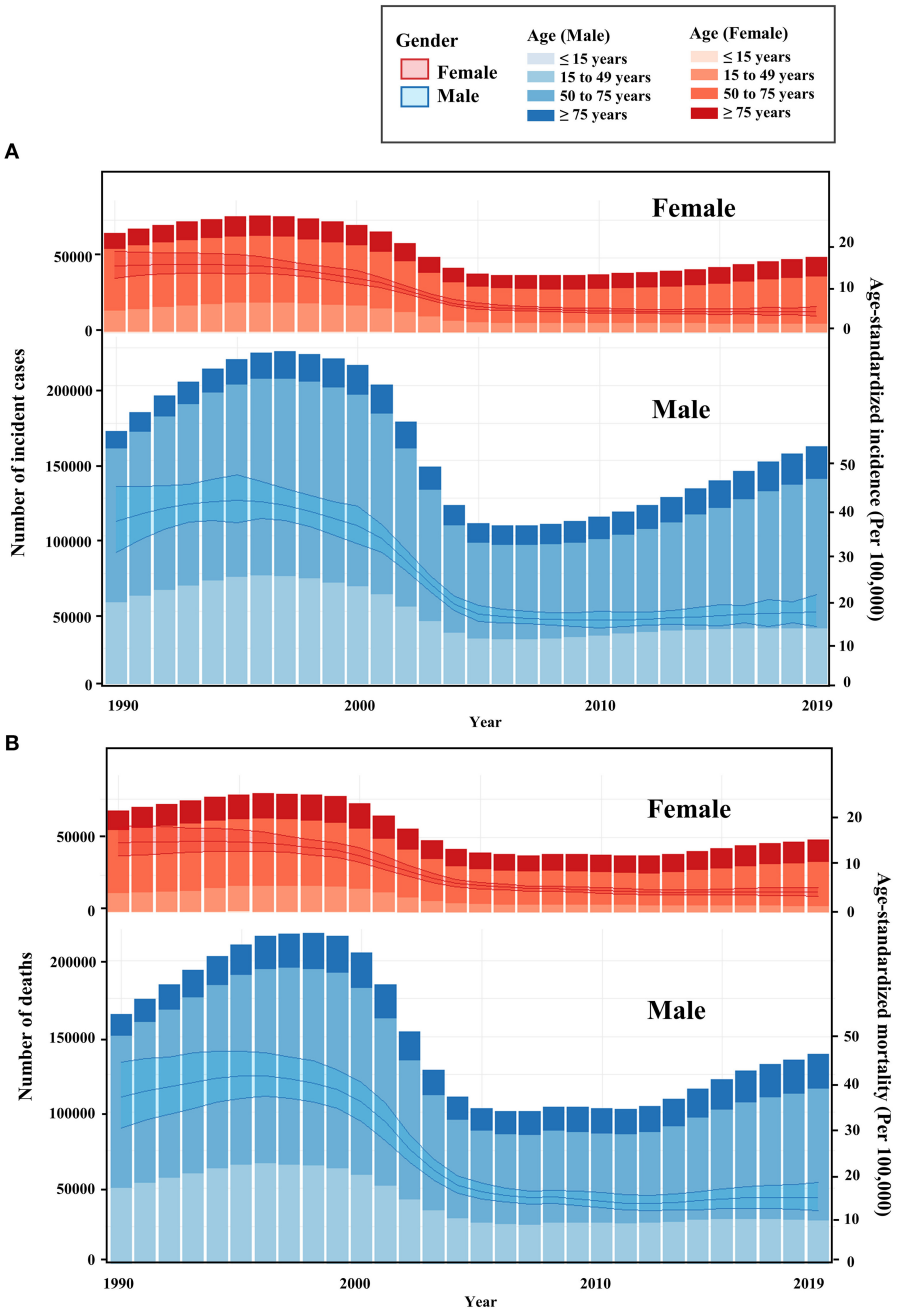

FIGURE 1
Temporal trend of liver cancer in China. **(A)** Temporal trend of age-standardized incidence and number of cases for liver cancer from 1990 to 2019 in China; **(B)** Temporal trend of age-standardized mortality and number of deaths for liver cancer from 1990 to 2019 in China. The bar was the number of liver cancer cases and liver cancer-associated deaths from 1990 to 2019. The line with 95% UI represents incidence and mortality from 1990 to 2019.

mortality from 2020 to 2044. Our study found that the risk of LC incidence and mortality was higher in males than in females. The absolute number of LC incident cases was approximately three times higher in males than in females. Most LC cases were found in males aged between 50 and 54 years, and the average age of male patients was 15 years younger than female patients. This finding is in agreement with a global cancer burden study that liver cancer is one of the most common causes of death in males (38). Based on the GBD data from 1990 to 2019, we observed an increase in LC-associated incident cases, deaths, and DALY rates among patients >75 years old, probably because of the aging population in China (9). However, there might be a

TABLE 2 Temporal trend of LC incidence and mortality from 1990 to 2019 in China.

Year	All patients		Female patients		Male patients	
	APC (%) (95% CI)	Average APC (%) (95% CI)	APC (%) (95% CI)	Average APC (%) (95% CI)	APC (%) (95% CI)	Average APC (%) (95% CI)
Age-standardized incidence rate						
1990 to 1995	1.7 (1.2 to 2.1)	−3.1 (−3.4 to −2.9)	0.4 (−0.3 to 1.0)	−3.8 (−4.1 to −3.5)	2.2 (1.7 to 2.7)	−2.8 (−3.0 to −2.5)
1995 to 1998	−2.5 (−3.8 to −1.2)		−3.2 (−5.1 to −1.3)		−2.2 (−3.6 to −0.8)	
1998 to 2001	−5.8 (−7.1 to −4.4)		−6.6 (−8.4 to −4.7)		−5.3 (−6.9 to −3.8)	
2001 to 2005	−16.9 (−17.4 to −16.3)		−15.4 (−16.1 to −14.7)		−17.3 (−17.8 to −16.8)	
2005 to 2010	−2.0 (−2.5 to −1.6)		−2.6 (−3.0 to −2.2)		−1.5 (−2.0 to −1.0)	
2010 to 2019	1.0 (0.8 to 1.2)		−0.2 (−0.4 to 0.1)		1.6 (1.4 to 1.7)	
Age–standardized mortality rate						
1990 to 1996	1.4 (0.9 to 1.9)	−3.4 (−3.7 to −3.1)	0.1 (−0.3 to 0.6)	−4.0 (−4.2 to −3.8)	2.0 (1.4 to 2.6)	−3.1 (−3.4 to −2.7)
1996 to 2000	−3.7 (−4.7 to −2.8)		−4.7 (−5.4 to −3.9)		−3.3 (−4.4 to −2.1)	
2000 to 2004	−17.1 (−18.0 to −16.2)		−15.7(−16.4 to −14.9)		−17.5 (−18.6 to −16.5)	
2004 to 2007	−5.2 (−7.0 to −3.3)		−5.3 (−6.8 to −3.8)		−4.8 (−7.0 to −2.6)	
2007 to 2012	−2.3 (−3.0 to −1.6)		−3.2 (−3.7 to −2.8)		−1.8 (−2.6 to −1.1)	
2012 to 2019	1.2 (0.8 to 1.6)		0.1 (−0.2 to 0.4)		1.6 (1.2 to 2.1)	

APC, Annual percentage change; ASIR, Age-standardized incidence rate; ASMR, Age-standardized mortality rate.

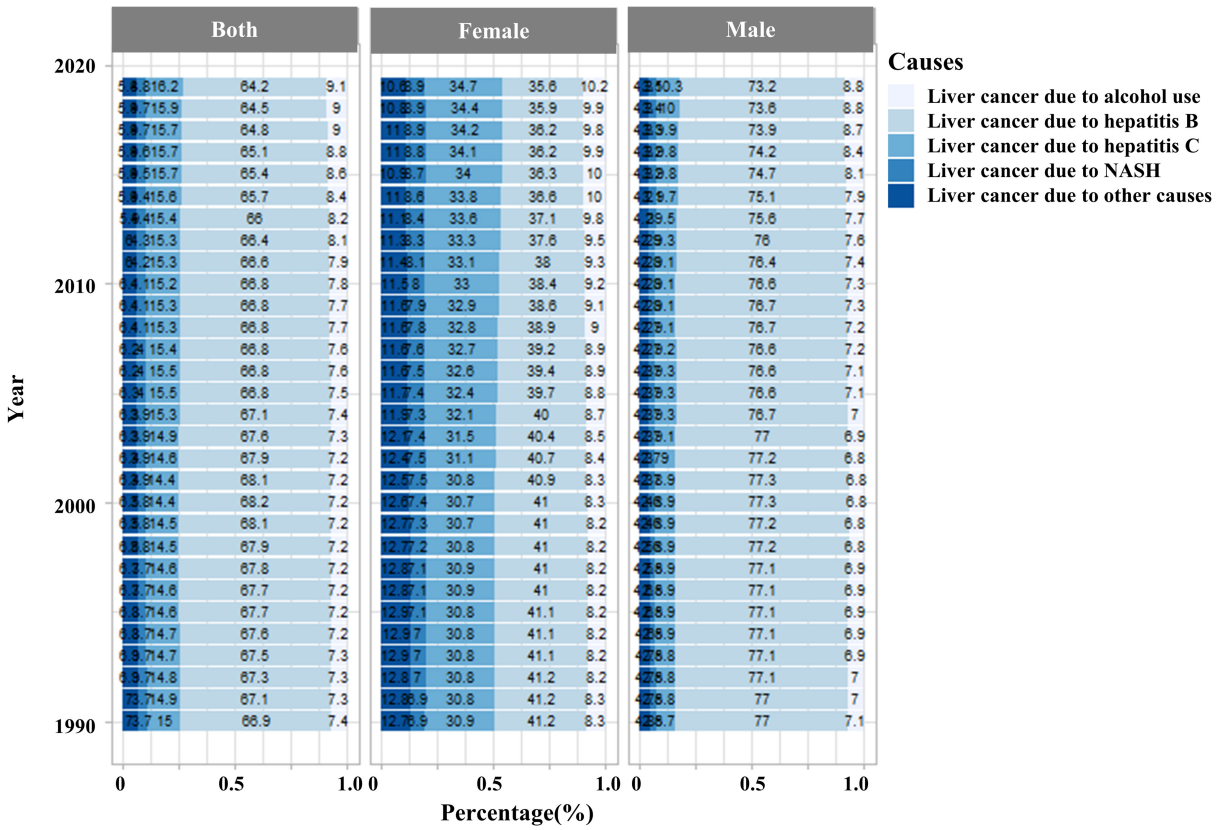

FIGURE 2
The disease burden of liver cancer incidence rates in the Chinese population is attributable to five risk factors (alcohol use, hepatitis B, hepatitis C, non-alcoholic steatosis hepatitis, and other causes) between 2010 and 2019. (NASH, non-alcoholic steatosis hepatitis).

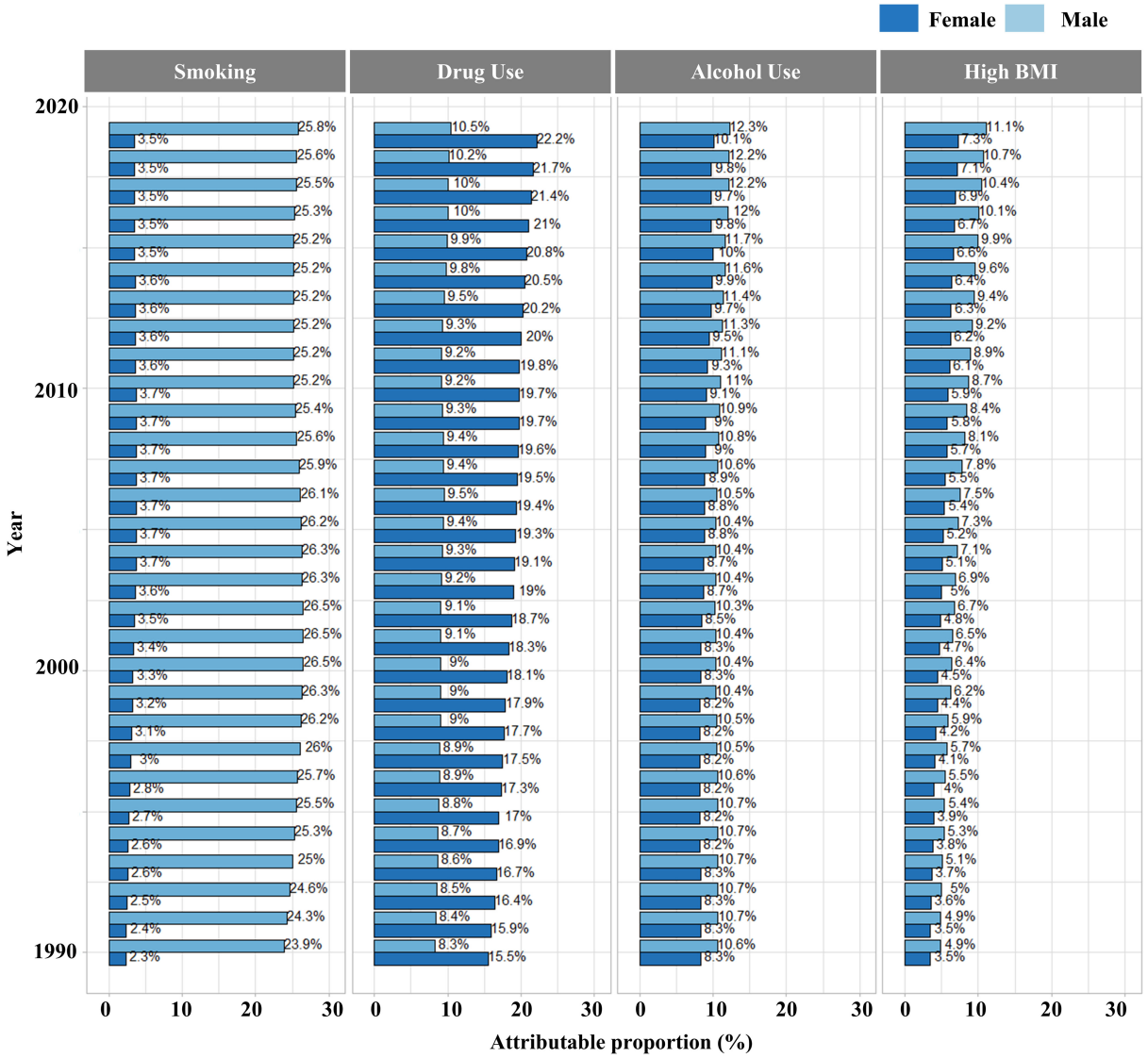

FIGURE 3
Proportions of LC-associated deaths attributable to four risk factors (alcohol use, drug use, high BMI, smoking) from 1990 to 2019.

gender difference between HCV-associated and HBV-associated LC because the incidence and mortality of HCV-associated LC were higher in females but that of HBV-associated LC were higher in males (>70%).

Our study analyzed the proportion of five specific etiologies in LC incident cases. We showed that HBV infection remains the most important cause of LC in China, although the incidence of LC due to hepatitis B has been gradually decreasing (Supplementary Figure S3). The decrease in the proportion of HBV-associated LC could be explained by enormous efforts in China to control HBV infection over the past 30 years as well as the application of HBV treatments and vaccines (6). The incidence rates of five specific etiologies induced liver cancer have decreased over time. Since 1993, mandatory anti-HCV screening and other preventive measures to prevent the spread of blood-borne diseases have been widely implemented, therefore substantially reducing the spread of HCV in China (39). Furthermore, the drug discovery of direct-acting antiviral drugs (DAAs) has successfully cured many HCV-infected patients (40–45). In 2017, sofosbuvir was the first DAA approved by China Food and Drug Administration. Since then, the wide application of DAAs has gained popularity to treat HCV infections in China, whereas the absence of HCV vaccines hampers HCV prevention in China and other countries

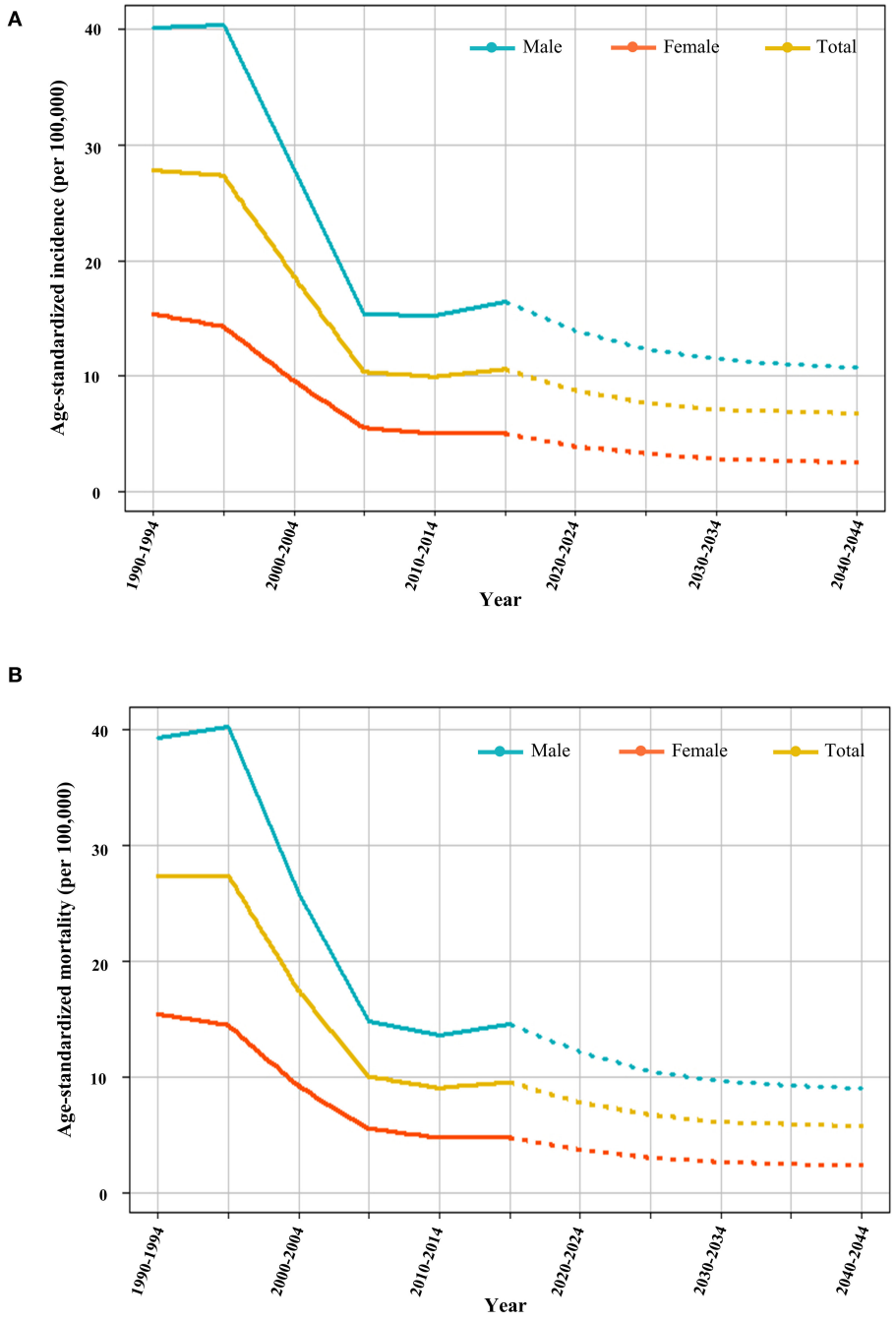

FIGURE 4
Prediction of incidence and mortality of liver cancer. **(A)** Plots of age-standardized incidence of liver cancer from 1990 to 2044. The solid lines indicate the observed values (1990 to 2019) and the dotted lines are the predicted values (2020 to 2044). **(B)** Plots of LC age-standardized mortality from 1990 to 2044.

(46). During the past 30 years, China's alcohol consumption dramatically increased (47). This also made alcohol use the second most common cause of end-stage liver diseases. The easy access to cheap alcoholic drinks also challenges liver disease control in China (48). Moreover, the disease burden of LC caused by non-alcoholic steatohepatitis is increasing globally (20, 21), particularly in Asian countries (22). This is largely due to the improved economic conditions, urbanization, dietary and lifestyle changes, as well as the increased incidence of obesity and hyperlipidemia (17, 23, 24).

It is known that death-associated risk factors of liver cancer include marital status, race, gender, age (49, 50), alcohol and tobacco use (51), complications of diabetes, hypertriglyceridemia (52), and clinical characteristics such as grade and size of the tumor (53, 54). The comparative risk assessment from the GBD project has a risk-factor hierarchy that covers 4 levels of 87 risk factors. Risk factors at level 1 include behavioral, environmental, occupational, and metabolic factors. Three behavioral factors (tobacco use, alcohol use, and drug use) and one metabolic factor (high BMI) were selected to analyze their effect on liver cancer in our study. Our result showed that smoking (20%) was a leading factor associated with LC mortality. In China, the smoking population has barely declined over the past 30 years. Previous studies also suggested a higher risk of LC in smokers than in non-smokers (16, 55). Smoking is an independent risk factor for liver fibrosis, and 4,000 tobacco-related chemicals could cause a variety of body damage including liver damage (56, 57). Our study also revealed other risk factors, such as high BMI (10.1%), drug use (13.6%), and alcohol use (11.7%). Accumulated evidence suggests that overweight and obesity increase the risk of LC and deaths (58–60) and obesity is associated with an increasing burden of non-alcoholic steatohepatitis that causes liver cancer (61, 62). The association of alcohol with LC is known (63, 64) and alcohol is considered a liver toxin (65), which could increase the risk of adverse outcomes of liver diseases (66). Overall, the proportion of LC-associated deaths attributed to smoking, alcohol use, and high BMI was approximately 45%, with the other 55% attributed to drug use and other factors that are not covered in our study. Approximately 80% of liver cancer cases are associated with HBV/HCV infections, and the proportion of LC-associated deaths attributed to drug use was nearly 13.6%. It is known that drug use is associated with viral hepatitis (67–69) and effective control of drug use will help to reduce the incidence and mortality of LC.

We found a decline in the incidence, mortality, and DALY rate of liver cancer in China over the past 30 years, which is consistent with previous studies from other data resources (6, 34). This is probably due to the improvement of economic conditions, the increase in medical resources, and the development and application of new drugs. Based on the estimated population structure and LC data from 1990 to 2019, we used the Nordpred R package to predict LC incidence and mortality from 2020 to 2044. There will be a steady decrease in the incidence and mortality of liver cancer in both males and females, but both incidence and mortality rates are much higher in men than in women, suggesting that males will be the key group for prevention and control in the future.

Our study has limitations. First, the GBD 2019 database from the University of Washington (18, 19) is used in our study. Because the GBD 2019 dataset was estimated by the DisMod-MR 2.1 model (20), there might be some derivations but the database has been consistently maintained and corrected by the Institute for Health Metrics and Evaluation at the University of Washington. Second, our study included only four LC-associated factors, whereas it is known that LC incidence and mortality can be affected by many factors such as aflatoxin and the grade of the tumor. Third, treatment and prevention strategies exert an impact on the development of liver cancer. To reduce the disease burden of liver cancer in China, future studies are still needed to investigate LC-associated risk factors as well as effective treatment and prevention strategies.

Conclusions

The disease burden of liver cancer in China has declined over the past 30 years. A high risk of liver cancer is commonly found among elderly males with high BMI, alcohol use, tobacco use, or drug abuse. Despite the decline in LC incidences and mortality in China, it remains a need to control liver cancer among high-risk populations with better treatment and prevention strategies.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found below: http://ghdx.healthdata.org/gbd-results-tool.

Ethics statement

Ethical review and approval was not required for the study because this study disclosed no personal information and used public data freely shared by the Global Burden of Disease (GBD) database (https://www.healthdata.org/about/data).

Author contributions

TY performed statistical analyses and drafted the manuscript. MX and TC contributed with data interpretation. HZ, MP, and ED discussed the contents and ideas of the manuscript. GL obtained funding and revised the manuscript. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2022.956712/full#supplementary-material

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Cross-sectional study of gender differences in physical activity-related injuries amongst Chinese college students majoring in rehabilitation

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The main objective of the paper was to explore the potential risk factors for physical activity-related injuries (PARI) amongst college students majoring in rehabilitation and to analyse gender differences. A random whole group sampling method was used to recruit freshmen to seniors aged 15–25 years from over 90 universities in China that offer rehabilitation. The total number of people included was 6,032, of which 1,989 were male and 4,043 were female. The underlying risk factors for PARI of different genders were assessed using a structured self-management questionnaire including sociodemographic characteristics, physical activity levels, risk-taking and protective behaviors, and PARI. Totally 6,032 questionnaires were obtained for final analysis, with 792 total number of injured persons (415 males, 377 females), the sum of the cumulative frequency of injuries to injured persons is 1,607 (881 males, 726 females) and a PARI risk of 0.27 (males: 0.44, females: 0.18; $p < 0.001$; sum of the cumulative frequency of injuries/total number of people surveyed/year). For male and female students, participation in sports teams, having a high level of PA as well as with antisocial behavior were risk factors for developing PARI. Regarding female students, regional differences was associated with elevated odds to suffer from PARI. The prevalence rates of PARI vary between male and female students. The research subjects were university students in rehabilitation. Compared to general college students, rehabilitation students have a certain knowledge base related to injuries, which defines the specificity and research value of this subjects. This study provides guidance for reducing PARI in students in rehabilitation and may provide a basis for developing future injury prevention mechanisms for university students in general.

KEYWORDS

exercise, sports injury, risk-taking behaviours, injury incidence, young adults

Introduction

Physical activity (PA) is any kind of physical movement that is performed through skeletal muscle contraction that requires energy expenditure. Active PA may decrease the risk of chronic non-communicable diseases (1, 2). Increased physical activity may lead to increased wellbeing in young people (3). Besides, active engagement in PA has been reported to improve physical fitness, such as VO_2 max indicators (4).

The World Health Organization (WHO) global recommendation for healthy physical activity for adults is 150 min of moderate-intensity activity (or equivalent) per week. For adolescents, the recommendation is 60 min of moderate- to vigorous-intensity activity per day (5). According to the WHO, one in four adults and 81% of adolescents worldwide are physically inactive (not in line with the WHO global recommendations on physical activity for health) (6). Whereas in China, the problem of physical inactivity amongst adolescents is even more serious, with a physical inactivity rate of 84.3% (7). A global study shows that the inactivity rate among college students is about 41.4% (8). The level of physical activity among university students has declined in different countries (9). Physical inactivity is the fourth most important risk factor for the occurrence of chronic diseases worldwide and is associated with higher mortality rates for Chinese residents (10). Appropriate strategies are adopted to promote increased physical activity (11).

Currently, almost all countries and regions, including China, are involved in a global movement to promote physical activity (12). Prevention of physical activity related injuries (PARI) should also be on the agenda throughout the promotion of physical activity (13, 14).

Physical activity-related injuries generally refers to injury to the human body during PA. The PARI covered in this study is consistent with the concept cited by Mechelen in Sports Medicine, 1992, and adapted by Bloemers (14, 15).

In the short term, the fear of re-occurrence of previous physical activity-related injuries among college students ultimately leads to a decrease in physical activity participation (16, 17). PARI not only affect the academic performance of university students but are also detrimental to future social progress and development in the long run (18). In addition, PARI among university students have a more direct and indirect economic and social cost to families and society (19).

There are significant differences in PARI between male and female (20). Males report more PARI than females in all countries, but the extent of these gender differences varies considerably between countries (21).

Therefore, injury prevention should be targeted. According to the "prevention sequence" model, to develop appropriate prevention strategies, epidemiological surveys should first be carried out to determine the characteristics of the target population (15). Previous studies have disclosed some influential factors in PARI (22, 23).

This study focuses specifically on the group of university students majoring in rehabilitation, a group for which there is a great demand due to the limited number of rehabilitation students and the severely overrepresented population in need of rehabilitation. At the same time, given the specific curriculum structure, rehabilitation students have a certain knowledge base related to sports injuries compared to general college students, which makes this group uniquely valuable to study. The prevalence and characteristics of PARI in the group of university students majoring in rehabilitation are not well understood. Therefore, the aim of this study was to explore gender-related predictors of PARI among university students majoring in rehabilitation. This will also provide a basis for more in-depth development of injury prevention mechanisms for general university students in the future.

Materials and methods

Sampling

Random whole-group sampling was used to identify eligible schools by economic region (eastern, central, western, and north-eastern). College students majoring in rehabilitation from freshman to senior year were recruited between October 2020 and January 2021. Inclusion criteria were as follows: (a) college students majoring in rehabilitation, (b) those who signed the electronic informed consent form, and (c) those who completed $\geq$95% of the questionnaire.

Data collection

This survey used a structured self-management questionnaire (Cronbach's coefficient alpha = 0.816). An electronic version of the questionnaire was administered to all students who signed the informed consent form by our trained staff, collecting relevant information on sociodemographic characteristics, PA levels, risk-taking behaviors and PARI and protective behaviors that occurred in the past year.

The demographic characteristics of the participants are summarized in Table 1. Demographic information includes age, grade, gender, family status, place of origin, weight and height, Near-sightedness, sports team membership, annual per capita household income and parental education level, etc.

The International Physical Activity Questionnaire (IPAQ) long form (24) assesses daily work, transportation, daily life, leisure exercise, and sedentary time, and calculates the level of PA that an individual engages in each week. The IPAQ has been validated to have a good validity and reliability in China (25, 26).

TABLE 1 Sociodemographic contrast of PARI and non-PARI in different sexes of the population.

Characteristics	Males ($n = 1,989$)			Females ($n = 4,043$)		
	PARI ($n = 415$) n (%)	Non-PARI ($n = 1,574$) n (%)	χ^2/t	PARI ($n = 377$) n (%)	Non-PARI ($n = 3,666$) n (%)	χ^2/t
Region						
Eastern region	166 (20.6)	641 (79.4)	13.600**	191 (10.1)	1,708 (89.9)	10.716*
Central region	147 (25.3)	435 (74.7)		84 (11.1)	670 (88.9)	
Western region	92 (17.8)	426 (82.2)		87 (7.3)	1,113 (92.8)	
Northeast region	10 (12.2)	72 (87.8)		15 (7.9)	175 (92.1)	
Grade						
Freshman	142 (18.7)	619 (81.3)	5.319	149 (9.7)	1,384 (90.3)	0.852
Sophomore	119 (23.4)	390 (76.6)		98 (8.8)	1,010 (91.2)	
Junior	115 (22.4)	399 (77.6)		92 (9.0)	927 (91.0)	
Senior	39 (19.0)	166 (81.0)		38 (9.9)	345 (90.1)	
Place of origin						
Urban	170 (21.5)	619 (78.5)	0.368	167 (11.5)	1,280 (88.5)	13.092***
Rural	245 (20.4)	955 (79.6)		210 (8.1)	2,386 (91.9)	
Body mass index (BMI) (kg/m^2)						
BMI <18.5 (underweight)	36 (14.5)	213 (85.5)	7.146	70 (7.1)	912 (92.9)	12.056**
18.5 ≤ BMI ≤ 23.9 (normal range)	268 (21.9)	953 (78.1)		252 (9.6)	2,380 (90.4)	
24.0 ≤ BMI ≤ 27.9 (overweight)	81 (21.4)	298 (78.6)		40 (12.6)	277 (87.4)	
BMI ≥ 28 (obese)	30 (21.4)	110 (78.6)		15 (13.4)	97 (86.6)	
Near-sightedness						
Yes	313 (21.4)	1,149 (78.6)	0.99	321 (9.6)	3,033 (90.4)	1.408
No	102 (19.4)	425 (80.6)		56 (8.1)	633 (91.9)	
Only child						
Yes	146 (20.6)	563 (79.4)	0.05	120 (11.7)	909 (88.3)	8.916**
No	269 (21.0)	1,011 (79.0)		257 (8.5)	2,757 (91.5)	
Sports teams						
Yes	128 (37.3)	37.30%	67.953***	86 (22.6)	295 (77.4)	87.307***
No	287 (17.4)	17.40%		291 (7.9)	3,371 (92.1)	
Annual per capita household income						
≤10,000	94 (18.1)	425 (81.9)	9.724*	96 (7.8)	1,127 (92.2)	7.132
10–50,000 (including 50,000)	166 (19.5)	684 (80.5)		160 (9.3)	1,563 (90.7)	
50–100,000 (including 100,000)	104 (24.9)	313 (75.1)		78 (10.7)	648 (89.3)	
>100,000	51 (25.1)	152 (74.9)		43 (11.6)	328 (88.4)	
Mother's education level						
Elementary school and below	155 (21.6)	564 (78.4)	2.478	119 (8.5)	1,277 (91.5)	7.847
Junior high school or vocational school	132 (20.4)	516 (79.6)		123 (8.6)	1,307 (91.4)	
High school or junior college	60 (18.5)	264 (81.5)		75 (10.8)	618 (89.2)	
Tertiary	36 (24.3)	112 (75.7)		35 (12.8)	238 (87.2)	
Bachelor's degree or above	32 (21.3)	118 (78.7)		25 (10.0)	226 (90.0)	
Father's education level						
Elementary school and below	96 (21.0)	362 (79.0)	2.591	76 (8.4)	827 (91.6)	4.795
Junior high school or vocational school	156 (20.3)	611 (79.7)		155 (9.4)	1,486 (90.6)	
High school or junior college	85 (20.8)	324 (79.2)		70 (8.5)	757 (91.5)	

(Continued)

TABLE 1 (Continued)

Characteristics	Males ($n = 1,989$)			Females ($n = 4,043$)		
	PARI ($n = 415$) n (%)	Non-PARI ($n = 1,574$) n (%)	χ^2/t	PARI ($n = 377$) n (%)	Non-PARI ($n = 3,666$) n (%)	χ^2/t
Tertiary	45 (25.1)	134 (74.9)		39 (11.5)	300 (88.5)	
Bachelor's degree or above	33 (18.8)	143 (81.3)		37 (11.1)	296 (88.9)	
PA level						
Low	121 (16.0)	633 (84.0)	33.829***	94 (6.0)	1,474 (94.0)	40.869***
Moderate	97 (18.3)	432 (81.7)		144 (10.1)	1,284 (89.9)	
High	197 (27.9)	509 (72.1)		139 (13.3)	908 (86.7)	

*p < 0.05.
**p < 0.01.
***p < 0.001.

Participants were asked to complete 4 questions, which were questionnaires about their personal behaviors whilst engaging in PA. For example, (a) "Do you perform warm-up exercises before participating in physical activities?" (b) "Do you use protection when participating in physical activities?" (c) "Are you physically active in an appropriate environment?" (d) "Do you stretch or relax after participating in physical activities?" The 5-point Likert scale was provided for the responses, including "always," "often," "sometimes," "hardly ever," and "never".

Risk-taking behavior refers to the choices individuals make in uncertain situations and with different tasks. It reflects the willingness of individuals to adopt behaviors that carries a significant degree of risk. That is, when individuals are faced with convergent conflict avoidance, they adopt risky behaviors in order to converge on a valuable or beneficial outcome that satisfies their needs. The Adolescent Risk-taking Questionnaire-Risk Behavior Scale (ARQ-RB) developed and revised by Zhang et al. (27), in China, with 17 revised items classified into four dimensions: stimulus-seeking behavior, reckless behavior, rebellious behavior and antisocial behavior (Cronbach's alpha = 0.734). Each item consists of five levels from one point to five points. The score of each risk-taking behavior factor is directly proportional to the willingness to participate in risk-taking behavior.

In addition, relevant information about PARI in the past 12 months was collected. PARI are generally injuries that occur during PA in humans. The PARI covered in this study are based on the concept mentioned by Mechelen in Sports Med in 1992 and adapted by Bloemers (14, 15) as any injury caused by physical education classes, sports, or recreational exercise with one or more of the following consequences: (1) the necessity to stop the current PA (sport), (2) the inability or inability to have a hand in the next planned PA (sport) overall, (3) the inability to attend class the next day and (4) the need to seek medical support. All participants were asked to report PARI based on the four criteria above, and a tally was finally performed. Those who had experienced PARI were asked to provide details of their most recent PARI.

Processes and ethics

All institutions were required to ask student participants to accomplish the questionnaires within the same time. Before filling out the questionnaire, participants were asked to sign the informed consent form after reading the information sheet for the study and instructions for completing the survey. The return rate of the electronic questionnaire was 100%. A total of 6,710 questionnaires were collected, and 6,032 valid questionnaires were obtained after eliminating invalid questionnaires with regular or mixed answers, representing a valid response rate of 89.8%.

The study was approved by the Ethics Committee of the Sixth Hospital of Sun Yat-sen University (IEC Ref: E2020035).

Statistical analysis

Categorical and continuous variables were presented with frequency (percentages) or means and standard deviations (SD). The discrepancies between the two groups, PARI and non-PARI, were tested by Pearson's chi-square test or independent samples t-test, respectively. A binary multivariate logistic regression analysis was conducted to screen the influences on males and females separately, using whether they were injured as the dependent variable and the statistically significant variables from the initial univariate analysis as independent variables. The data were analyzed using SPSS 26.0 software (IBM® SPSS®).

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TABLE 2 Contrast of PA related behaviors for PARI and non-PARI by gender.

Physical activity (PA)-related behaviors	Males (n =1,989)			Females (n = 4,043)		
	PARI (n = 415) n (%)	Non-PARI (n = 1,574) n (%)	χ^2	PARI (n = 377) n (%)	Non-PARI (n = 3,666) n (%)	χ^2
Doing warm-up						
Always	112 (24.1)	353 (75.9)	12.211*	70 (10.6)	591 (89.4)	0.979
Often	116 (23.0)	388 (77.0)		100 (10.8)	825 (89.2)	
Sometimes	125 (18.0)	570 (82.0)		140 (8.5)	1,508 (91.5)	
Almost never	54 (21.4)	198 (78.6)		54 (7.9)	626 (92.1)	
Never	8 (11.0)	65 (89.0)		13 (10.1)	116 (89.9)	
Use protective equipment						
Always	53 (26.1)	150 (73.9)	6.629	15 (11.4)	117 (88.6)	6.635
Often	46 (24.6)	141 (75.4)		27 (17.0)	132 (83.0)	
Sometimes	92 (20.1)	365 (79.9)		63 (9.3)	612 (90.7)	
Almost never	102 (20.5)	395 (79.5)		113 (8.8)	1,166 (91.2)	
Never	122 (18.9)	523 (81.1)		159 (8.8)	1,639 (91.2)	
Exercise in appropriate environment						
Always	96 (24.1)	303 (75.9)	8.536	79 (10.5)	673 (89.5)	7.859
Often	156 (20.6)	602 (79.4)		134 (9.3)	1,308 (90.7)	
Sometimes	123 (18.1)	556 (81.9)		132 (8.6)	1,407 (91.4)	
Almost never	26 (27.7)	68 (72.3)		18 (8.0)	207 (92.0)	
Never	14 (23.7)	45 (76.3)		14 (16.5)	71 (83.5)	
Stretch or relax						
Always	91 (21.4)	334 (78.6)	6.03	80 (9.9)	728 (90.1)	6.166
Often	99 (22.2)	346 (77.8)		86 (8.2)	968 (91.8)	
Sometimes	123 (20.4)	481 (79.6)		119 (9.2)	1,174 (90.8)	
Almost never	73 (23.0)	245 (77.0)		77 (11.3)	605 (88.7)	
Never	29 (14.7)	168 (85.3)		15 (7.3)	191 (92.7)	

*$p < 0.05$.

Results

Sociodemographic characteristics

As shown in Table 1, in total, 6,032 participants were incorporated for analysis, including 1,989 males and 4,043 females, and their mean age was 19.82 years (SD = 1.43). In the entire sample, 792 students (13.1%) reported at least one PARI in the past year. There was a significant difference in the incidence of injury between males and females (χ^2 = 155.652, $p < 0.001$), where the injury incidence was 20.9% (415/1,989) for males and 9.3% (377/4,043) for females. According to statistics, the sum of the cumulative frequency of injuries to the injured was 1,607 (males: 881, females: 726). The results showed that the overall risk of injury was 0.27 (sum of the cumulative frequency of injuries/total number of people surveyed/ year; males: 0.44, females: 0.18; $p < 0.01$).

The effect of demographic characteristics between males and females on PARI is shown in Table 1. For males, those with high levels of PA, in the eastern region, participation in sports teams and high annual per capita household income were associated with the occurrence of PARI. As for females, those with high levels of PA, in the eastern region, urban, obese, the only child, and those who participating in sports teams were more likely to report PARI ($p < 0.05$).

Behaviors related to physical activity

Differences were observed between males and females in behavior related to PA. Males who almost never warmed up before PA were more vulnerable to develop PARI than those who sometimes warmed up ($p < 0.05$), as shown in Table 2.

TABLE 3 Contrast of ARQ-RB scores of college students with PARI and non-PARI by gender.

ARQ-RB factors	Males ($n = 1,989$)			Females ($n = 4,043$)		
	PARI ($n = 415$) n (%)	Non-PARI ($n = 1,574$) n (%)	t	PARI ($n = 377$) n (%)	Non-PARI ($n = 3,666$) n (%)	t
Thrill-seeking behavior	3.29 ± 2.748	3.60 ± 3.632	1.918	3.64 ± 2.703	3.35 ± 2.697	−1.969
Rebellious behavior	2.30 ± 3.543	1.94 ± 3.645	−1.784	1.13 ± 2.268	0.79 ± 1.966	−2.764
Reckless behavior	0.22 ± 0.908	0.27 ± 1.064	0.814	0.07 ± 0.529	0.08 ± 0.548	0.337
Anti-social behavior	1.74 ± 2.307	1.44 ± 2.393	−2.337*	1.39 ± 1.824	1.02 ± 1.660	−3.789*
Total	7.55 ± 7.865	7.25 ± 8.96	−0.63	6.23 ± 5.508	5.25 ± 5.247	−3.449

*$p < 0.05$.

Risk-taking behaviors

The total score for risk-taking behavior was much higher in the PARI group compared with the non-PARI group. Higher scores were associated with the occurrence of PARI. By contrast, both in the PARI group scored significantly higher on antisocial behavior ($p < 0.05$), as shown in Table 3.

Factors affecting males' PARI

The variables with significant differences in the above chi-square test or t-test were used to determine the odds ratios (ORs) and corresponding 95% CIs for PARI in logistic regression model. Non-athletic team members had a lower risk of PARI development (OR = 0.452, 95% CI: 0.346–0.591). High levels of PA were related to a greater risk of PARI compared with low PA levels (OR: 1.875, 95% CI: 1.443–2.436). In addition, high antisocial behavior scores were associated with elevated risk of PARI (OR = 1.069; Table 4).

Factors affecting females' PARI

As Table 5 shows, college students in the region of West China had a lower risk of developing PARI compared with the East (OR = 0.716, 95% CI: 0.546–1.587). Non-sports team members had a lower risk of developing PARI (OR = 0.353, 95% CI: 0.266–1.587). High levels of PA were related to a greater risk of PARI in a dose-dependent manner compared with low levels of PA (OR: 1.678–2.047). Individuals with high antisocial behavior scores had an increased risk of PARI (OR = 1.107, 95% CI: 1.048–1.587).

Discussion

This cross-sectional survey revealed that ∼13% of college students majored in rehabilitation in China had suffered at least one PARI in the past 12 months, which was lower compared with the 22.7% prevalence rate in the previous study (28). In a survey on sports injuries among university students in Wuhan, the incidence of injuries among university students was 15.59% (29). In a survey of medical students, their lack of knowledge about physical health care led to a higher incidence of PARI (30). In contrast, the incidence of PARI was relatively low among university students in rehabilitation. The discrepancies in the rate of PARI found in this study could be related to the different study sample populations. Students in rehabilitation have background knowledge and skills in PARI concepts and related preventive measures (31).

In our study, males were at significantly higher risk of injury compared to females (0.44 vs. 0.18). Consistent with previous studies, different potential risk factors associated with PARI were observed between genders (14, 32). Males tend to be more actively involved in PA than females (6), which may increase their incidence of PARI. In addition, males are more likely to participate in competitive team sports such as basketball and football, which mostly involve high speed contact, jumping, sprinting, and spinning that are associated with common injury mechanisms (33). Given the gender-difference issue, the potential risk factors for the occurrence of PARI were experimentally explored separately by gender separately in our study.

Results of the study showed that the prevalence of PARI was higher in urban-dwelling females than those living in rural area ($X^2 = 13.092, p < 0.01$). This may be explained by several factors between urban and rural residence, including economic level, awareness and habit of regular PA (34). The popularity of bike-sharing in cities has made urban students keen to get around by bicycle (35). Improvements in urban sports infrastructure, such as the creation of basketball courts and large squares, as well as public sports equipment, such as outdoor fitness equipment and sports facilities, have increased opportunities for students living in urban areas to participate in sports and leisure activities (36). To some extent, the above factors may be accounted for the different PARI rate between urban and rural dwelling students. Regarding the geographic and economic regional distribution,

TABLE 4 Risk factors for PARI amongst males.

Variables	Partial regression coefficient (β)	Standard error (SE)	Odds ratios (ORs)	95% confidence interval (CI)	*p*-Value
Sports teams					
Yes			1		
No	−0.793	0.136	0.452	0.346–0.591	**<0.001**
PA level					
Low			1		
Moderate	0.265	0.154	1.303	0.964–1.762	0.085
High	0.628	0.134	1.875	1.443–2.436	**<0.001**
Anti-social behavior	0.067	0.023	1.069	1.023–1.118	**0.003***
Constants	−0.723	0.163	0.485		**<0.001**

The bold values indicate a *p*-value of less than 0.01.

TABLE 5 Risk factors for PARI amongst females.

Variables	Partial regression coefficient (β)	Standard error (SE)	Odds ratios (OR)	95% confidence interval (CI)	*p*-Value
Region					
Eastern region			1		
Central region	0.182	0.143	1.200	0.907–1.587	0.202
Western region	−0.334	0.139	0.716	0.546–1.587	**0.008***
Northeast region	−0.159	0.284	0.853	0.489–1.587	0.576
Sports teams					
Yes			1		
No	−1.042	0.143	0.353	0.266–1.587	**<0.001**
PA level					
Low			1		
Moderate	0.517	0.140	1.678	1.274–1.587	**<0.001**
High	0.717	0.144	2.047	1.545–1.587	**<0.001**
Anti-social behavior	0.102	0.028	1.107	1.048–1.587	**<0.001**
Constants	−1.327	0.201	0.265		**<0.001**

The bold values indicate a *p*-value of less than 0.01.

injury rates were much higher for both males and females in the eastern China, which may be due to differences in PA levels and awareness of injury prevention in each region (37).

Additionally, it is found that the rate of PARI was higher amongst members of sports teams than those non-sports team members, for both males and females ($p < 0.05$). This is partly because members of sports teams are usually required to attend regular training sessions and participate in different types of sports competitions, so the chances of PARI are higher (38).

For males, the higher the annual household income per capita, the greater the risk of PARI (Chi Square, same as above $x^2 = 9.724$, $p < 0.05$). Those with higher household income are likely to be of middle-class or above social status and may place more emphasis on exercise and physical fitness. Students in a low-income family are less likely to be aware of the need for physical activity and afford popular sports, such as judo, gymnastics, tennis and so on (39).

In the current study, 29.1, 32.4, and 38.5% of the college students in rehabilitation responded engaged in high-, medium- and low-level PA, respectively. A significant correlation/association was observed between PA levels and the incidence of PARI in both males and females. Higher PA levels were associated with an increased risk of experiencing PARI, which echoed previous findings (40). The occurrence of PARI, in the short run, could place a negative impact on the motivation of college students to persevere in active PA due to fear of injury reoccurrence or aggravation (16, 17). In the long term, PARI may also increase the risk of other damage or disorders related to PA (41). Therefore, prophylactic measures to prevent PARI need to be advocated whilst promoting active PA engagement.

According to the findings, males who never warm up before exercise were less likely to be injured than those who always warm up. Several studies suggest that warming up

is not associated with PARI (42), and more alternatives to warming up before exercise are more conducive to reducing PARI risk (43).

Risk-taking behaviors have been identified as a major contributor to PARI (44), and the results of this study showed that students with antisocial behaviors were at a higher risk for PARI ($p < 0.05$). Risk-taking behavior may be related to cognitive ability, which could explain why risk-taking behavior increases the risk of PARI (37). Poor awareness of risks also increases the odds of developing PARI (45).

In summary, this cross-sectional study had a relatively large sample size. It was possible to conduct a nationwide survey of rehabilitated college students in a low-cost electronic format. However, there are several limitations in the study. First, the cross-sectional design limited the findings of the study and no causal relationships could be drawn. In addition, the study was a self-administered questionnaire and did not include objective measures. Considering these limitations, longitudinal studies should be conducted in the future to expand the total sample size and sample specialty. Where necessary, measurement tools that objectively record physical activity could be used to avoid these limitations.

Conclusions

Physical activity-related injuries is not an uncommon health issue amongst Chinese college students majored in rehabilitation. The prevalence rates of PARI vary between male and female students. Different risk factors were found associated with the occurrence of gender-specific PARI in the study. For male students, participation in sports teams, having a high level of PA as well as with antisocial behavior were risk factors for developing PARI. Regarding female students, sports team membership, a higher level of PA, with antisocial behavior, as well as regional differences, were associated with elevated odds to suffer from PARI. Our findings may play an important role in the development of physical activity-related prevention programmes for college students majoring in rehabilitation, with attention to differences between genders. In addition, they also play a more important role in promoting physical activity and physical activity-related injury prevention among college students in general majors. These results could increase young people's awareness of physical activity and physical activity-related injuries and better avoid sports injuries while promoting physical activity. Also, in the future prevention of physical activity-related injuries among general college students, different measures could be taken to address the gender differences in physical activity injuries.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by the study was approved by the Ethics Committee of the Sixth Hospital of Sun Yat-sen University (IEC Ref: E2020035). The patients/participants provided their written informed consent to participate in this study.

Author contributions

YY and WY: conception of ideas and experimental design. YY and YW: data collection, analysis, and manuscript writing. LX, YW, FB, WY, and YJ: writing—review and editing. WY: editing and supervision. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Gender differences in family meal frequency and their association with substance use and mental health among middle and high school students

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Background: Family meals are associated with adolescent health outcomes. Studies have reported that girls are less likely than boys to have dinner with their families.

Purpose: This study examined gender differences in family meal frequency and the relationship between meal frequency and other health measures, using a large and representative sample of California middle and high school students.

Methods: This study analyzed data from the 2019–2020 California Student Tobacco Survey (159,904 students in grades 8, 10, and 12). Dinner with the family 5–7 times per week was defined as high frequency. Students reported substance use (of tobacco, marijuana, and alcohol) and rated their mental health and happiness in their home life. All analyses were weighted to reflect the California student population.

Results: Fewer than half (44.7%) of students reported a high frequency of family meals, with boys more likely than girls and those who identified their gender in another way the least likely to do so (48.3%, 42.2%, 34.0%, respectively). Gender differences persisted across demographics and the quality of family relationships, and were evident as early as eighth grade. Less frequent family meals were associated with poorer mental health (OR=1.34, 95% CI: 1.29–1.40) and substance use (OR=1.27, 95% CI: 1.21–1.32), controlling for the effects of demographics and family dynamics.

Conclusion: Gender differences in family meal frequency emerge early in adolescence and persist across demographics and family relationships. Given that family meals play a protective role in an adolescent's life, these gender differences are concerning.

KEYWORDS

family meal frequency, gender differences, family dynamics, substance use, mental health

Introduction

Family meals provide opportunities for parents to connect with their children on a regular basis, communicate with them about daily activities, exchange social context, monitor children's moods and behaviors, and set an example for them (1–5). Frequent family meals have been demonstrated to be associated with numerous benefits for adolescents, including better dietary intake (6, 7), better school performance (8), less substance use (9), fewer problematic behaviors (9), and fewer mental health issues (8, 9). Studies have also found that frequent meals are

associated with stronger family relationships and communication between family members, leading to a happy home life (5, 8, 9). The value of family meals has been so well established that the National Center on Addiction and Substance Abuse in 2001 designated the fourth Monday in September as "Family Day—A Day to Eat Dinner with Your Children" (4).

A study of secondary-school students found that the frequency of family meals decreased by 3% from 1999 to 2010 (10). Moreover, the decrease varied by demographics. Frequent family meals decreased by 9.3% among the lowest-income students, whereas the highest-income students experienced a 5.1% increase over the same time period (10). The reasons for this difference are not completely known. Another notable discrepancy in mealtime frequency is by gender. In 1999, girls were slightly less likely to participate in family meals than boys (10). By 2010, the rate of participation in family meals for girls decreased by 5% while remaining constant for boys (10).

Several other studies have also reported on gender differences in family meal frequency, although it has not been the focus of the work (8–12). Where gender differences are observed, they are limited to those who identify as male or female. The pattern is consistent: boys are more likely to report having frequent family meals than girls of the same age (8, 12, 13). Proposed explanations for gender differences include the suggestion that girls are more likely than boys to be affected by family instabilities (8, 12, 14), such as family economic problems and parents' negative feelings, and more likely to skip family meals because they are uncomfortable or as a way to control their weight (15–17).

This study focuses on the gender differences in family meal frequency, using a large population survey of middle and high school students in California. The study examines gender differences in three categories (male, female, and those who identify in another way) and investigates the relationship between family meal frequency and students' mental health and substance use.

Methods

Study participants

This study presents data from the 2019–2020 California Student Tobacco Survey (CSTS), which used a two-stage cluster sampling design to obtain a representative sample of the state's public school students (18). The survey was conducted among secondary schools (grades 8, 10, and 12). The school served as the primary sampling unit and the classroom served as the secondary sampling unit. For middle schools, a simple statewide random sampling approach was used. High schools were first stratified into 35 regions before being randomly sampled (12). The number of high schools selected from each region was determined by the region's proportion of students in the state. Overall, 608 out of the 3,056 eligible schools were invited to participate, and 482 schools agreed to participate in the survey. A total of 369 schools (47 were middle schools and 322 were high schools) responded to the survey prior to the COVID-19 closures. The survey was fielded from September 2019 to March 2020. The survey was planned to end in April 2020 but ended in March 2020 instead because schools across the state began to close due to the COVID-19 pandemic. While closures occurred on different dates, most schools closed between March 13 to 18, 2020. The data from 27 schools were excluded because their response rate was below 40% due to the COVID-19 outbreak and thus considered unacceptable. The overall response rate among eligible students was 68.3%. The sampling design and response rates were taken into account in the analysis through proper weighting. Furthermore, a post-stratification adjustment was applied, with weighted totals by grade recalibrated to equal population totals of eligible students in the region for each grade, based on California Department of Education enrollment data (18). The survey, available in English and Spanish, was anonymous and administered online during class time. There were 162,675 students who took the survey, but 2,771 (or 1.7%) did not respond to either frequency of family meals or gender (the variables of interest) and were excluded from the analysis, leaving an effective sample size of 159,904. The study was approved by the University of California Human Research Protections Program, Institutional Review Board #170787.

Measures

The CSTS was primarily designed to determine the prevalence of tobacco use in California's population of secondary students, but it also included other questions of interest. Family meal frequency was measured by asking: "In a usual week, how many times do all of the people in your family who live with you eat dinner together?" with response options of 0, 1, 2, 3, 4, 5, 6, and 7+ times a week (7, 9, 15). For analysis, response options were classified into two categories: 0–4 times per week and 5–7 times per week, with the latter category considered frequent family meals (FFM). This single-item measurement and classification of family meals has been applied in many studies (7, 8, 10, 19, 20).

Gender was assessed by the question "How do you describe yourself?" Seven options were given: (1) Male, (2) Female, (3) Female-to-Male/Transgender Male/Trans Man, (4) Male-to-Female/Transgender Female/Trans Woman, (5) Genderqueer, neither exclusively male nor female, (6) Additional gender category or other, and (7) Choose not to disclose. For analysis, the options were classified as Male, Female, Identified in Another Way (comprised of options 3–6), and Declined to answer. It is noted that the measurement of gender in this study is limited by questions asked in the survey and we adopted students' response to these questions as an approximation of their gender identity.

The study included other demographic factors that have been associated with FFM (1, 21): ethnicity/race, parental education, and being the youngest child in the home. Ethnicity was defined using two questions: "Are you of Spanish or Hispanic (Latino or Latina) origin?" with answer options of yes and no and "How do you describe yourself?" with multiple options for race. Answers were recoded to Non-Hispanic (NH) White, NH-Black, Hispanic, NH-Asian, NH-others (including NH-American Indian, NH-Native Hawaiian and Pacific Islander, and NH-other race), and NH-multiple race. Parental education was assessed with the question: "Do either of your parents have a college education?" with options of yes, no, and "I do not know." The youngest child was measured with a yes or no to the question: "Are you the youngest person living in your house?"

The survey also included two measures of family dynamics. Home life was assessed with the statements "I have a happy home life" (22) and "I can talk about my problems with my family" (23). Response options of strongly agree and somewhat agree were recoded as Yes, while somewhat disagree and strongly disagree were recoded as No for the analyses.

Substance use in this study was defined as any use of tobacco products, alcohol, or marijuana in the past 30 days. The survey contains many detailed questions on substance use. For tobacco use behavior, the survey asked whether the student had used cigarettes, vapes (e-cigarettes), little cigars and cigarillos, big cigars, smokeless tobacco, and hookah. Participants were presented with images and descriptions of each product and were asked if they had ever used it. Those who reported ever using a product were further asked if they had used it in the past 30 days. For marijuana use behavior, the survey asked if they had: smoked, ate, drank, dabbed, vaped, or used marijuana in some other way. For those who had ever used marijuana, they were asked if they had used the product in the past 30 days. Alcohol use was assessed by two questions: whether they had ever used alcohol (even just a few sips of any alcoholic drink) and whether they had used it in the last 30 days. Students who used any of these products in the last 30 days were considered current substance users.

Mental health was measured by the question, "In general, how would you rate your mental health?" Poor mental health was defined as anyone who chose the responses of "fair" or "poor" from the five options (excellent, very good, good, fair, or poor) (24).

Analysis

Descriptive statistics were used to describe family meal frequency by demographic characteristics and family dynamics. Multiple logistic regression analysis was used to further assess the relationship between gender and FFM, controlling for other factors. A separate logistic regression examined the relationships between FFM and mental health, and the relationship between FFM and substance use, while controlling for other factors. The estimates of rates and proportions were presented with their 95% confidence intervals. The results were weighted to account for the complex survey design to be representative of California students. SAS software 9.4 was used for the analyses.

Results

A total of 159,904 students were included in the study. By gender, the percentages were 45.7% males, 48.8% females, 2.9% who identified their gender in another way, and 2.5% who declined to provide their gender. While fewer 8th graders (7.4% of the sample) participated than 10th (50.2%) and 12th graders (42.4%), the rates and proportions reported in the results section were all weighted to reflect the population of these students in California. The ethnic breakdown was 52.7% Hispanic, 20.3% NH-White, 12.4% NH-Asian, 2.7% NH-Black, 3.6% NH-others, and 8.3% NH-multiple race. Almost half of the students (45.5%) reported that at least one of their parents had a college degree, and nearly two-fifths (38.4%) were the youngest child at home.

Table 1 shows the percentage of frequent family meals by gender. Girls were significantly less likely to have FFM than boys, 42.1% vs. 48.3%. Those who identified their gender in another way were the least likely (34.0%) to have FFM. Of those who declined to provide their gender, 43.7% reported FFM, a rate similar to that for girls.

Table 1 also shows a consistent gender pattern for FFM across demographic variables. While FFM declined with age (52.2% of 8th graders vs. 44.4% of 10th graders vs. 37.2% of 12th graders, respectively), the gender pattern of boys being the most likely to have FFM and students who identified in another way being the least likely to have FFM is clear at each age.

Likewise, while there were differences in FFM across ethnicity/race, the pattern across genders within each ethnic/racial group is the same. As shown in Table 1, NH-White students and NH-Asian students were more likely to have FFM than Hispanic students, and Hispanic students were, in turn, more likely to have FFM than NH-Black students. However, in each of these groups more boys than girls reported FFM (although among NH-Black students, the gender difference failed to reach significance). Again, students who identified in another way were the least likely to have FFM; however, due to smaller sample sizes, the confidence intervals were too large to determine significance. A similar pattern was evident with parental education. Students who had at least one parent with a college education more often reported FFM compared to students with lower parental education (49.6% vs. 38.9%, respectively), but within each of these education groups, boys participated in FFM more often than girls (52.6% for boys vs. 47.2% for girls among higher parental education and 43.0% for boys vs. 36.3% for girls among lower parental education). Those identifying in another way had the lowest FFM rates, although again, not all these differences reached significance. Finally, the same gender pattern emerged regardless of whether the student was the youngest child in the home. Being the youngest child at home was related to lower FFM (41.3% vs. 46.9%). But in either case (youngest or not), boys reported more FFM than girls, who in turn reported more FFM than students who identified in another way.

To rule out the possibility that the gender difference in FFM is caused by girls and boys having a different quality of life with their family members, Table 2 presents the rates of FFM separately for those who reported having a happy home life versus those who did not. On average, 83.9% of students reported that they had a happy home life and 60.7% said they were able to talk to their family about problems. However, gender differences persisted across these dimensions: regardless of whether students had positive or negative views of their family dynamics, boys were more likely than girls to have FFM. For students identifying their gender in another way, the pattern of being the least likely to have FFM was clear both among students who rated their home life as happy and among those who said they could talk with their family about problems. However, among those who identified in another way and indicated not having a happy home life or family to talk to, there was no significant difference in their rate of FFM compared to girls in households similarly perceived as unhappy and unsupportive.

Table 3 shows the multiple logistic regression results between FFM and gender, controlling for demographics and family dynamics (including all variables in Tables 1, 2). Compared to boys, girls were 15% less likely to have FFM (OR = 0.85). Students who identified their gender in another way were even less likely to report FFM (OR = 0.68). The multivariate analysis confirmed the drop in FFM over age. Tenth and 12th graders were less likely than 8th graders to have FFM (OR = 0.75 and OR = 0.55, respectively). Using NH-White students as the reference, NH-Black students were significantly less likely (OR = 0.63) and NH-Asian students were more likely (OR = 1.28) to participate in FFM. Students from other ethnic groups did not differ in FFM from NH-White students when controlling for other factors. Students with a college-educated parent were 36% more likely to indicate having FFM than those without. Students with younger siblings in the home were 33% more likely to report FFM than those who were the youngest (OR = 1.33). When controlling for other factors, family dynamics were strongly related to FFM. Compared to students with a happy home life,

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TABLE 1 Percentage of middle and high school students having frequent family meals, by gender.

	Sample size	Total	Male	Female	Identified in another way	Declined to answer
	N	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)
Mean	159,904	44.7 (43.9–45.6)	48.3 (47.4–49.2)	42.1 (41.0–43.2)	34.0 (31.6–36.4)	43.7 (40.9–46.5)
Grade						
8	11,786	52.2 (50.2–54.2)	55.2 (53.3–57.2)	50.2 (47.5–52.9)	39.7 (34.1–45.4)	47.6 (40.5–54.7)
10	80,105	44.4 (43.7–45.1)	48.6 (47.8–49.5)	41.3 (40.4–42.2)	33.4 (30.9–35.9)	41.5 (39.2–43.9)
12	68,013	37.2 (36.5–38.0)	40.2 (39.3–41.1)	34.9 (34.0–35.7)	27.7 (25.1–30.4)	41.6 (38.5–44.7)
Race						
NH-White	32,431	47.5 (45.5–49.5)	50.5 (48.1–53.0)	45.2 (42.7–47.6)	38.9 (32.1–45.7)	46.1 (37.4–54.7)
NH-Black	4,323	35.2 (30.4–40.0)	40.5 (33.0–48.0)	30.9 (26.1–35.7)	25.5 (16.6–34.4)	35.4 (24.9–45.9)
Hispanic	83,886	42.8 (42.0–43.6)	46.3 (45.3–47.2)	40.3 (39.3–41.4)	33.0 (29.7–36.3)	39.7 (36.1–43.2)
NH-Asian	19,880	50.9 (48.5–53.2)	54.3 (51.6–57.0)	48.5 (46.0–51.0)	33.8 (28.2–39.5)	44.5 (38.3–50.7)
NH-Others	5,680	45.1 (42.4–47.8)	49.2 (45.7–52.7)	40.8 (36.9–44.8)	35.9 (26.3–45.6)	48.1 (41.8–54.5)
NH-Multiple	13,322	46.5 (44.4–48.5)	50.3 (47.5–53.0)	43.3 (40.7–45.9)	32.7 (25.6–39.8)	52.3 (43.3–61.4)
Parental education						
College degree	72,743	49.6 (48.4–50.8)	52.6 (51.3–53.9)	47.2 (45.6–48.8)	43.1 (38.5–47.7)	44.6 (39.4–49.8)
No college degree	65,490	38.9 (38.2–39.6)	43.0 (42.1–43.9)	36.3 (35.2–37.4)	24.2 (20.1–28.3)	34.5 (29.5–39.5)
I do not know	21,359	45.6 (44.2–47.1)	48.1 (46.1–50.0)	44.1 (41.6–46.5)	31.6 (28.0–35.3)	49.1 (45.0–53.2)
Youngest child in the home						
Yes	61,344	41.3 (40.2–42.4)	44.2 (42.9–45.6)	39.2 (37.8–40.6)	31.3 (27.8–34.8)	40.0 (35.4–44.6)
No	98,371	46.9 (45.9–47.8)	50.8 (49.8–51.9)	43.9 (42.7–45.1)	36.0 (32.5–39.4)	45.2 (41.8–48.5)

those who did not have a happy home life were 46% less likely to have FFM (OR = 0.54, 95% CI: 0.51–0.57), and compared to those who could talk openly with their families, those who could not talk openly were 40% less likely to have FFM (OR = 0.60, 95% CI: 0.57–0.62).

Figure 1 shows that FFM predicts the likelihood of substance use for the study's students. The rate of substance use was 25.1% for those who had meals with their family fewer than 5 times per week and 17.7% for those who had meals together at least 5 times per week. A multiple logistic regression model that controls for the effects of demographics and family dynamics (all variables shown in Table 3) confirms that this difference is statistically significant (OR = 1.27, 95% CI 1.21–1.32). In other words, students with low family meal frequency were 27% more likely to use substances than students who reported frequent family meals.

Figure 1 also shows that FFM predicts the mental health status of these students. The rate of poor mental health was 36.4% for those who had meals with their family fewer than 5 times per week versus 23.9% for those who had FFM. A multiple logistic regression model that controls for the effects of demographics and family dynamics (all variables shown in Table 3) confirms that this difference is statistically significant, with Odds Ratio = 1.34 (95% CI 1.29–1.40). In other words, students with low family meal frequency were 34% more likely to report poor mental health than students with FFM.

Discussion

This study examined gender differences in the frequency of family meals among a representative sample of secondary students in California. Fewer than half of students reported FFM (at least 5 times/week). There were strong gender differences in FFM, with boys consistently reporting higher rates of FFM than girls, while students who identified their gender in another way had the lowest rates of FFM. Gender differences in FFM were already evident by middle school and were robust across demographic factors and family dynamics. This study also confirmed that frequent family meals were generally associated with better mental health and lower rates of substance use, controlling for all demographic and family-dynamic variables. Given the real-world consequences of poor mental health and substance use in adolescence, the persistent gender differences seen in the frequency of family meals warrant scrutiny.

The gender difference between boys and girls in FFM found in this study is consistent with previous findings both in direction and size (9, 10, 13). The most comparable study was that of Fulkerson et al., which used a large, nationally representative sample of 6th to 12th graders to examine participation in FFM (9). Although the study sample was primarily (86%) NH-White students and did not have gender classifications beyond male and female, it used the same FFM measure and definition as the current study (9). The focus of that work was the relationship of FFM to high-risk behaviors (e.g., tobacco, alcohol, and drug use) and the role of internal assets, such as achievement motivation, and external assets, such as family support (9). Of note, the Fulkerson et al. study found that male students were more likely to participate in FFM than female students (47.0% vs. 42.6%, respectively), a 4.4% difference (9). The study, in its focus on internal and external developmental assets, classified the gender difference as "slight" (9). The male and female difference found in this study was in the same direction and appeared to be larger, 6.2 percentage points. Sampling differences between these two studies prevent direct comparison, making

TABLE 2 Percentage of students having frequent family meals by family dynamics and gender.

Happy home life?	Yes (*N*=133,291)	% (95% CI)	No (*N*=25,899)	% (95% CI)
Male	63,753	50.4 (49.5–51.3)	9,012	31.7 (29.8–33.6)
Female	63,734	46.2 (45.1–47.3)	14,223	23.9 (22.5–25.4)
Identified in another way	3,007	38.6 (35.6–41.7)	1,517	24.6 (21.2–28.1)
Declined to answer	2,797	46.3 (43.4–49.3)	1,147	38.1 (33.0–43.1)
Can talk with family?	**Yes (*N* =95,960)**		**No (*N* =63,157)**	
Male	47,000	53.1 (52.0–54.2)	25,730	38.9 (37.6–40.3)
Female	44,685	50.2 (49.0–51.4)	33,244	31.4 (30.1–32.6)
Identified in another way	2,199	37.3 (33.9–40.7)	2,322	31.2 (27.7–34.7)
Declined to answer	2,076	49.4 (45.4–53.4)	1,861	37.8 (34.3–41.4)

TABLE 3 Association of demographics and family dynamics on frequent family meals, multiple logistic regression modeling (*N*=158,418).

Variables		OR (95% CI)
Gender	Male	Ref
	Female	0.85 (0.82–0.88)
	Identified in another way	0.68 (0.60–0.77)
	Declined to answer	0.97 (0.86–1.10)
Grade	8	Ref
	10	0.75 (0.70–0.80)
	12	0.55 (0.51–0.59)
Race	NH-White	Ref
	NH-Black	0.63 (0.50–0.78)
	Hispanic	0.96 (0.90–1.02)
	NH-Asian	1.28 (1.17–1.41)
	NH-Others	0.95 (0.84–1.07)
	NH-Multiple	0.96 (0.86–1.06)
Parental college education or higher	No	Ref
	Yes	1.36 (1.31–1.43)
	I do not know	1.11 (1.04–1.18)
Youngest child	Yes	Ref
	No	1.33 (1.28–1.38)
Happy home life	Yes	Ref
	No	0.54 (0.51–0.57)
Can talk with family	Yes	Ref
	No	0.60 (0.57–0.62)

it difficult to ascertain if 6.2% is indeed a larger difference than 4.2%. It is worth noting, however, that Fulkerson et al.'s study was based on a 2006 survey, while the present study was based on a 2019–20 survey. It is possible that the gap has widened over time, a trend that the Neumark-Sztainer et al. study (10) mentioned previously also suggests.

What is notable in the current study is how the gender differences persist across multiple demographic and family-dynamic variables. The differences are evident in middle school and expand throughout the high school years; they are persistent regardless of whether students reported having a good family relationship or not. Being a girl is associated with a lower frequency of family meals and represents an additional risk factor that can compound the effects of other demographic factors on substance use and poor mental health. The findings are even more profound for students who do not identify as male or female.

Gender differences may be underappreciated if they are attributed to factors that are less amenable to intervention. For example, boys may be hungrier during puberty due to hormones (25, 26) or girls may be more responsive to tensions in the home (8, 12, 14). While it is true that the trajectories for appetite suppressant hormones differ by gender, the differences in FFM emerge quite early making it unlikely to be the full story. Likewise, even if girls are more responsive to tensions in the home, this does not fully explain the gender differences in FFM seen in happy and supportive homes.

One possible explanation of why the gender differences are so pervasive is related more to the structure and expectations of family meal participation. For example, this study found that students who had younger siblings were more likely to participate in family meals. Gender at birth is not contingent on birth order. Among all genders, ethnicities, parental education levels, and family dynamics, some students have younger siblings and others do not. And yet, having younger siblings at home increases the likelihood of FFM. A child with younger siblings may benefit from the structure of family meals and participate simply because the meal is there. In homes with no young siblings, families may stop providing the safety net of family meals, undervaluing the many advantages of family meals apart from providing food. It makes sense that girls, who mature earlier than boys, might face this to an even greater degree. Girls may start eating at their friends' homes or go out to eat. Parents focused primarily on whether the child is fed may not even be aware that family meals are decreasing.

Many studies have focused on the relationship between FFM and healthy eating patterns, and most of these have been conducted with girls (17, 27). Frequent family meals have been associated with a decrease in problematic eating behaviors such as extreme dietary restriction, anorexia and bulimia, skipping meals, overeating, and poor food choices (15, 28, 29). Interventions for families with overweight adolescent girls have had some success in increasing family meal participation by stressing its importance in their daughters' weight loss efforts (30, 31). Yet this focus is perhaps too narrow and more reactive than would be ideal.

Most previous studies related to family meals have provided gender choices of male or female (7–10). By allowing students to identify as transgender, genderqueer, or in other terms, this study contributes to the literature on gender differences in family meals. Students who identified as other than male or female consistently had the lowest percentage of FFM. It is not clear what to make of this finding except

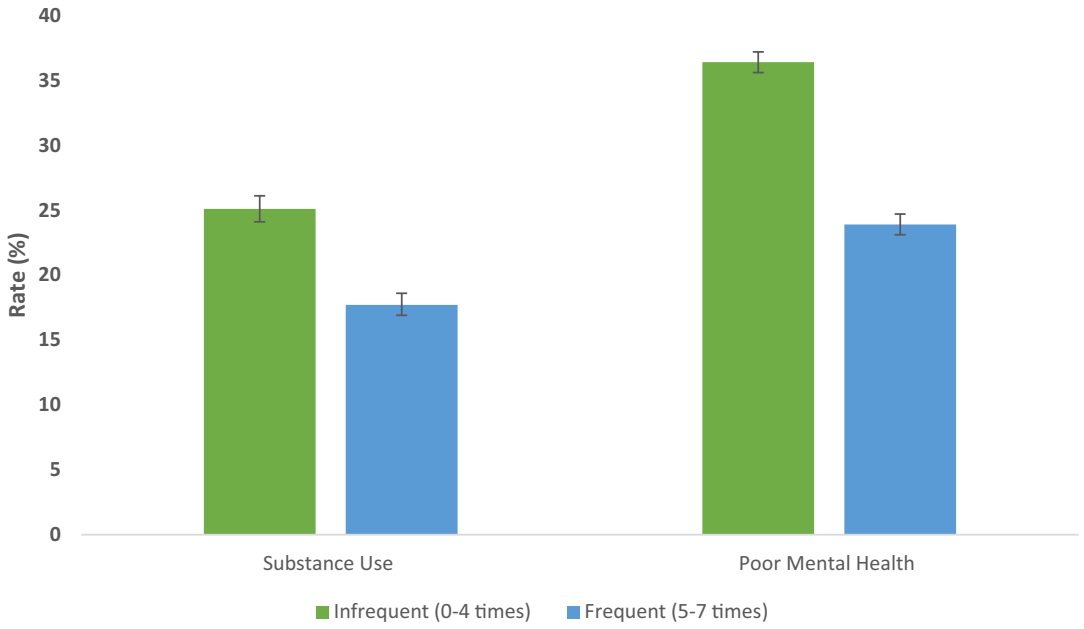

FIGURE 1
Percentage of substance use and poor mental health among adolescents with infrequent and frequent family meals.

to suggest that identifying in ways outside of the traditional male/female classification is associated with greater risk and merits further research. Recent work by VanKim and associates on gender expression and sexual orientation concluded from their analysis of the longitudinal Growing Up Today Study (1997–2011) that the relationship between sexual orientation, gender expression, diet quality, breakfast consumption, and family differences is complex (11).

Limitations and strengths

The 2019–2020 California Student Tobacco Survey used a two-stage cluster sampling design to obtain data from a large, representative sample of secondary students and included an expansive definition of gender. The survey is representative of students in California, nearly 55% of whom identify as Hispanic, which may limit the generalizability of the findings to other populations. Also, the survey was developed primarily to provide stable prevalence estimates of tobacco use, not family meal frequency. As a result, additional factors relevant to FFM (e.g., family income, parental occupation and marital status, and attitudes and knowledge about the importance of family meals) were not measured. And because the survey was cross-sectional rather than longitudinal, no conclusions can be drawn about the causal nature of the relationships observed. Still, the careful sampling design, the large sample size (N > 159,000 students), and the multivariate analyses increase confidence in the findings.

Conclusion

The current study with a large probability sample of students in California shows that frequent family meals are associated with less substance use and better mental health. It also suggests that families may be unaware of how the practice of having family meals together benefits adolescents, regardless of how mature they are perceived to be. And, finally, it confirms that there is a gender difference in family meals that starts early and can compound other risk factors for girls and students who identify their gender in ways other than male or female.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by University of California Human Research Protections Program, Institutional Review Board. Written informed consent from the participants' legal guardian/next of kin was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

TL: conceptualization, data curation, formal analysis, methodology, software, validation, visualization, writing original draft, and writing review and editing. SC: conceptualization, project administration, and writing review and editing. S-HZ: conceptualization, data curation, formal analysis, funding acquisition, investigation, methodology, project administration, resources, software, supervision, validation, and writing review and editing. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Gender differences in lung cancer epidemiology – do Austrian male lung cancer patients still die earlier in life?

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Objective: Previous analyses reported an unexpected decline of mean age of death of Austrian male lung cancer patients until 1996 and a subsequent turnaround of this epidemiological trend after the mid-1990s until 2007. In light of ongoing changes in smoking behavior of men and women, this study aims to investigate the development of mean age of death from lung cancer in Austria during the past three decades.

Materials and methods: This study used data about the annual mean age of death from lung cancer, including malignant neoplasm of trachea, bronchus and lung, between 1992 and 2021 obtained from Statistics Austria, Federal Institution under Public Law. One-way analysis of variance (ANOVA) and independent samples *t*-tests were applied to explore any significant differences of mean values in the course of time as well as between men and women.

Results: Overall, mean age of death of male lung cancer patients increased consistently throughout the observed time periods, whereas women did not show any statistically significant change in the last decades.

Conclusion: Possible reasons for the reported epidemiological development are discussed in this article. Research and Public Health measures should increasingly focus on smoking behaviors of female adolescents.

KEYWORDS

mean age of death, lung cancer, cancer epidemiology, public health, smoking, cigarettes, tobacco, gender differences

1. Introduction

Lung cancer is the second most common cancer type in Austrian men and women (1). The Austrian National Cancer Registry, maintained by Statistics Austria, reported 2.770 men and 2.061 women newly diagnosed with malignant neoplasm of trachea, bronchus and lung (ICD 10—C33, 34) in 2019 (2). Incidence and mortality rates of men and women developed differently over the past decades (see Figure 1). Austrian men showed a large incidence and mortality decline, whereas the female rates increased constantly (3). In 2019, the age standardized mortality rate per 100,000 persons was 59 for men and 34 for women (4). The overall 5-year relative survival rate increased between the period 2000–2004 and 2010–2014 from 15% to 20%. For the last mentioned period the reported average 5-year relative survival for men and women was 17.4% and 24.5%, respectively (3).

In the early 2000s, epidemiological findings suggested that, despite increasing life expectancy and declining lung cancer incidence and mortality in men, the mean age of death of Austrian male lung cancer patients had been decreasing until 1996 (5). Consequently, Borsoi et al. reported an increase of mean age of death after the mid-1990s, but still accounted for a difference between men and women of about half a year in 2007 (6). Despite the continuing increase of life expectancy in Austria, the existing gender differences in lung cancer incidence, mortality and smoking behavior and the advances made over the past decades in the management of non-small cell lung cancer (NSCLC) (7) as well as small cell lung cancer (SCLC) (8), recent reports about mean age of death from lung cancer in Austria are missing. This study aims to provide an update on the development of the mean age of death of Austrian male and female lung cancer patients.

2. Materials and methods

Data about the annual mean age of death from lung cancer, including malignant neoplasm of trachea, bronchus and lung (ICD 10—C33, 34), was available upon request from Statistics Austria, Federal Institution under Public Law. The calculation of the exact empirical mean age of death is based on the difference between date of birth and date of death in days. Contrary to the life expectancy at birth, which is an age standardized measured value, the exact empirical mean age of death reflects the mean of the distribution of the actual deaths from lung cancer (9). Data was divided into three groups, comprising the following three time periods: 1992–2001, 2002–2011 and 2012–2021. In order to explore any statistically significant differences of the mean values between the three groups a one-way analysis of variance (ANOVA) was applied. Pair-wise comparisons were performed using *post-hoc* tests. All analyses were done for men and women separately. Independent samples *t*-tests were performed to explore gender differences. *p*-values ≤ 0.05 were considered to be statistically significant. IBM SPSS Statistics 28.0 was utilized to perform the statistical analyses.

The assumptions for ANOVA (normal distribution of data and homogeneity of variances in all groups) were tested. Normal distribution of data in all groups was visually verified using scatter plots (Supplementary material). The assumption of homogeneity of variances was assessed by applying Levene's test. The according *p*-values of the male and female analysis were less than 0.05 (0.002 and 0.021) indicating a violation of this assumption. Hence, Welch's ANOVA and Games-Howell *post-hoc* tests, which are more robust in case of unequal variances, were performed.

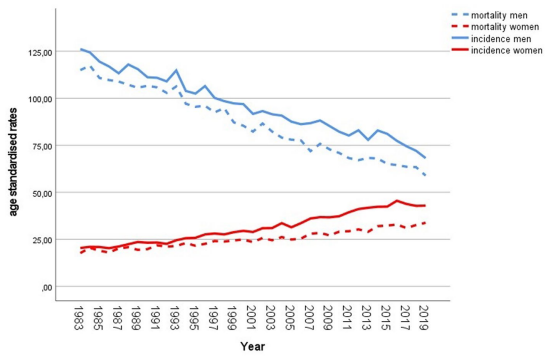

FIGURE 1
Incidence and mortality of lung cancer in Austria since 1983. Age standardized rates per 100,000 population, European Standard Population 2013. Source: Statistics Austria (2–4).

3. Results

Table 1 shows the number of deaths from lung cancer as well as the mean age of death of male and female Austrian lung cancer patients in each time period, the standard deviation, the 95% confidence interval and the *p*-value of the Welch ANOVA. The results indicate statistically significant differences of the mean values between the three groups in men and women. According to the Games-Howell *post-hoc* tests (Table 2), mean age of death of female lung cancer patients decreased significantly by 0.5 years between the periods 1992–2001 and 2002–2011 and increased by 0.7 years between 2002–2011 and 2012–2021. The difference between the periods 1992–2001 and 2012–2021 is statistically not significant ($p = 0.680$).

Mean age of death of male lung cancer patient increased consistently throughout the observed time periods. As shown by Table 2, significant differences of mean values can be observed between each group. Overall, from the period 1992–2001 to the period 2012–2021, mean age of death increased sharply by 2.6 years, finally reaching the level of female patients.

Figure 2 shows the development of male and female mean age of death over the included time periods.

Differences of mean age of death between men and women were statistically significant in the periods 1992–2001 and 2002–2011 ($p < 0.001$) and accounted for 2.31 and 0.93 years, respectively. In the last period (2012–2021), the mean age of death of male lung cancer patients was 0.06 years higher than that of women, but the difference was statistically not significant in the independent samples *t*-test (two-tailed $p = 0.85$).

4. Discussion

The mean age of death provides substantial information, reflecting the length and intensity of exposure to risk factors as well as the quality of the health system (6). Nevertheless, epidemiologic and demographic studies rarely use the mean age of death as the core metric (10). This study reports the continuous increase of mean age of death of Austrian male lung cancer patients from the period 1992–2001 (68.12 years) to the period 2012–2021 (70.72 years; $p < 0.001$). In contrast, women showed no significant change between the first and the last period (70.43 and 70.66 years; $p = 0.68$). However, a small but statistically significant decline in the period 2002–2011 can be detected (69.93 years). The empirical mean age of death does not consider demographic changes in the observed population, especially changing age structures. Between 1990 and 2019, the life expectancy at birth of Austrian men and women increased by 7.3 years and 5.3 years, respectively. The remaining life expectancy at the age of 65 increased by 4.2 and 3.7 years for men and women in the same period (11). This demographic development in Austria might be partly

TABLE 1 Descriptive statistics and ANOVA.

	Period	Years	Deaths	Mean	SD	95% CI	*p*-value
Male	1992–2001	10	23471	68.12	0.131656	68.03; 68.21	<0.001
	2002–2011	10	23448	69.00	0.290593	68.79; 69.21	
	2012–2021	10	23991	70.72	0.608824	70.28; 71.16	
Female	1992–2001	10	8904	70.43	0.41379	70.13; 70.73	0.009
	2002–2011	10	11321	69.93	0.340098	69.69; 70.17	
	2012–2021	10	15178	70.66	0.750111	70.12; 71.20	

Number of included years, number of deaths from lung cancer, mean age of death, standard deviation (SD) and 95% confidence interval of each time period. *p*-value refers to the Welch-ANOVA of male and female lung cancer patients.

TABLE 2 Multiple Comparisons.

	(a) Period	(b) Period	Mean difference (a–b)	*p*-value	95% CI
Male	1992–2001	2002–2011	−0.88	<0.001	−1.15; −0.61
		2012–2021	−2.60	<0.001	−3.14; −2.06
	2002–2011	1992–2001	0.88	<0.001	0.61; 1.15
		2012–2021	−1.72	<0.001	−2.28; −1.16
	2012–2021	1992–2001	2.60	<0.001	2.06; 3.14
		2002–2011	1.72	<0.001	1.16; 2.28
Female	1992–2001	2002–2011	0.50	0.02	0.07; 0.93
		2012–2021	−0.23	0.68	−0.94; 0.48
	2002–2011	1992–2001	−0.50	0.02	−0.93; −0.07
		2012–2021	−0.73	0.04	−1.42; −0.04
	2012–2021	1992–2001	0.23	0.68	−0.48; 0.94
		2002–2011	0.73	0.04	0.04; 1.42

Games-Howell *post-hoc* test.

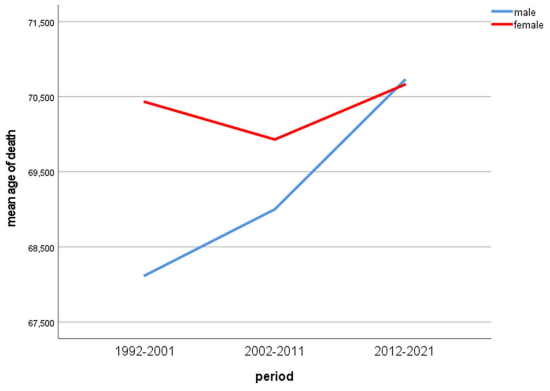

FIGURE 2
Mean age of death of male and female lung cancer patients 1992–2021.

reflected by the trend of mean age of death from lung cancer in men. However, the trend in women seems to be unaffected, as the mean age of death from lung cancer did not change significantly in the observed period.

As the reason for this development of mean age from lung cancer remains unclear, some possible influencing factors will be discussed in the following section.

In Western countries, patterns of smoking behavior have changed over time in women and men. International literature suggests that gender differences in smoking behavior still exist, but they are remarkably smaller in younger age groups (12, 13). In Austria, the share of men aged 16 years and above, who smoke on a daily basis, decreased continuously from 38.7% in 1972 to 23.7% in 2019, whereas the share of daily female smokers increased from 9.8% in 1972 to 22.2% in 2014 and decreased to 17.9% in 2019 (14). These changes in smoking prevalence are held responsible for the opposite trends of lung cancer incidence and mortality in Austria (6). Gender differences relating to the age of onset of regular smoking decreased during the past decades. In recent years, the age of smoking initiation of female smokers approached that of male smokers. According to data of the last Austrian Health Interview Survey (ATHIS 2019), 77.0% of male and 75.4% of female daily smokers aged 15–29 years started to smoke before the age of 17, whereas in the age group 45–59 years 62.0% of male and only 55.7% of female smokers initiated their smoking habit before the age of 17. Even bigger differences were detected in the higher age groups (14). Moreover, smoking intensity decreased in male as well as in female smokers since the early 2000s. In 2019, women still smoked less cigarettes per day than men (17.1 and 13.3 cigarettes). Regarding the share of heavy smokers, a decline can be observed across all three ATHIS waves. In 2006, about 20% of male and 8% of female smokers consumed more than 20 cigarettes per day. The percentage rates decreased in 2014 to 17.3 and 5.6% and in 2019 to 15.8 and 5.5%, respectively. Finally, when looking at the quit rates of Austrian smokers

in 2019, the percentage of former smokers, relating to the (previously) smoking population, did not differ substantially between men and women (58.0% and 57.1%). Nevertheless, younger female smokers and accordingly women of reproductive age showed higher quit rates compared to men of the same age. In contrast, higher quit rates were observed in men aged 45 years and above. Overall quit rates of men and women increased in the last years from 48.0 and 45.0% in 2006, to 54.6 and 51.3 in 2014 and to 58.0 and 57.1% in 2019 (14–16).

To summarize, in recent years, male smoking habits took a turn to the better regarding various aspects like smoking prevalence, intensity and quitting. Although women show similar improvements in some smoking behaviors, they change for the worse in other aspects, especially smoking prevalence and age of smoking initiation. Remarkably, only minor differences in the reported age of smoking onset between young men and women were detected in the most recent ATHIS wave, whereas the gender gap was well defined in older age groups. This trend is observable not only in Austria, but also in other Western populations (12). Hence, it can be hypothesized that male smokers and lung cancer patients, respectively, benefit from recent advancements in early diagnosis and treatment of lung cancer with concomitant improvements of smoking habits, leading to a considerable increase of mean age of death from lung cancer. Contrariwise, women cannot take any further advantage of these clinical advancements, since early age of smoking onset is supposed to be an independent risk factor for the development of lung cancer. Studies suggest that this increase in risk continues until the age of 25 for women, but only until the age of 20 for men (17).

Moreover, it has to be mentioned that tar and nicotine yields of cigarettes decreased steadily since the 1950s, mainly due to improvements in filter technology and changes in cigarette design and composition. In the European Union, tar yields of cigarettes were reduced stepwise from 15 mg per cigarette as from 1993 to 12 mg as from 1998 and are now limited at 10 mg per cigarette since 2004 (18–20). Multiple studies demonstrated a dose-response relationship between tar exposure and lung cancer risk in cigarette smokers (21–23). Presumably, Austrian male smokers with their above-described smoking habits could benefit from these constant reductions of tar yields in cigarettes in terms of mean age of death. The increased usage of nicotine replacement therapy (NRT) might have further contributed in reducing tar exposure, especially in men, as supposed by several studies (24).

To conclude, the continuous increase of life expectancy at birth as well as of further life expectancy at the age of 65 in the last decades of the Austrian population is not reflected in female lung cancer patients and only slightly reflected in male patients. Thus, from a Public Health perspective, measures should increasingly focus on smoking behaviors of female adolescents and should endeavor to continue the recently observed decline of smoking prevalence among women in Austria. Particularly, price policy and taxation are effective strategies to reduce tobacco consumption and especially to prevent smoking initiation among adolescents (25, 26).

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

RF: conception of the work, data collection, data analysis, data interpretation, and drafting the article. UK: critical revision of the article and final approval of the version to be published. EG: data interpretation, critical revision of the article, and final approval of the version to be published. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2023.1099165/full#supplementary-material

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Synchronous and metachronous multiple primary cancers in melanoma survivors: a gender perspective

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Background: Long-term survivors of cutaneous malignant melanoma (CMM) risk subsequent malignancies due to both host-related and environmental risk factors. This retrospective population-based study differentially assesses the risk of synchronous and metachronous cancers in a cohort of CMM survivors stratified by sex.

Methods: The cohort study (1999–2018) included 9,726 CMM survivors (M=4,873, F=4,853) recorded by the cancer registry of all 5,000,000 residents in the Italian Veneto Region. By excluding subsequent CMM and non-CMM skin cancers, the incidence of synchronous and metachronous malignancies was calculated according to sex and tumor site, standardizing for age and calendar year. The Standardized Incidence Ratio (SIR) was calculated as the ratio between the number of subsequent cancers among CMM survivors and the expected number of malignancies among the regional population.

Results: Irrespective of the site, the SIR for synchronous cancers increased in both sexes (SIR=1.90 in males and 1.73 in females). Both sexes also demonstrated an excess risk for synchronous kidney/urinary tract malignancies (SIR=6.99 in males and 12.11 in females), and women had an increased risk of synchronous breast cancer (SIR=1.69). CMM male survivors featured a higher risk of metachronous thyroid (SIR=3.51, 95% CI [1.87, 6.01]), and prostate (SIR=1.35, 95% CI [1.12, 1.61]) malignancies. Among females, metachronous cancers featured higher SIR values than expected: kidney/urinary tract (SIR=2.27, 95% CI [1.29, 3.68]), non-Hodgkin's lymphoma (SIR=2.06, 95% CI [1.24, 3.21]), and breast (SIR=1.46, 95% CI [1.22, 1.74]). Females had an overall increased risk of metachronous cancers in the first 5years after CMM diagnosis (SIR=1.54 at 6–11months and 1.37 at 1–5years).

Conclusion: Among CMM survivors, the risk of metachronous non-skin cancers is higher than in the general population and differs significantly by sex. These results encourage sex-tailored interventions for metachronous secondary cancer prevention.

KEYWORDS

cutaneous melanoma, multiple cancers, second primary cancer, subsequent primary cancer, metachronous cancer, synchronous cancer

Introduction

Over the last few decades, we have seen a constant increase in cutaneous malignant melanoma (CMM), particularly among fair-skinned populations (1). Accounting for 5.6% of all newly-diagnosed cancer cases, CMM is currently the fifth most common type of cancer worldwide (2).

In the United States alone, the incidence of CMM went from 7.9/100,000 in 1975 to 25.3/100,000 in 2018, more than a 320% increase. In Italy in 2020, CMM was the third most common malignancy, with 14,900 new cases and a 5 year survival rate of 88% for men and 91% for women (3). In the same year, 169,900 people were living with a positive CMM diagnosis (3).

In CMM, as with other cancers, long-term survivors risk subsequent malignancies due to both host-related and environmental risk factors (4–6). A previous meta-analysis addressing the risk of developing subsequent cancers in CMM survivors showed an overall increased cancer risk of 1.57 (95% CI [1.29, 1.90]) (5). The most involved secondary primary sites were as follows: soft tissue, non-melanoma skin cancer, bone, non-Hodgkin's lymphoma, kidney, prostate, female breast and colon-rectum (5).

Although the increased risk of developing second primary cancers in CMM survivors is known, we still need to analyze the different temporal onset patterns of subsequent malignancies, including a gender-based point of view. Also, studies on multiple primary cancers may provide powerful insights into cancer etiology, including the cancer-promoting role of environmental and genetic risk factors, and may offer the clinical rationale for developing secondary prevention strategies (including counseling), as well as decision-supporting tools. The current retrospective population-based study differentially assesses the risk of synchronous and metachronous cancers in a cohort of CMM survivors stratified by sex.

Methods

Study population

In Northeast Italy, the Veneto region covers approximately 18,345 square kilometers, with a resident population of over 4.8 million (7). Mortality, measured by the standardized death rate, is lower than the national average (7.9 vs. 8.2 per 1,000 inhabitants in 2016) (8) with the main causes of death represented by cancer and cardiovascular disease (9). The Regional healthcare system is based on the fundamental values of universality, free access, freedom of choice, pluralism of supply and equity (9).

Data sources

Data for the study were retrieved from the population-based dataset in the Veneto Cancer Registry ("*Registro Tumori Veneto*" [RTV]), which was first established in 1987. The population coverage increased from 1,154,000 inhabitants in 1987 to nearly five million (encompassing the entire regional population) in 2014 (see Supplementary Table S1). The fraction of the population covered by the Registry has risen from 53% in 2008–2013 to 100% (approximately 5 million residents) from 2014 onwards. Supplementary Table S2 shows that the older registration area gave cancer incidence estimates that were comparable with the more modern data available for the whole population.

This retrospective cohort study included all CMM patients diagnosed from January 1st, 1999, to December 31st, 2018. All multiple (synchronous and metachronous) primary malignancies except for skin cancers (melanomatous and non-melanomatous) were considered. An interval time of 6 months from the index-CMM was used to distinguish synchronous (time elapsed ≤6 months) versus metachronous (time elapsed >6 months) multiple malignancies (6, 10, 11).

Statistics

Cancer incidence rates were calculated from the RTV database, stratifying patients by sex, malignancy site, age bracket (0–4, 5–9, 10–14, … 85+ years) and calendar year group (1999–2003, 2004–2008, 2009–2013, 2014–2018). The Standardized Incidence Ratio (SIR) was calculated as the ratio between the observed cancers and the number that would be expected based on the incidence rates for the general population (12). The observed number of cases was defined as the number of all malignancies (excluding melanoma and non-melanoma skin cancers) diagnosed in the cohort. The occurrence of three or more cancers was not investigated, due to its negligible incidence (less than 1% of the general population).

To calculate the expected number of malignancies, the accumulated person-years at risk (PY) was multiplied by the rates to be expected if CMM survivors experienced the same cancer rates as the general reference population. The PY were defined as the period between a patient's melanoma diagnosis and one of these following events: a second cancer diagnosis, death, or the end of the period considered (i.e., December 31st, 2018). Byar's accurate approximation to the exact Poisson distribution was used to calculate 95% confidence intervals (95% CI) (13). The Benjamini and Hochberg False Discovery Rate correction was adopted to adjust for multiple comparisons (14). To assess the true excess of burden of second cancers in the population of CMM survivors, the Absolute Excess Risk (AER) per 1,000 PY was also obtained using the formula:

$$[(\text{observed number} - \text{expected number}) \div \text{PY}] \times 1{,}000.$$

Results were deemed statistically significant at the $p < 0.05$ level. The Multiple Primary – Standardized Incidence Ratios session of SEER*Stat 8.4.0 (a publicly-available, interactive, Windows-based program produced by NCI) was used for the analysis (15).

Results

Between January 1st, 1999 and December 31st, 2018, 9,726 CMM patients (M = 4,873, $F = 4{,}853$) were retrospectively considered. In 65,046 PY, 833 s malignancies (92 synchronous and 741 metachronous) were recorded.

Both synchronous (M:F = 61:31, $p = 0.0018$) and metachronous (M:F = 412:329, $p = 0.0018$) malignancies were more common among males.

The overall Standardized Incidence Ratio (SIR) was 1.84 (95% CI [1.48, 2.26]) for synchronous and 1.12 (95% CI [1.04, 1.21]) for metachronous malignancies. The Absolute Excess Risk (AER) per

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1,000 PY was 8.93 (95% CI [4.00, 13.85]) for synchronous and 1.33 (95% CI [0.12, 2.54]) for metachronous cancers.

Synchronous cancers

Irrespective of the cancer site, the SIR of synchronous cancers was higher than expected in males (SIR = 1.90, 95% CI [1.45, 2.44]) and females (SIR = 1.73, 95% CI [1.17, 2.45]) (Table 1).

Both sexes featured an increased risk, compared to the general reference population, of synchronous kidney/urinary tract cancer (SIR in males = 6.99, 95% CI [3.35, 12.86]; SIR in females = 12.11, 95% CI [4.42, 26.36]). Females also had an increased risk of synchronous breast cancer.

Metachronous cancers in males

Between the 7th month and the end of the 12th month, the SIR of metachronous cancers was 1.29 (95% [CI 0.92, 1.78]), while from the 13th to the 60th month from the CMM index, and the SIR was 1.01 (95% CI [0.86, 1.17]).

For metachronous cancer sites, the SIRs for prostate (1.35, 95% CI [1.12, 1.61]) and thyroid (3.51, 95% CI [1.87, 6.01]) cancers were significantly higher than expected (Table 2). Consistent results were obtained when the Absolute Excess of Risk (AER) per 1,000 PY was assessed (prostate: 1.10, 95% CI [0.11, 2.10]; thyroid: 0.33, 95% CI [0.05, 0.61]).

The SIR of metachronous prostate cancer was higher in the 13–60 month interval (SIR = 1.36, 95% CI [1.02, 1.78]). Similar findings were also obtained for thyroid malignancies (SIR in the interval time of 7–12 months = 11.75, 95% CI [2.36, 34.37]; SIR in the interval time of 1–5 years = 3.16, 95% CI [1.02, 7.38]).

Metachronous cancers in females

Regardless of the cancer site, both SIR (1.27, 95% CI [1.14, 1.41]) and AER per 1,000 PY (2.19, 95% CI [0.71, 3.67]) showed an increased risk of metachronous malignancies. Between the 7th and the end of the 12th month and from the 13th to the 60th month, the SIR for metachronous cancers were 1.54 (95% CI [1.01, 1.44]) and 1.37 (95% CI [1.16, 1.62]), respectively (Table 1).

When considering individual cancer sites, breast (SIR: 1.46, 95% CI [1.22, 1.74]) kidney/urinary tract (SIR: 2.27, 95% CI [1.29, 3.68]), and hematological (i.e., non-Hodgkin's lymphoma [NHL] SIR: 2.06, 95% CI [1.24, 3.21]) featured significantly higher SIRs. The AER of metachronous breast cancers was 1.25 (95% CI [0.36, 2.15]), while the AER per 1,000 PY for kidney/urinary tract (0.28, 95% CI [0.01, 0.58]) and for NHL (0.31, 95% CI [0.02, 0.63]) were not significant.

The SIRs of metachronous breast cancer were found to be significantly higher in the 13–60 month interval (1.54, 95% CI [1.16, 2.01]) as well as more than 10 years after diagnosis (1.55, 95% CI [1.04, 2.23]). Similarly, the SIRs of metachronous kidney/urinary malignancies were also significant at 7–12 months from diagnosis (6.47, 95% CI [1.30, 18.89]).

Discussion

This population-based cohort study analyzed data for 9,726 CMM survivors and found that the risk for synchronous cancers increased in both sexes, irrespective of cancer site. An excess risk for synchronous kidney/urinary tract malignancies was detected in both sexes, while women also had an increased risk of synchronous breast cancer. Concerning metachronous cancers, male survivors had a higher risk of thyroid and prostate malignancies, while females had an increased risk of kidney/urinary tract cancer, non-Hodgkin's

TABLE 1 SIR of second cancers at different time points after a diagnosis of melanoma (significant estimates in bold).

Sex	Second malignancy site	Follow-up time since diagnosis months		Follow-up time interval since diagnosis months				
		Overall (synchronous and metachronous)	Overall (metachronous)	Synchronous	Metachronous			
		≥0	≥7	0–6	7–12	13–60	61–120	120+
Males	Total	1.09	1.03	**1.90**	1.29	1.01	1.05	0.92
	Prostate	**1.37**	**1.35**	1.55	1.69	**1.36**	1.32	1.24
	Kidney/urinary tract	**1.68**	1.26	**6.99**	3.05	1.53	0.52	1.19
	Thyroid	**3.77**	**3.51**	7.29	**11.75**	**3.16**	3.38	1.46
Females	Total	**1.30**	**1.27**	**1.73**	**1.54**	**1.37**	1.15	1.17
	Breast	**1.48**	**1.46**	**1.69**	1.26	**1.54**	1.34	**1.55**
	Kidney/urinary tract	**2.91**	**2.27**	**12.11**	**6.47**	2.10	2.31	1.28
	NHL	**2.12**	**2.06**	3.10	3.31	1.33	2.47	2.44

Skin melanomatous and non-melanomatous malignancies are excluded. NHL, non-Hodgkin's lymphoma.

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TABLE 2 SIR and AER per 1,000 PYs of second metachronous cancers after a diagnosis of melanoma (significant estimates in bold).

Second malignancy site	Males					Females				
	O	SIR	95% CI	AER per 1,000 PY	95% CI	O	SIR	95% CI	AER per 1,000 PY	95% CI
Total	412	1.03	(0.93, 1.13)	0.37	(−1.58, 2.32)	329	**1.27**	**(1.14, 1.41)**	**2.19**	**(0.71, 3.67)**
Oral cavity	8	0.71	(0.31, 1.40)	−0.11	(−0.41, 0.19)	5	1.23	(0.40, 2.88)	0.03	(−0.16, 0.21)
Esophagus	5	0.85	(0.28, 1.99)	−0.03	(−0.26, 0.20)	1	0.65	(0.01, 3.64)	−0.02	(−0.11, 0.08)
Stomach	12	0.83	(0.43, 1.46)	−0.08	(−0.44, 0.27)	6	0.83	(0.30, 1.8)	−0.04	(−0.26, 0.18)
Colon	38	1.00	(0.71, 1.38)	0.00	(−0.59, 0.60)	27	1.15	(0.75, 1.67)	0.11	(−0.33, 0.54)
Rectum	8	0.55	(0.24, 1.08)	−0.23	(−0.56, 0.10)	11	1.41	(0.70, 2.52)	0.10	(−0.17, 0.37)
Liver	12	0.63	(0.32, 1.10)	−0.25	(−0.63, 0.14)	4	0.71	(0.19, 1.81)	−0.05	(−0.24, 0.14)
Pancreas	10	0.69	(0.33, 1.27)	−0.16	(−0.50, 0.18)	14	1.28	(0.70, 2.14)	0.10	(−0.21, 0.40)
Lung	51	0.87	(0.65, 1.14)	−0.27	(−0.99, 0.45)	22	1.20	(0.75, 1.82)	0.12	(−0.27, 0.51)
Bone	1	2.13	(0.03, 11.84)	0.02	(−0.06, 0.10)	1	3.03	(0.04, 16.86)	0.02	(−0.05, 0.09)
Mesotheliomas	2	0.87	(0.10, 3.14)	−0.01	(−0.15, 0.13)	1	1.72	(0.02, 9.59)	0.01	(−0.06, 0.09)
Soft tissue	4	1.75	(0.47, 4.49)	0.06	(−0.11, 0.23)	4	3.03	(0.82, 7.76)	0.08	(−0.06, 0.23)
Breast	1	0.98	(0.01, 5.45)	0.00	(−0.10, 0.10)	126	**1.46**	**(1.22, 1.74)**	**1.25**	**(0.36, 2.15)**
Prostate	**121**	**1.35**	**(1.12, 1.61)**	**1.10**	**(0.11, 2.10)**	–				
Testis	2	1.47	(0.17, 5.31)	0.02	(−0.10, 0.15)	–				
Other male genitalia	1	5.88	(0.08, 32.73)	0.03	(−0.05, 0.10)	–				
Cervix uteri	–					4	1.42	(0.38, 3.64)	0.04	(−0.12, 0.20)
Corpus uteri	–					12	1.03	(0.53, 1.81)	0.01	(−0.29, 0.31)
Ovary	–					8	1.10	(0.47, 2.17)	0.02	(−0.22, 0.26)
Kidney/urinary tract	23	1.26	(0.80, 1.89)	0.17	(−0.27, 0.61)	16	**2.27**	**(1.29, 3.68)**	0.28	(−0.01, 0.58)
Urinary Bladder	42	1.02	(0.74, 1.39)	0.04	(−0.59, 0.66)	11	1.36	(0.68, 2.43)	0.09	(−0.18, 0.36)
Eye	3	4.69	(0.94, 13.7)	0.08	(−0.05, 0.21)	1	2.44	(0.03, 13.57)	0.02	(−0.05, 0.09)
Brain and other CNS sites	3	0.49	(0.10, 1.44)	−0.11	(−0.32, 0.10)	5	1.30	(0.42, 3.02)	0.04	(−0.15, 0.22)
Thyroid	**13**	**3.51**	**(1.87, 6.01)**	**0.33**	**(0.05, 0.61)**	14	1.40	(0.76, 2.34)	0.12	(−0.18, 0.43)
Hodgkin's lymphoma	3	2.42	(0.49, 7.07)	0.06	(−0.08, 0.20)	2	2.06	(0.23, 7.44)	0.03	(−0.07, 0.14)
Non-Hodgkin's lymphoma (NHL)	14	1.05	(0.57, 1.76)	0.02	(−0.34, 0.38)	19	**2.06**	**(1.24, 3.21)**	0.31	(−0.02, 0.63)
Multiple myeloma	2	0.36	(0.04, 1.31)	−0.12	(−0.31, 0.07)	3	0.78	(0.16, 2.28)	−0.03	(−0.19, 0.13)
Leukemia	8	1.01	(0.43, 1.99)	0.00	(−0.27, 0.28)	5	1.00	(0.32, 2.34)	0.00	(−0.19, 0.19)
Myeloproliferative diseases	4	1.36	(0.37, 3.48)	0.04	(−0.14, 0.22)	3	1.27	(0.25, 3.70)	0.02	(−0.12, 0.16)
Myelodysplastic syndromes	2	0.60	(0.07, 2.18)	−0.05	(−0.20, 0.11)	2	1.18	(0.13, 4.25)	0.01	(−0.11, 0.13)

Skin melanomatous and non-melanomatous malignancies are excluded. O: observed cancers.

lymphoma, and breast cancer. Females had also an overall increased risk of metachronous cancers in the first 5 years after CMM diagnosis.

In western populations, the rising incidence of cancer and the increasing number of cancer survivors (which are frequently exposed to adjuvant carcinogenic therapies) has in turn increased the number of multiple primary malignancies (6, 11, 16, 17). Based on the definition applied, the incidence of second primaries varies significantly from 2.4 to 17% (11). An international consensus needs to be reached so that we can make obtaining comparable, clinically valuable information a priority.

By applying SEER's criteria in a cohort of 10,857 CMM survivors, Bradford et al. reported a significantly increased risk for non-melanomatous malignancies, particularly for breast, prostate, and non-Hodgkin's lymphoma (observed to expected ratio [E:O] = 1.10, 1.15, and 1.25, respectively) (18).

In this context, the sex-related incidence of multiple primaries is a critical issue that needs to be investigated further. A US study (on 117,000 CMM patients followed from 1992 to 2006) showed a sex-independent increase of subsequent thyroid cancer, NHL, and chronic lymphocytic leukemia, with a higher risk of second kidney and prostate cancers in males, and a higher risk of breast cancer in females (4).

To delve deeper into the effect of sex on cancer incidence, the current retrospective population-based study assessed data on multiple (synchronous and metachronous) primary malignancies in 9,726 CMM patients stratified by sex and followed up for 65,046 person-years.

Synchronous and metachronous multiple cancers: the clinical impact of the definition

Our study shows that CMM patients carry a greater risk of multiple malignancies within 6 months of the index case. When patients develop a secondary primary cancer, these are categorized as either synchronous or metachronous primaries, depending on the length of time between the two cancers. However, the timeframe considered differs significantly according to SEER and IARC definitions. The SEER database considers any malignancy diagnosed within 2 months from the index cancer as synchronous, while the IARC considers any malignancy diagnosed within 6 months of the index cancer. This enormous nosology inconsistency results in significant differences in the epidemiological profile and the clinical interpretation of multiple primaries.

From an epidemiological viewpoint, inconsistent definitions result in unreliable data interpretation and comparisons. From a clinical viewpoint, real-world experience shows that the two-month interval is too narrow to accomplish all diagnostic/staging cancer procedures, thus increasing the relative number of metachronous malignancies recorded. By expanding the timeframe of synchronous malignancies to 6 months, the IARC definition is more consistent with the natural cancers' history, and also supports the clinical-biological rationale of secondary prevention strategies. Thus, the present study considered all multiple malignancies in different sites diagnosed within 6 months from the index CMM as synchronous.

Synchronous cancers

Consistent with the IARC conventional definition, synchronous cancers may plausibly be considered as side-effects of the diagnostic procedures triggered by the index cancer.

This study documented that the overall risk of synchronous cancers was higher in both sexes, irrespective of the site. Both sexes featured an excess risk for synchronous kidney/urinary malignancies, while females showed a short-term increased "detection" of breast cancer.

Although shared pathogenic risk factors cannot be excluded, the higher incidence of synchronous cancers could also be interpreted as an effect of increased access to the diagnostic imaging procedures that CMM patients undergo during the staging process of the index melanoma. These procedures may lead to the incidental discovery of asymptomatic/undiagnosed tumors in the first month after the index CMM (5, 19–22).

Metachronous cancers in males

Among CMM male survivors, the present findings did not feature any overall excess of metachronous cancer risk. Consistent with previous studies however, male patients did feature an excess risk of metachronous prostate and thyroid malignancies (5). This increased thyroid cancer risk remained higher until 60 months after the index CMM, which could suggest the involvement of cancer-promoting genetic abnormalities (i.e., BRAFv600e, CDKN2A) which could potentially be involved in the pathogenesis of both malignancies (23–26). Due to the small number of tested cases (26), the real pathogenetic impact of these association(s) needs to be further confirmed. Beyond any cancer-prone molecular profile, the significant relationship between CMM and metachronous thyroid malignancies could also result from the increasing incidence of thyroid cancers (papillary and undifferentiated), the detection of which has increased due to more widespread access to diagnostic imaging procedures.

Metachronous cancers in females

If we exclude skin melanomatous and non-melanomatous malignancies, females consistently featured an overall excess of metachronous cancer risk. When looking at single cancer sites, breast, kidney/urinary tract, and hematological (NHL) malignancies also showed a significant excess of risk. This is in line with a previously-reported two-way association between invasive CMM and NHL (27–29). The present findings thus further support the hypothesis that the two malignancies may share similar risk factors (4), such as impaired immunological status (30–32) or genetic susceptibility (i.e., chromosome 9p21 deletion) (33–36).

While the increased risk of synchronous breast cancer likely results from the increased medical surveillance triggered by the CMM staging protocols, the excess of breast cancer risk (which can be confirmed up until 10 years after the index-CMM) also suggests a potential pathogenetic involvement of BRCA2 and CDKN2A mutations (37–40). Thus, performing next-generation sequencing (NGS) analysis could be useful not only in detecting tumor heterogeneity and potentially finding new targetable mutations for systemic drug therapies, but also in verifying potential genetic profiles that could predict metachronous and synchronous tumor risk (41).

Strengths and limitations

An important limitation of the present study is the lack of detailed information on environmental cancer risk factors, including socioeconomic status, genetic variants, and behavioral characteristics: collecting this level of patient-profiling data will be the next frontier of high-resolution cancer registration. Furthermore, only a fraction of

the regional population was covered by the cancer registry in the first few years assessed in this study, which could affect generalizability. Nonetheless, the historical registration area yielded incidence estimates for various cancer sites that were proven to be comparable with those available for the whole population area.

Conclusion

The present study found a significantly increased risk of synchronous and metachronous cancers in survivors of CMM, especially in terms of prostate, thyroid, or kidney and urinary tract cancers in men, and NHL, breast, or kidney and urinary tract cancers in women. Studies on multiple primary cancers may provide powerful insights into cancer etiology, including the cancer-promoting role of environmental and genetic risk factors.

In CMM cancer patients, the results of this study provide the clinical rationale for developing secondary prevention strategies (including counseling), as well as decision-supporting tools. Moreover, in CMM survivors, the present results add clinically helpful information for sex-tailored surveillance protocols. Patients diagnosed with melanoma should therefore remain under surveillance, not only for recurrences but also for new primary melanomas and other cancers.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by Veneto Oncological Institute's Ethics Committee (No. 52/2016). Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

Author contributions

AB, SG, MR, and SM: conceptualization. PF and MZ: methodology, software, and formal analysis. AB, EB, ST, LD, and CR: investigation. MZ: data curation. PF, ST, LD, CR, and SM: visualization. GG and MM: writing – original draft preparation. AB, SM, and MR: writing – editing supervision. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2023.1195458/full#supplementary-material

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Socio-economic inequalities in body mass index among preschool children: do sports programs in early childhood education and care centers make a difference?

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Background: Overweight in childhood is considered to be one of the most serious public health challenges. Many studies have investigated individual-level determinants of children's body mass index (BMI), yet studies exploring determinants at the meso-level are sparse. The aim of our study was to examine how a sports focus at early childhood education and care (ECEC) centers moderates the effect of parental socio-economic position (SEP) on children's BMI.

Methods: We used data from the German National Educational Panel Study and included 1,891 children (955 boys and 936 girls) from 224 ECEC centers in our analysis. Linear multilevel regressions were used to estimate the main effects of family SEP and the ECEC center sports focus, as well as their interaction, on children's BMI. All analyses were stratified by sex and adjusted for age, migration background, number of siblings, and employment status of parents.

Results: Our analysis confirmed the wellknown health inequalities in childhood overweight with a social gradient toward a higher BMI for children from lower SEP families. An interactive effect between family SEP and ECEC center sports focus was found. Boys with low family SEP not attending a sports-focused ECEC center had the highest BMI among all boys. In contrast, boys with low family SEP attending a sports-focused ECEC center had the lowest BMI. For girls, no association regarding ECEC center focus or interactive effects emerged. Girls with a high SEP had the lowest BMI, independent of the ECEC center focus.

Conclusion: We provided evidence for the gender-specific relevance of sports-focused ECEC centers for the prevention of overweight. Especially boys from low SEP families benefited from a sports focus, whereas for girls the family's SEP was more relevant. As a consequence, gender differences in determinants for BMI

at different levels and their interaction should be considered in further research and preventive measures. Our research indicates that ECEC centers may decrease health inequalities by providing opportunities for physical activity.

KEYWORDS

BMI, children, meso-level, sport, early childhood education and care center, pre-school, health equalities

1. Introduction

Worldwide, the proportion of children being overweight has notably increased within the last decades (1). Overweight is defined as abnormal or excessive fat accumulation, which is associated with a higher chance of subsequent overweight, disability, and premature death in adulthood (2, 3). In addition, overweight children suffer from respiratory problems, hypertension, early signs of cardiovascular diseases, and psychological health problems (2, 4–6).

Overweight in childhood is considered one of the twentyfirst century's most serious public health challenges, which is arising from complex interactions between biological, behavioral, socio-environmental, and basic environmental factors (5–9). Despite major efforts to promote weight reduction, early childhood overweight has reached epidemic proportions in high-income countries (10). In 2019, ∼38 million children under the age of 5 years were classified as overweight or obese worldwide (2). In Germany, a representative study has revealed that the percentage of overweight children is 10.8% for 3–6-year-old girls and 7.3% among boys. The prevalence of obesity among 3–6-year-old girls and boys is 3.2% and 1.0%, respectively (11).

In addition to the factors mentioned above, health in early childhood also depends on the socio-economic position (SEP) of the family, which is usually defined by parental education, occupation, and household income (12). In high-income countries, epidemiological studies have consistently shown that children with socio-economic disadvantages (i.e., low family SEP) have disproportionately poorer health outcomes than socio-economic advanced children and are more likely to be affected by childhood overweight (11, 13–16). Since health-related attitudes and behaviors formed at an early age are often carried into adulthood, health inequalities during childhood and adolescence might provide the foundation for health inequalities across the life course (17–20). Therefore, childhood and adolescence are particularly suitable time frames for health prevention and promotion (13, 21, 22).

One of the most effective interventions for childhood overweight is physical activity (23, 24). Preschool age is considered a critical window for the development of young children's physical activity habits (25). Scientists agree that children in these early years should be abundantly physically active through structured and unstructured play (26–28). Movement, play, and sports are of great importance in early childhood education and care (ECEC) centers as they function as a central socialization instance and have a formative influence on the health behavior of preschool children (29–32). Moreover, a sports focus of ECEC centers in the form of specific physical activity programs enjoys great popularity with parents and educators in Germany (33). Thus, ECEC centers represent feasible settings for health interventions, as 92% of children under 6 years of age are cared for in a daycare center in Germany (34). This study, therefore, aimed to examine the independent and interaction effects of family SEP and an ECEC center sports focus on the body mass index (BMI) of preschoolers. As significant gender differences could be expected in the relevance of these factors, all analyses were stratified by sex (35, 36).

Abbreviations: BMI, body mass index; ECEC, early childhood education and care; ISEO, International Socio-Economic Index of Occupational Status; NEPS, National Educational Panel Study; SEP, socio-economic position.

2. Material and methods

Secondary data analysis was performed using data from the German National Educational Panel Study (NEPS) (37) of the Leibniz Institute for Educational Trajectories (LIfBi) at the University of Bamberg. The NEPS is a nationwide representative study with a multi-cohort sequence design. The main objective of the NEPS is the collection of life span data on the development of competencies, educational processes, educational decisions, and returns to education in different contexts. Surveys were carried out with children and their parents, as well as with educators and the institution heads of the ECEC centers. The clustering within ECEC centers makes multilevel analyses to consider the meso-level possible (38). In this study, we used the first wave of Starting Cohort 2 "Kindergarten" (SC2). Of the 2,996 children, 1,891 children (955 boys and 936 girls) from 224 ECEC centers had valid data on relevant variables (see below) and were included in our analyses.

2.1. Outcome: children's BMI

The parents gave information on the weight and height of their children. The BMI was defined by the standard formula: body weight in kilograms divided by the square of its height in meters (kg/m^2). Implausible values were excluded (BMI < 10 or > 100). For children, age needs to be considered since the relationship between body size and weight changes due to growth. Thus, we adjusted all analyses for age (2, 39). As boys and girls also have different BMIs, analyses were stratified for gender.

2.2. Independent variables

2.2.1. Family SEP

Family SEP was included by tertiles (low, middle, and high SEP) from the highest occupational status of the mother or the father in the family, measured by the International Socio-Economic Index of Occupational Status (ISEI 08). The ISEI is an established international index that measures socio-economic status based on educational attainment, occupation, and income (40, 41).

2.2.2. Meso-level: ECEC center with a sports focus

The information on whether an ECEC center had a sports focus or not was given by the institution heads by their answer to the following question with either yes or no: "Does your facility focus on a special field of activity (motor skill activity/movement) in addition to normal pedagogic work?" According to study information, also given in the interviews, an ECEC center was designated as a sports-focused ECEC center, "…, if an essential portion of everyday kindergarten life is used to promote this focus on a regular basis and the staff used for that purpose has the appropriate qualification" (37).

2.3. Covariates

The gender and the age of the child were given by the respondents (37). The respondents also stated the number of siblings in the household (categorized into none, one, two, or more) and their own employment status (full-time, part-time, side job, and unemployed). Migration background was coded if German was not the predominant language spoken at home.

2.4. Analyses

All analyses were stratified by sex, and all tests were considered significant at a p-value of <0.05. All analyses were performed in February 2022 using Stata SE (version 14). The sample characteristics of girls and boys and according to SEP tertiles were compared using the chi-square test or the F-test. Linear multilevel regression analyses (level 1 = children, level 2 = ECEC center) were conducted to calculate the main effects of family SEP and ECEC center sports focus, as well as their interaction, on children's interval-scaled BMI. In addition, predictive margins (delta method) were estimated. To standardize results, BMI was Z-transformed, and all analyses were adjusted for age, migration background, number of siblings (none, one, two, or more), and employment status of the interviewed (full-time, part-time, side job, and unemployed).

3. Results

Of the total 1,891 children from the 224 ECEC centers, 936 were girls and 955 were boys, representing a sufficient sample size for multilevel investigations (42, 43). Of these, 983 children were enrolled in an ECEC center with a sports focus. Children were 5 years old on average (mean = 4.98, SD = 0.34). Table 1 shows an overview of all demographic variables stratified by sex. Boys had a significantly higher mean BMI than girls (boys: mean = 15.59, SD = 3.52; girls: mean = 15.17, SD = 2.44; $p = 0.0025$). There were no significant differences in the other independent variables.

Table 2 depicts children's demographic variables stratified for each SEP tertile. BMI was the highest in the low-family SEP tertile and the lowest in the high-family SEP tertile. Slightly more than half of the examined children in the sample attended an ECEC center with a sports focus (51.98%). There were no differences in the attendance rate regarding the SEP ($p = 0.643$).

The results of the multilevel analysis of the main and interaction effects of family SEP and ECEC center focus on BMI are presented in Table 3. For boys, a significant main effect indicated a generally lower BMI in the middle SEP tertile and in the highest SEP tertile compared to the lowest SEP category. Another main effect showed that boys attending an ECEC center with a sports focus had a lower BMI than boys who do not attend a center with a sports focus. In addition, interactive effects between family SEP and ECEC center sports focus occurred (Table 3). Considering the predictive margins (Figures 1, 2), boys with low family SEP not attending a sports focus ECEC center had the highest BMI, while boys with low family SEP attending a sports focus ECEC center had the lowest BMI. For girls, a significant main effect revealed a generally lower BMI in the middle and high family SEP tertiles compared to the lowest SEP tertile. No association of ECEC center focus or interactive effect emerged for girls. Girls with high family SEP had the lowest BMI in both ECEC center types (with or without sports focus).

4. Discussion

The analysis of 1,891 German preschool children revealed that the BMI of the preschoolers was related to the family SEP. Our results show that boys and girls from lower SEP families had a higher BMI on average. For boys, the sports focus of the ECEC center also played a role. We found that the association between SEP and BMI among boys was moderated by the sports focus of ECEC centers. Visiting an ECEC center with a sports focus appears especially health-promoting for boys from a weaker socio-economic background.

Our analysis showed a social gradient toward higher BMI for socio-economically disadvantaged children for both sexes. However, we found evidence for the relevance of ECEC center sports focus for BMI for boys only. Therefore, it might be speculated that for boys' factors outside the family might be relevant concerning BMI, whereas for girls, the family SEP seems to play a more important role (44). Our finding is all the more surprising considering that girls are known to have more sedentary lifestyles and lower levels of physical activity than boys (45). For this reason, it would be expected that girls within an ECEC will particularly benefit from a specific and consolidated curriculum for the promotion of physical activity.

Regarding socio-economic inequalities in health, surprisingly little is known about factors located at the meso-level since

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TABLE 1 Study population description stratified by sex.

	Total (n = 1,891)		Boys (n = 955)		Girls (n = 936)			
	mean/%	SD/n	mean/%	SD/n	mean/%	SD/n	Test value	P-value
Micro-level								
BMI	15.39	3.04	15.59	3.52	15.17	2.44	9.17	0.0025
Family SEP								
Low	32.63	617	31.41	300	33.87	317	1.599	0.450
Middle	35.91	679	37.07	354	34.72	325		
High	31.46	595	31.52	301	31.41	294		
Covariates								
Age	4.98	0.34	4.98	0.33	4.98	0.35	0.538	0.463
Migration background (yes)	10.74	203	9.74	93	11.75	110	2.001	0.157
Employment status respondent								
Full-time	19.46	368	19.58	187	19.34	181	1.400	0.705
Part-time	41.57	786	41.57	397	41.56	389		
Side job	8.14	154	8.80	84	7.48	70		
Unemployed	30.83	583	30.05	287	31.62	296		
Siblings								
No sibling	22.37	423	21.68	207	23.08	216	0.759	0.684
1 sibling	51.51	974	51.52	492	51.5	482		
2+ siblings	26.12	494	26.81	256	25.43	238		
Meso-level								
ECEC center: sports focus (yes)	51.98	983	50.99	487	52.99	496	0.755	0.385

Test value, F-test for continuous variables and the chi-square test for categorical variables.

previous research on preschool children's BMI has focused predominantly on the micro level (46). One explanation might be the complexity and dynamics of the system studied (47, 48). As a consequence, there is little empirical knowledge about the role of institutions that form a central link between the individual and the macro level in the emergence of patterns of health inequalities in the developmental stages from early childhood to early adulthood (49, 50). This hinders the effective design of institutional interventions to promote better health, which is especially important, as childhood overweight is related to a higher risk of illness in adulthood (e.g., cardiovascular diseases or chronic illness), stigma, reduced self-esteem (51, 52), and a higher psychological stress perception (53). Certainly, the negative consequences of overweight on health do not occur as late as adulthood. Gender differences in the relationship between overweight and social inequality increase with age (54) and can be explained by sex differences (e.g., hormonal balance and neurological factors) and gender differences (e.g., gender-based stereotypes and related parental expectations that influence parenting) (55). Further studies should focus on how these biological and socio-cultural factors interact with the BMI and SEP of children already in preschool age and how ECEC centers can impact these effects in a positive way to prevent health and gender inequalities during the life course.

In addition to the sports focus of the ECEC center, other relevant factors might also be conceivable. For example, the composition of the group, the experience and expertise of the teachers, and the equipment available at the ECEC center might play relevant roles. Thus, further research might reveal other relevant ECEC characteristics.

In addition, further research might investigate which type of supply (e.g., sports courses, swimming, physical activity offers, enrichment of outdoor areas, equipment of the indoor area, or the sheer size of the facility) is related to the greatest increase in physical activity time. In this context, it would be also interesting to investigate whether physical aspects (e.g., area, number of playground equipment, and attractiveness of playground equipment) and social aspects (e.g., staff, qualification, and attitude of staff) interact.

In ECEC centers, a suitable physical activity environment should be created so that preschoolers can develop physical activities. In addition, evidence exists that the amount of physical activity in preschool age positively influences the amount of time people are active in adulthood (56). Wellqualified pedagogical staff promoting physical activity should therefore instruct the children's exercises (57).

It appears advisable that overweight prevention and treatment interventions should address the most disadvantaged groups to not

TABLE 2 Main outcome and correlates at the micro- and meso-level according to socio-economic position (family SEP).

	Family SEP high		Family SEP middle		Family SEP low			
	mean/%	SD/*n*	mean/%	SD/*n*	mean/%	SD/*n*	Test value	*P*-value
Micro-level								
BMI	15.11	2.03	15.16	1.95	15.90	4.45	13.36	<0.001
Covariates								
Age	4.94	0.33	4.99	0.34	5.02	0.35	2.97	0.227
Migration background (yes)	5.88	35	7.51	51	18.96	117	65.57	<0.001
Employment status respondent								
Full-time	18.15	108	20.62	140	19.45	120	50.22	<0.001
Part-time	49.75	296	42.86	291	32.25	199		
Side job	5.21	31	9.13	62	9.89	61		
Unemployed	26.89	160	27.39	186	38.41	237		
Siblings								
No sibling	18.82	112	22.24	151	25.93	160	25.43	<0.001
1 sibling	55.8	332	54.93	373	43.6	269		
2+ siblings	25.38	151	22.83	155	30.47	188		
Meso-level								
ECEC center: sports focus (yes)	53.28	317	50.66	344	52.19	322	0.884	0.643

Test value, F-test for continuous variables and Chi^2 test for the categorical variable.

TABLE 3 Main and interaction effects of ECEC center sports focus and socio-economic position (family SEP) on BMI for boys and girls.

	Boys (n = 955, centers = 223)			Girls (n = 936, centers = 224)		
	Coef.	Std. Err.	*P*-value	Coef.	Std. Err.	*P*-value
Main effects						
Family SEP (ref: Low)						
Middle	−0.635	0.128	<0.001	−0.228	0.093	0.014
High	−0.586	0.134	<0.001	−0.339	0.099	<0.001
Employment status respondent (ref: full-time)						
Part-time	0.057	0.102	0.574	0.075	0.073	0.306
Side job	−0.050	0.151	0.740	−0.049	0.114	0.666
Unemployed	−0.092	0.109	0.401	−0.039	0.079	0.620
Age (years)	−0.065	0.039	0.096	0.006	0.027	0.833
Migration background (yes)	0.507	0.127	<0.001	0.093	0.085	0.273
Siblings (ref: no)						
1 sibling	0.151	0.096	0.116	0.007	0.067	0.915
2+ siblings	0.291	0.110	0.008	0.126	0.079	0.111
ECEC center: sports focus (yes)	−0.067	0.133	<0.001	−0.048	0.092	0.601
Interaction effect						
Middle SEP × ECEC sports focus	0.758	0.179	<0.001	0.057	0.129	0.655
High SEP × ECEC sports focus	0.687	0.186	<0.001	0.127	0.132	0.337

further exacerbate inequalities in weight (58). Effectively tackling overweight, therefore, requires a "proportionate universalism" (59), whereby interventions are delivered at the level that meets the need across the social gradient. In our study, boys in the lowest family SEP tertile seem to benefit most from an ECEC center with a focus on sports. Accordingly, ECEC centers could play a

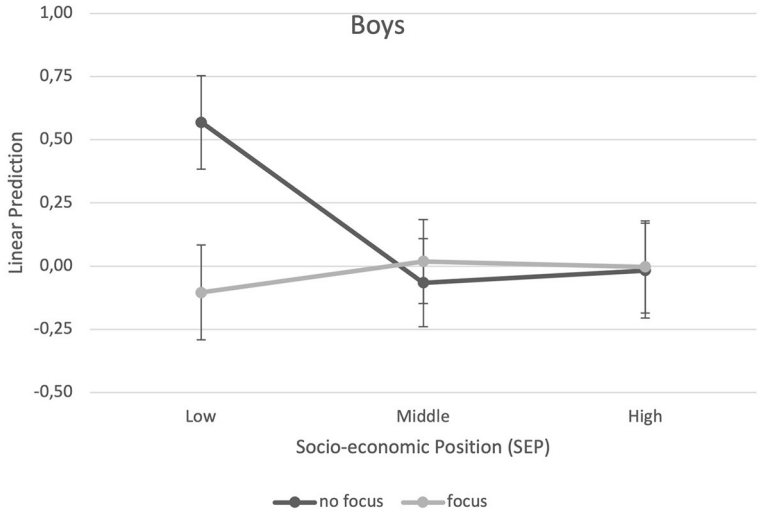

FIGURE 1
Predictive margins of ECEC center sports focus (yes vs. no) and socio-economic position (family SEP) on BMI for boys.

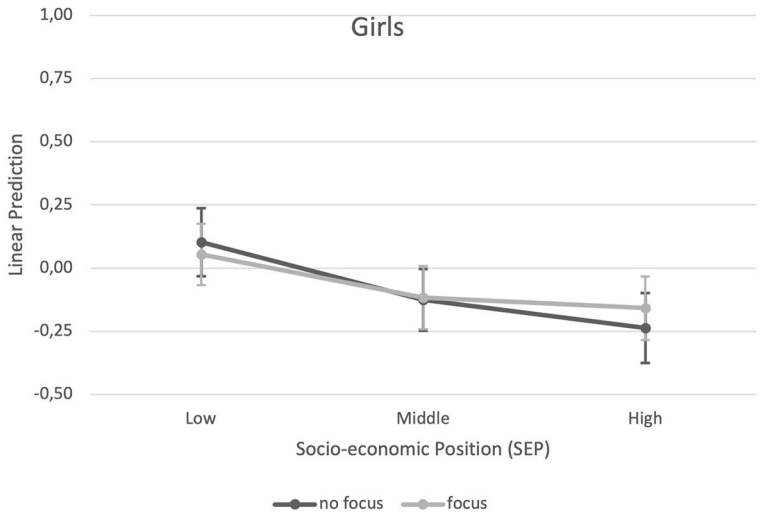

FIGURE 2
Predictive margins of ECEC center sports focus (yes vs. no) and socio-economic position (family SEP) on BMI for girls.

critical role in addressing health inequalities regarding BMI, at least for boys.

All analyses were repeated with an alternative calculation for the BMI in children (60). The standard deviation score of the BMI (SDS BMI) was calculated based on representative data for Germany (61). The SDS BMI is standardized for age and gender and transformed to the value range of a standard normal distribution. This sensitive analysis generally yielded comparable results.

Several limitations have to be considered. Since this was a secondary data analysis, the possibilities for capturing individual and meso-level aspects were limited. In particular, further characteristics of the ECEC would be relevant here. These are usually differentiated into physical (sports equipment, movement areas, and architecture), economic (kindergarten fees), political (curriculum, rules, and timetables), and socio-cultural (attitudes and social norms) characteristics. Whether a child moves a lot or little in an ECEC center is then determined by a complex interplay of these characteristics (62). Another limitation refers to the outcome. The BMI represents a simple index of weight-for-height that is commonly used to classify overweight and obesity. Other measures might appear more suitable in the age of preschoolers, for example, skinfold thickness measurement or waist-to-hip ratio (2). Nevertheless, the BMI has the advantage that it is easy to measure and can therefore also be used with preschool children. However, this indicator does not consider the typical growth spurts in the preschool age group, which can lead to a statistical overshadowing of possible effects of physical activity promotion. In addition, improper body posture and body deformities, which are usually associated with increased BMI and obesity, should be considered in further studies. Furthermore, a

selection effect cannot be ruled out; children who are already more active might be more likely to be enrolled in sports-focused ECEC centers. This means that the variable BMI is potentially endogenous which could bias the analysis. Another source of bias might be in the measurement of height and weight to calculate BMI. As in other large-scale population-based studies, this study used parent-rated data to assess height and weight. These estimates appear, however, less sensitive for underweight and overweight and might bias results (63, 64). Further studies are therefore needed to confirm the findings by applying professionally measured data for weight and height. In addition, it was not considered, whether the children examined lived with only one parent as there is evidence that children of single parents are more physically active and play outside a lot more (65). Future research could also take this aspect into consideration.

In conclusion, this study revealed the importance of daily physical activity for boys regarding their BMI in ECEC centers, especially for boys with low family SEP. Particularly boys from socio-economically disadvantaged families seem to benefit from visiting an ECEC center with a sports focus. However, for girls, no association of the ECEC center sports focus or interactive effects with SEP with BMI was found. Taken together, our analysis indicates that attempts to reduce the social gradient in BMI should take the gender as well as the characteristics of the ECEC center into account as they play an independent and interactive role.

Data availability statement

Publicly available datasets were analyzed in this study. This data can be found here: https://www.neps-data.de/Datenzentrum/Datenzugangswege.

Ethics statement

The studies involving human participants were reviewed and approved by a special data protection and security officer of the NEPS. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

RH analyzed the data. RH and AM interpreted the data. AM, RH, EW, and SS drafted the manuscript. SH, MB, KD, DJ, LS, TK, and MA critically revised the manuscript. All authors read and approved the final manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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Gender as a determinant of physical activity levels and mental health of medical students from Poland and Belarus in the context of the COVID-19 pandemic

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Background: COVID-19 pandemic has brought about unfavourable changes regarding both physical activity (PA) levels and patterns of behaviour associated with mental health. The study sought to assess PA levels and kinesiophobia in medical students from Poland and Belarus taking account of gender.

Methods: A total of 779 students (405 students from University of Grodno (UG), Belarus, and 374 students from John Paul II University of Applied Sciences (ABNS) in Biala Podlaska, Poland) took part in the study. Women constituted 74.2% of the study population. A diagnostic survey as well as two research tools, i.e., the International Physical Activity Questionnaire (IPAQ)—short form, and the Tampa Scale for Kinesiophobia (TAMPA) were employed in the study.

Results: Students from ABNS manifested significantly higher levels of PA. Taking into account gender, male respondents displayed significantly higher levels of MET-min/week (MET—metabolic equivalent of task). As for kinesiophobia, significantly higher levels were demonstrated by students from UG. Its higher levels were also noted among women.

Conclusion: The findings of the study did not reveal strong correlations between kinesiophobia and PA levels in students from Poland and Belarus in the context of different approaches to the pandemic that both countries adopted. Students from ABNS proved to be more physically active. In turn, participants from UG exhibited significantly higher levels of kinesiophobia. Gender was the factor that significantly differentiated levels of kinesiophobia, with women displaying its higher levels.

KEYWORDS

physical activity, COVID-19, kinesiophobia, medical students, gender

1. Introduction

Physical activity (PA) is one of the most important and fundamental human needs that contributes to maintaining and improving health. It helps to prevent and treat non-infectious diseases and exerts a positive influence on mental health, quality of life and well-being (1). Properly administered, it can reduce negative effects of ageing processes and help to maintain full physical, mental and social health for as long as possible (2). Unfortunately, some negative changes in the levels of PA and well-being caused by COVID-19 have been noted recently. After the World Health Organization (WHO) had declared the state of pandemic in 2020 (3), a lot of countries (including Poland) imposed restrictions aimed at reducing the spread of SARS-CoV-2. The restrictions forced people to change their PA habits (4).

Similar to other European Union countries, Poland introduced tough restrictions (lockdown) to prevent the spread of the disease. The approach adopted by Belarus was much less restrictive compared to that taken in Poland. Belarus was one of the few Eastern European countries that did not impose any quarantine. Belarus did not adopt a similar antipandemic strategy, denied the presence of the virus and took no action during the first months of the pandemic. The two countries adopted completely different attitudes to the COVID-19 pandemic, which may have affected PA and kinesiophobia levels in the populations.

1.1. Pandemic background worldwide and in the two studied countries

COVID-19 was first noted in Wuhan (China) in December 2019. It quickly spread to all parts of the world. In most countries, coping with the virus was based on introducing social distancing. The fact that people were forced to stay at home longer had a negative impact on their PA levels (5, 6). Such lifestyle changes caused by the COVID-19 pandemic may have long-term effects on physical and mental health of the population (7). A lot of individuals affected by the disease experienced various emotional, cognitive and physical disorders. These include stress, anxiety, depression, post-traumatic stress disorders and insomnia (8, 9). COVID-19 may also cause stress in individuals directly exposed to the virus, which may result in chronic anxiety and create financial difficulties (10). The factors that may magnify negative consequences of the pandemic include self-isolation, social distance or quarantine (10–12).

While some pandemic-related stressors affect everyone, many have an impact on women in particular (13). Research shows that women experience higher levels of stress, anxiety, depression and post-traumatic stress disorders (14, 15).

Alsalhe et al. (10) confirm that the COVID-19 pandemic exerts a considerable influence on mental health, which is manifested, among others, by anxiety. Simultaneously, they stress the importance of PA in the process of alleviating anxiety symptoms. More and more evidence points to numerous benefits of taking up PA (16). Moderate-intensity PA improves immunological functions and reduces the risk of viral respiratory infections (17).

1.2. Physical activity and mental health

PA seems to be effective when it comes to maintaining or improving physical and mental health particularly during the COVID-19 pandemic. In terms of the population, a number of guidelines and recommendations regarding PA levels have been developed (1, 18, 19). Being physically active brings a lot of benefits to mental health such as preventing the deterioration of cognitive abilities or relieving symptoms of depression and anxiety as well as improving educational achievements. Regular physical activity reduces the risk of cardiovascular diseases, improves muscle and bone mass, reduces pain and fatigue, and improves well-being (20). It also contributes to maintaining proper body mass and fosters well-being (21). The pandemic enhanced the role of providing conditions for and possibilities of being physically active regardless of age, gender, financial status, ethnic origin or PA levels (19). As Global status report on physical activity (19) states, the COVID-19 showed that PA can no longer be perceived as an additional (secondary) element of public policy. The time has come for all countries to formulate a policy that would promote PA as "must have" and to give everyone equal chances of being active (22). Even though it is common knowledge that regular PA improves mental and physical health at every age, currently more than 80% of adolescents and 27% of adults do not meet WHO's recommendations regarding PA (19). Data show that 1.4 billion adults (27.5% of world adult population) do not reach recommended levels of PA (23). What is disturbing is that no improvement has been observed (24).

Considerable differences in PA levels between regions, countries, age groups and gender can be observed (23). In the majority of countries, women are less active than men. When a slight increase in PA levels in adolescents was noted, it was usually among boys, which enhances gender differences in PA that are lifelong (19).

1.3. Physical activity and kinesiophobia

Regular PA performed at a younger age may be a significant motivator for activity at an older age. It can be explained through the continuity theory (25), which states that human beings are inclined to lead the lifestyle as it has been when it comes to leisure time and habits (26). Knapik et al. (27) noted a strong negative correlation between kinesiophobia and habitual physical activity in women aged 60 or older. It points to lower levels of fear of movement in physically active older women.

The issues of physical activity and kinesiophobia, correlations between manifested levels of these variables as well as possible health consequences provided inspiration to carry out the present study.

In the literature of the subject, the term "kinesiophobia" is mainly used to describe an irrational state of fear of movement stemming from previous injuries. A person experiencing it is afraid as they feel susceptible to injuries (28). Anxiety (more or less conscious) accompanies us throughout life, and it is linked to the need of security (29). The term "phobia" is mainly associated with deep anxiety states manifested through psychosomatic symptoms and specific behaviours. In the case of PA, typical phobic symptoms occur quite rarely due to the fact that not taking up PA is treated as avoidance behaviour (30). According to Saulicz et al. (25), we deal with a more or less conscious reaction ("lack of time", "no immediate results") or denial (removing the need for activity from one's awareness).

Kinesiophobia belongs to is a category of avoidance behaviours (31). It should be treated not as fear of pain but as a broader element, i.e., fear of movement-related pain—feeling physical and/or mental discomfort (pain, fatigue, exhaustion, fear of being ridiculed for being unfit, negative perception of particular forms of activity by the society).

It is a manifestation of personality predisposition to physical activity (32). It can be seen as fear of fatigue or exhaustion and, from a psychological standpoint, as fear of being ridiculed for not performing any PA. Socio-demographic factors such as gender may affect kinesiophobia levels (29, 33).

Fear of movement (kinesiophobia) seems to be insufficiently investigated in the context of the COVID-19 pandemic. Most commonly, it is assessed in patients with musculoskeletal pains, spinal pains, degenerative changes in peripheral joints and chronic diseases (34–36). It may contribute greatly to decreasing PA levels and, consequently, to increasing the risk of occurrence of musculoskeletal disorders and chronic diseases (diabetes, cardiovascular diseases) (37). Based on the literature review, Alpalhão et al. (38) noted that kinesiophobia is one of the most important factors determining PA levels.

The study aimed to assess the levels of PA and kinesiophobia in students from two countries in which different approaches to the COVID-19 pandemic were adopted. In Poland, a lot of restrictions were introduced, whereas a completely different approach was favoured in Belarus. Bearing in mind that, from the point of view of mental health, young people (including students) and women may be more susceptible to negative effects of the COVID-19 pandemic (39), the current study sought to assess the levels of PA and kinesiophobia in medical students from Poland and Belarus taking into consideration gender. It involved finding out what (if any) correlations there are between these variables.

2. Materials and methods

2.1. Participants

The study was carried out on medical students from Poland and Belarus. A purposive sampling method was employed—the number of participants and gender distribution were similar in both groups. A total of 779 respondents (374 students from John Paul II University of Applied Sciences (ABNS) in Biala Podlaska, Poland, and 405 students from University of Grodno (UG), Belarus) took part in the study. In both study groups, women (W) constituted the majority of participants. Taking into consideration the age of the respondents, students from UG were younger (Table 1). It stems from the fact that in Poland, students complete their secondary education and begin higher education at a later age.

TABLE 1 Characteristics of the study population taking account of the respondents' age (*N*=779).

Group				Age				Total
				17–20	21–30	31–40	>40	
ABNS	Gender	M	N	19	74	8	4	105
			%	20.0%	35.2%	18.6%	15.4%	28.1%
		W	N	76	136	35	22	269
			%	80.0%	64.8%	81.4%	84.6%	71.9%
	Total		N	95	210	43	26	374
			%	100.0%	100.0%	100.0%	100.0%	100.0%
V Kramer		0.182	12.387[a]	3	**0.006***	**0.005***		
UG	Gender	M	N	93	4	0	0	97
			%	24.9%	12.9%	0%	0%	24.0%
		W	N	281	27	0	0	308
			%	75.1%	87.1%	0%	0%	76.0%
	Total		N	374	31	0	0	405
			%	100.0%	100.0%	0%	0%	100.0%
Phi		0.075	2.249[a]	1	0.134	0.188[c]		
Total	Gender	M	N	112	78	8	4	202
			%	23.9%	32.4%	18.6%	15.4%	25.9%
		W	N	357	163	35	22	577
			%	76.1%	67.6%	81.4%	84.6%	74.1%
	Total		N	469	241	43	26	779
			%	100.0%	100.0%	100.0%	100.0%	100.0%
V Kramer		0.107	8.928	3	**0.030***	**0.030***		
Coefficient		Value	Chi-squared	*df*	*p*	*p* Monte Carlo		

*Statistically significant differences at $p < 0.05$.

2.2. Methods

A diagnostic survey as well as three research tools, i.e., the International Physical Activity Questionnaire (IPAQ)—short form, the Tampa Scale for Kinesiophobia (TAMPA) and the authors' own questionnaire regarding respondents' socio-demographic data were employed in the study. Due to the issues discussed, research results were analysed with regard to gender.

IPAQ short form consists of seven questions concerning types of PA which constitute elements of everyday life (moderate-to-vigorous PA, walking and time spent sitting). The questions refer to PA performed in the last 7 days. Activities done for at least 10 min at a time are taken into consideration. Total energy expenditure is calculated by multiplying frequency and duration of PA and corresponding intensity expressed in Metabolic Equivalent of Task (MET) units, followed by adding up the obtained results for all activities performed in the last 7 days. MET corresponds to an energy expenditure at rest with an oxygen uptake of 3.5 mL/min/kg of body mass. Three categories (levels) of PA were distinguished, i.e., high, moderate and low (40). In this study, the Cronbach's alpha coefficient for IPAQ was 0.74.

TAMPA was developed by Kori et al. in order to assess fear of movement-related pain or (re)injury (41). This questionnaire consists of 17 items, where each item is assessed on a four-point Likert scale. The total score of the scale ranges from 17 to 68, and scores above 37 point to a high degree of kinesiophobia (42). Internal consistency assessed with Cronbach's alpha was 0.72.

2.3. Study design

The participants' socio-demographic data as well as data on variables of PA were gathered. The respondents were informed about anonymity of data collection. All the participants gave their informed consent to take part in the study. The study was carried out in April and May 2022. The survey questionnaires, i.e., IPAQ, TAMPA and the authors' questionnaire on socio-demographic data (paper version), were completed by the respondents at their place of study, with one of the researchers present. The Bioethics Committee of the ABNS in Biala Podlaska approved the study protocol (Resolution no. 4/2022). This study was conducted within the project 'Physical activity and mental health of medical students from Poland and Belarus in the context of the dynamically changing situation of the COVID-19 pandemic' funded by the National Agency for Academic Exchange (NAWA). The usefulness of the research as well as project outline had been presented in an earlier publication (43).

2.4. Statistical analysis

The data collected were analysed using SPSS 17.0 (Softonic, Ashburn, VA, United States). Quantitative variables were presented taking into account mean $\overline{x}$, median, standard deviation (SD), ranges and 95% confidence intervals. Categorical variables were presented as percentage and the number of units from the same group.

To calculate qualitative data, correlation coefficients based on the chi-squared test, i.e., Phi and V Kramer, were used. Comparative analysis between groups ABNS and UG was performed using the *t*-test for independent samples. In order to determine effect size, weighted standard deviation was used as a denominator in the case of Cohen's *d*. As for Hedges' *g*, summary standard deviation together with correction coefficient were used, whereas for Glass's delta, standard deviation of the control group was applied. Correlations between qualitative variables were calculated using Spearman's rho, which measures the strength and direction of correlations between variables. The coefficient values always range from −1 to 1, and the strength of correlations was classified as follows: 0 to 0.3—weak correlation, 0.3 to 0.5—moderate correlation, and 0.5 to 1—strong/very strong correlation (44). Statistical significance was set at $p < 0.05$. The Cronbach's alpha coefficient was used to measure internal consistency of the results. The coefficient values range from 0 to 1, and the higher the value (closer to 1), the greater the reliability of the scale. In psychometric studies, it is assumed that results above 0.7 point to satisfactory reliability of the scale.

3. Results

Men (M) constituted 25.8% of all the study participants ($N = 779$). This proportion reflects a tendency that women dominate when it comes to attending medical courses in both countries (Table 1). Taking into account gender, significant differences were noted in the whole study population as well as in respondents from ABNS.

The first step to achieve the aim of the study was to determine PA levels in students from Poland and Belarus.

The data presented in Table 2 show that students from ABNS were considerably more active, and the difference was significant. Taking into account gender, significantly higher values of MET-min/week were found in men.

Students who met the criteria of IPAQ for the moderate level of PA constituted the largest proportion of the study population, while high levels of PA were manifested by a third of the respondents. MET-min/week median was 2970.0, which points to considerable involvement of students in broadly understood physical culture. Taking into consideration the place of study, it was noted that students from Poland were more active than their peers from Belarus (Me 3,246 MET-min/week and 2,880 MET-min/week, respectively). However, more students from UG met the criteria of high levels of PA. Detailed data are included in Table 3 and Figure 1.

Assuming that gender may determine PA levels, results presented in Figure 2 show that a larger proportion of men met the IPAQ criteria for the highest level of PA—more than half of the male respondents demonstrated high PA levels. This correlation was observed in students from both universities (Figure 2).

During the COVID-19 pandemic, kinesiophobia was significantly greater among students from UG (the index value >37 indicates its high level). Higher index values were also noted among women, and the difference was significant. Male and female students from ABNS did not manifest high levels of kinesiophobia (Table 4).

The next stage of the analysis involved determining the level of kinesiophobia in students manifesting certain levels of PA (established according to IPAQ methodology). Considering the cut-off point of 37 pts. (with mean index values), it was noted that the respondents demonstrating moderate levels of PA simultaneously displayed high levels of kinesiophobia (TAMPA<37 pts.). Taking median into account, the comparison revealed high index values in

TABLE 2 Differences in MET-min/week taking account of gender and the place of study (*t*-test).

Variable		*N*	$\bar{x}$ (±SD)	*t*	*df*	*p*	Quotient *F* variances	*p* variances
University	ABNS	374	4777.2 (±5197.3)	5.0720	777	0.001***	5.2918	0.001***
	UG	405	3339.6 (±2259.3)					
Gender	W	577	3710.5 (±3443.7)	3.7838	777	0.0002***	2.2999	0.001***
	M	202	4941.9 (±5222.5)					
W	ABNS	308	4281.2 (±4387.5)	3.7628	575	0.0002***	3.9202	0.001***
	UG	269	3212.0 (±2216.0)					
M	ABNS	97	6047.9 (±6708.8)	3.2029	200.0	0.0016**	8.0944	0.001***
	UG	105	3744.7 (±2358.1)					
ABNS	W	269	4281.2 (±6708.8)	2.9852	372	0.003**	2.3381	0.001***
	M	105	6047.9 (±6708.8)					
UG	W	308	3212.0 (±2216.0)	2.0327	403	0.0427*	1.1324	0.4310
	M	97	3744.7 (±2358.1)					

*Statistically significant differences at $p < 0.05$. **Statistically significant differences at $p < 0.005$. ***Statistically significant differences at $p < 0.001$.

TABLE 3 Respondents' PA levels (IPAQ—MET-min/week).

University	PA levels	*N*	$\bar{x}$ (±SD)	Min	Max	*Q*25	Median	*Q*75
Total	High	288	6023.1 (±4718.2)	1537.0	42,768	3190.0	4783.7	7087.8
	Moderate	334	3651.4 (±3244.1)	495.0	31,560	1546.0	2790.0	4358.0
	Low	157	1178.4 (±1066.9)	0.0	6,984	396.0	996.0	1596.0
	Total	**779**	**4029.8 (±4014.7)**	**0.0**	**42,768**	**1530.0**	**2970.0**	**5010.0**
ABNS	High	113	8298.1 (±6284.7)	1584.0	42,768	4551.0	6612.0	10,506
	Moderate	165	4472.2 (±4153.5)	495.0	31,560	1752.0	3492.0	5,832
	Low	96	1157.1 (±1249.9)	0.0	6,984	204.8	822.0	1,638
	Total	**374**	**8298.1 (±5197.3)**	**0.0**	**42,768**	**1386.0**	**3246.0**	**6,426**
UG	High	175	4554.0 (±2400.7)	1537.0	14,398	2777.0	4110.0	5695.4
	Moderate	169	2850.1 (±1646.8)	587.0	11,962	1535.0	2666.0	3770.0
	Low	61	1211.9 (±695.5)	113.0	3,558	763.4	1130.0	1530.0
	Total	**405**	**3339.6 (±2259.3)**	**113.0**	**14,398**	**1676.0**	**2880.0**	**4434.0**

Bold value indicates total PA.

all groups (PA levels) as well as in PA as a whole. In each case, the cut-off point was exceeded. In the case of gender, it was observed that fear of movement-related pain was greater in women—both for the whole study population and with regard to particular universities. However, it is worth noting that the value of the kinesiophobia index in female students from ABNS was below 37 pts.. The respondents from Belarus manifested high levels of fear of movement (Table 5).

Data presented in Table 6 indicate that for the whole study population, gender significantly differentiated both kinesiophobia and PA levels. As for the place of study, in the groups of students both from Poland and Belarus, significant differences between women and men were only noted in MET-min/week. Higher PA levels were observed in men.

In none of the analysed areas (groups) were strong correlations between kinesiophobia levels and MET-min/week found (Table 6). Table 7 shows data defining the strength of correlations between these indices. Both for the whole study population and for participants from ABNS and UG, small effect size was revealed.

4. Discussion

In the current study, an attempt was made at assessing PA levels as well as behaviours related to mental health (kinesiophobia) in two countries that adopted different approaches to the pandemic. When planning our research, we assumed that apart from different systemic activities, gender may constitute a variable determining health-related behaviours regarding physical (in)activity. The findings of our study showed that men displayed higher PA levels during the pandemic. Taking into account different approaches to the pandemic in the countries included in the study, we noted higher values of MET-min/week and lower levels of kinesiophobia in students from Poland.

The COVID-19 pandemic was the time of changes in everyday activities of students. During lockdown, young people spent most of the time at home and they were mainly inactive. They did not socialise enough; they did not have enough social interactions and opportunities to move around freely, which meant more sedentary behaviours (45). According to Huang et al. (46), young people are at

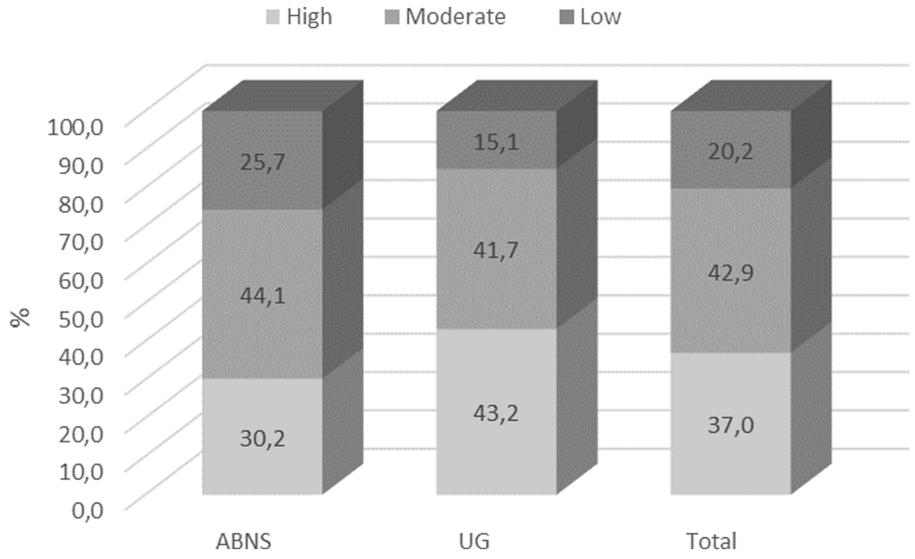

FIGURE 1
Percentage distribution of the respondents' PA levels (IPAQ).

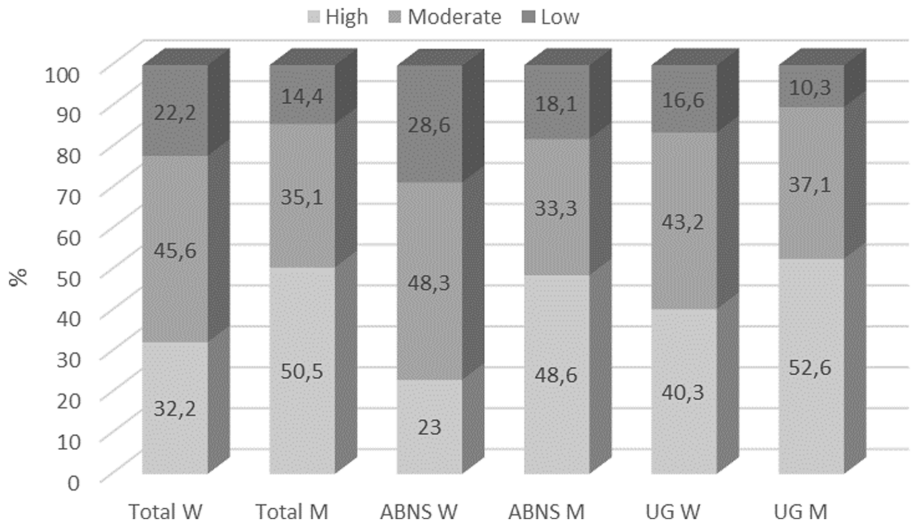

FIGURE 2
Percentage distribution of the respondents' PA levels taking account of gender (IPAQ).

a higher risk of suffering from mental disorders compared to other age groups.

Women are more susceptible to stress and, consequently, some disorders such as anxiety and depression (47, 48). It was confirmed in the case of medical students, where women exhibited higher levels of emotional exhaustion. They also manifested lower perceptions of physical and psychological quality of life as well as higher dispositions for emphatic concern and anxiety (49). It is in line with the findings of the present study, which prove that women demonstrate higher levels of fear of movement-related pain. It is also confirmed by Kluszczyńska et al. (32). They found higher levels of kinesiophobia in female participants compared to their male counterparts. The correlation between kinesiophobia and gender was also observed by Kocjan and Knapik (50). Women demonstrated higher levels of kinesiophobia in the psychological domain.

Qiu et al. (11) attempted to measure psychological distress (anxiety, concern, despair) in the general population of China during the COVID-19 pandemic. They stated that women were more prone to stress and more likely to develop post-traumatic stress disorder.

Due to the fact that PA is a significant element of our lifestyle and it forms the basis for all rehabilitation procedures, the issue of kinesiophobia should not only be thoroughly investigated in terms of theoretical knowledge but also recognised when it comes to particular social groups, situations or patients. There is still a scarcity of data on kinesiophobia in the context of the COVID-19 pandemic. Therefore, we decided to conduct an investigation on the group that was affected significantly by the pandemic (distance learning, limited socialising).

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TABLE 4 Differences in the levels of kinesiophobia taking account of the place of study and gender.

University	*N*	$\bar{x}$ (±SD)	Min	Max	*Q*25	Median	*Q*75	*t*	*df*	*p*	Quotient *F*	*p* variances
ABNS	374	34.70 (±5.72)	19.00	52.00	30.00	35.00	39.00	10.16	777	0.001***	1.141	0.197
UG	405	39.02 (±6.11)	23.00	61.00	35.00	39.00	43.00					
W	577	37.25 (±6.23)	19.00	61.00	33.00	38.00	41.00	−2.25	777	0.024*	1.074	0.526
M	202	36.09 (±6.45)	23.00	56.00	31.00	36.00	40.00					
ABNS W	269	34.99 (±5.80)	23.00	49.00	30.00	33.00	37.00	−1.55	372	0.122	1.129	0.477
ABNS M	105	33.97 (±5.46)	19.00	52.00	30.00	35.00	39.00					
UG W	308	39.22 (±5.91)	23.0	56.0	34.0	39.0	42.0	−1.18	403	0.238	1.276	0.125
UG M	97	38.38 (±6.68)	23.0	56.0	34.0	39.0	42.0					
Total	779	36.95 (±6.30)	19.00	61.00	32.00	38.00	41.00					

*Statistically significant differences at $p < 0.05$. ***Statistically significant differences at $p < 0.001$.

TABLE 5 The levels of kinesiophobia taking account of PA levels and gender.

	PA levels	*N*	$\bar{x}$ (±SD)	Min	Max	*Q*25	Median	*Q*75
Total	High	288	36.66 (±6.24)	20.00	56.00	32.00	37.00	41.00
	Moderate	334	37.37 (±6.47)	19.00	61.00	32.00	38.00	41.00
	Low	157	36.57 (±6.03)	23.00	49.00	33.00	37.00	40.00
	Total	779	36.95 (±6.30)	19.00	61.00	32.00	38.00	41.00
W	High	186	37.19 (±6.04)	20.00	55.00	33.00	38.00	41.00
	Moderate	263	37.53 (±6.56)	19.00	61.00	32.00	38.00	42.00
	Low	128	36.75 (±5.80)	23.00	49.00	33.00	37.00	40.00
	Total	577	37.25 (±6.23)	19.00	61.00	33.00	38.00	41.00
M	High	102	35.69 (±6.16)	23.00	56.00	31.00	35.00	40.00
	Moderate	71	36.80 (±6.15)	23.00	56.00	31.00	37.00	41.00
	Low	29	35.76 (±7.00)	23.00	49.00	30.00	36.00	42.00
	Total	202	36.09 (±6.45)	23.00	56.00	31.00	36.00	40.00
ABNS W	High	62.0	34.97 (±5.03)	20.00	52.00	28.00	36.00	40.00
	Moderate	130.0	34.98 (±5.03)	19.00	49.00	30.00	35.00	39.00
	Low	77.0	35.01 (±5.03)	23.00	47.00	31.00	35.00	39.00
	Total	269.0	34.99 (±5.03)	19.00	52.00	30.00	35.00	39.00
ABNS M	High	51	33.39 (±5.03)	25.00	45.00	29.00	33.00	37.00
	Moderate	35	35.46 (±5.86)	23.00	49.00	31.00	36.00	39.00
	Low	19	32.79 (±5.52)	23.00	45.00	30.00	31.00	37.00
	Total	105	33.97 (±5.46)	23.00	49.00	30.00	33.00	37.00
UG K	High*	124	38.31 (±5.40)	26.00	55.00	35.00	38.50	42.00
	Moderate*	133	40.02 (±6.39)	27.00	61.00	37.00	39.00	44.00
	Low	51	39.37 (±5.59)	28.00	49.00	35.00	39.00	44.00
	Total	308	39.22 (±5.91)	26.00	61.00	36.00	39.00	43.00
UG M	High	51	37.98 (±7.06)	23.00	56.00	32.00	39.00	43.00
	Moderate	36	38.11 (±6.22)	28.00	56.00	33.50	39.50	41.50
	Low	10	41.40 (±6.11)	29.00	49.00	37.00	42.50	46.00
	Total	97	38.38 (±6.68)	23.00	56.00	34.00	39.00	42.00

*Statistically significant differences at $p < 0.05$ between TAMPA values for high and moderate levels in group UG W.

Kinesiophobia may develop in individuals who do not have conditions that would prevent them from taking up PA also during the pandemic (51). Our study focused on medical students, i.e., young people who possess knowledge regarding health promotion and prevention. An interesting thing is that the highest levels of kinesiophobia were found in moderately active individuals (with the exception of UG M).

TABLE 6 Differences in kinesiophobia levels (TAMPA) and MET-min/week (IPAQ) taking account of gender—correlations (Spearman's rho).

University	Questionnaire	Gender	*N*	$\bar{x}$ (±SD)	Standard error of means	*t*-test for mean value equality							Correlations
						t	*df*	*p*	Difference in means	Standard error of dffferences	95% confidence interval for differences in means		
											Lower	Upper	
Total	TAMPA	M	202	36.09 (±6.45)	0.45	−2.26	777.00	**0.024***	−1.16	0.51	−2.17	−0.15	−0.07
		W	577	37.25 (±6.23)	0.26								
	IPAQ	M	202	4941.91 (±5222.48)	367.45	3.12	264.71	**0.002***	1231.40	394.43	454.78	2008.02	
		W	577	3710.51 (±3443.67)	143.36								
ABNS	TAMPA	M	105	33.97 (±5.46)	0.53	−1.55	372.00	0.121	−1.02	0.66	−2.31	0.27	0.002
		W	269	34.99 (±5.81)	0.35								
	IPAQ	M	105	6047.92 (±6708.81)	654.71	2.50	140.11	**0.014***	1766.67	707.26	368.40	3164.95	
		W	269	4281.25 (±4387.50)	267.51								
UG	TAMPA	M	97	38.38 (±6.68)	0.68	−1.18	403.00	0.238	−0.84	0.71	−2.24	0.56	−0.12
		W	308	39.22 (±5.91)	0.34								
	IPAQ	M	97	3744.68 (±2358.06)	239.42	2.03	403.00	**0.043***	532.64	262.04	17.50	1047.78	
		W	308	3212.04 (±2215.96)	126.27								

*Statistically significant differences at $p < 0.05$.

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TABLE 7 Effect size for independent samples—kinesiophobia levels (TAMPA) and MET-min/week (IPAQ).

University	Questionnaire	Coefficient	Standardiser	Score estimation*	Confidence interval 95%	
					Lower	Upper
Total	TAMPA	Cohen's *d*	6.288	−0.185	−0.345	−0.024
		Hedges' *g*	6.294	−0.184	−0.345	−0.024
		Glass's delta	6.230	−0.186	−0.347	−0.026
	IPAQ	Cohen's *d*	3980.78445	0.309	0.148	0.470
		Hedges' *g*	3984.63206	0.309	0.148	0.470
		Glass's delta	3443.67139	0.358	0.196	0.519
ABNS	TAMPA	Cohen's *d*	5.716	−0.179	−0.404	0.047
		Hedges' *g*	5.727	−0.178	−0.404	0.047
		Glass's delta	5.812	−0.176	−0.402	0.050
	IPAQ	Cohen's *d*	5143.08336	0.344	0.116	0.570
		Hedges' *g*	5153.48159	0.343	0.116	0.569
		Glass's delta	4387.49711	0.403	0.174	0.630
UG	TAMPA	Cohen's *d*	6.105	−0.137	−0.366	0.091
		Hedges' *g*	6.117	−0.137	−0.365	0.091
		Glass's delta	5.914	−0.142	−0.370	0.087
	IPAQ	Cohen's *d*	2250.62521	0.237	0.008	0.465
		Hedges' *g*	2254.82458	0.236	0.008	0.464
		Glass's delta	2215.96223	0.240	0.011	0.469

*0.2—small effect, 0.5—medium effect, and 0.8 and above—large effect.

Kinesiophobia levels in our study participants were linked to the time spent performing PA per week. High levels of kinesiophobia mainly observed in students from Belarus may stem from the fact that the investigation was carried out during the prolonged period of the COVID-19 pandemic and that individuals who had not been very active beforehand were also included in the analysis. Similar conclusions were also drawn by other researchers (51–54). Furthermore, the fact that the virus mutated into a more severe variant (55) may have contributed to higher levels of kinesiophobia in our study participants.

In the study on patients who were infected with SARS-CoV-2, Bahar Özdemir (56) noted a significant correlation between kinesiophobia and low back pain. This observation may indicate that pain increases fear of movement, and thus people become less active, which may constitute a vicious circle. Restrictions introduced during the pandemic (e.g., distance learning) forced our study participants to exhibit sedentary behaviours, which may have led to musculoskeletal pains.

In our study we analysed correlations between kinesiophobia and declared PA levels in students from Poland and Belarus in the context of different approaches to the pandemic adopted in these countries. The study did not show strong correlations between these variables, both in general and in particular groups (countries).

Bargı et al. (57) noted a positive linear correlation between insufficient PA levels and sedentary behaviours in the course of the pandemic. Interesting conclusions were reached by Bertrand et al. (58), who found that during the COVID-19 pandemic, women manifested higher levels of PA. They attributed it to higher motivation among women (peer pressure, weight loss or its maintenance). During the pandemic, a lot of people (men in particular), despite quarantine and restrictions, began to take up various forms of PA in order to strengthen their immune system, improve their mental health and reduce negative psychological effects of the pandemic (59). Bajramovic et al. (60) showed that women manifested lower levels of PA compared to men, which is consistent with our findings. However, the reported PA had a positive effect on students' well-being both among women and men (60). Despite pandemic-related restrictions, the vast majority of students from Poland and Belarus met WHO's recommendations regarding PA (1) Rousset et al. (61) drew similar conclusions with regard to young adult students from France. In the current study, IPAQ showed that respondents from both Biala Podlaska and Grodno manifested moderate and high levels of PA. Students from ABNS displayed significantly higher levels of PA in comparison to their peers from UG. Taking gender into account, significantly higher values of MET-min/week were noted among men. Similar observations were made by Orlandi et al. (62), who claimed that women demonstrated lower levels of PA before lockdown but they did not have a tendency to reduce PA levels during the pandemic to such an extent as men did. The findings of our study, which was carried out when the pandemic was being 'suppressed', point to higher levels of PA among men from both countries.

The introduction of drastic measures caused by the COVID-19 pandemic aimed to prevent the spread of SARS-CoV-2. However, it also produced negative effects such as mental health issues and post-traumatic stress disorder symptoms, avoiding other people, anger, anxiety, frustration, boredom, stigmatisation or financial losses (39, 54, 63, 64) as well as an increase in negative health consequences and routine behaviours like reduced PA (walking, exercising) and increased sedentary behaviours (65, 66). Negative effects of lockdown are linked with the development of unhealthy everyday habits in the population of students manifested by, e.g., decreasing levels of PA. These consequences

should not be ignored when it comes to the health of the population and young people in particular. We agree with Saulicz et al. (25), who stated that insufficient participation in PA at a later stage of life may be linked to high levels of kinesiophobia that appeared during adolescence. Reduced PA during youth produces high levels of kinesiophobia at later stages. Sedentary behaviours that are mainly a consequence of pandemic restrictions may become a permanent element of lifestyle. Research indicates that the COVID-19 pandemic may have a negative influence on PA (67). Restrictions introduced during the pandemic encourage people to stay at home, which increases the amount of time spent sitting and enhances sedentary behaviours. Should similar critical situations occur, special attention must be paid to anti-pandemic policies adopted by governments (closing schools or universities, limiting possibilities of realising sports and recreational programmes, etc.) in order to avoid negative effects not only on physical but also on mental health.

With regard to results presented in the current work as well the findings of the study conducted by Saulicz et al. (68), kinesiophobia is a feature inseparably connected with PA. As for the self-determination theory, high levels of kinesiophobia may create an emotional barrier determining inner motivation to perform PA (68). Interactions between low levels of PA and high levels of kinesiophobia constitute a barrier to getting involved in PA, thus forming the aforementioned "vicious circle".

4.1. Limitation

Like all scientific investigations, our study also has some limitations. One of them is the determination of socio-economic status of the participants. Due to the fact that the study involved students from Grodno and Biala Podlaska, it is difficult to generalise the findings to the whole population in both countries (Belarus and Poland) or to representatives of both genders. Still, we are convinced that they point to a certain trend.

Another limitation of the study is its retrospective and cross-sectional character. The respondents completed the questionnaires at one point in time only, which may have increased the probability of not remembering earlier situations in detail.

Identifying kinesiophobia and dealing with it by taking an individual multidisciplinary approach may lead to an improvement in the quality of life. The present study aimed to assess kinesiophobia and PA in medical students taking account of gender and thereby to provide a better insight into correlations between these variables.

Moreover, it should be stressed that the study did not include peaks of the COVID-19 pandemic in Poland and in Belarus as the aim was to determine the levels of PA and kinesiophobia in the context of the pandemic (effects of the COVID-19 pandemic). A longitudinal study conducted over a longer period of time might have provided more thorough data. However, due to the unpredictability and high dynamics of the spread of SARS-CoV-2, carrying out such research within the project was not possible (final stage of the COVID-19 pandemic).

5. Conclusion

Because of different approaches to the pandemic adopted in Poland and in Belarus, the participation of the students in broadly understood physical culture also differed. Students from Poland proved to be more physically active, which was confirmed by higher values of MET-min/week. In turn, study participants from Belarus manifested significantly higher levels of kinesiophobia. Gender was the factor that significantly differentiated levels of kinesiophobia, with women demonstrating its higher levels.

In the population under study, no significant correlations between kinesiophobia and PA levels taking account of gender were revealed, with the exception of women from UG, who displayed high and moderate levels of PA.

Data availability statement

The data analyzed in this study is subject to the following licenses/restrictions: The data analysed in this article are a database extract from a study carried out under the projket—NAWA Intervention Grants Program (BPN/GIN/2021/1/00084/U/00001). Requests to access these datasets should be directed to JB-K, email: j.baj-korpak@dyd.akademiabialska.pl.

Ethics statement

The studies involving human participants were conducted in accordance with the Declaration of Helsinki. They were reviewed and approved by Bioethics Committee of the ABNS in Biala Podlaska (protocol code 4/2022 18.05.2022). The patients/participants provided their written informed consent to participate in this study.

Author contributions

JB-K, KZ, and AS: conceptualisation, methodology, formal analysis, and writing—review and editing. JB-K, KZ, ES, and AS: investigation and data curation. JB-K and KZ: writing—original draft preparation. JB-K: supervision. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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Chronic conditions and multimorbidity among West African migrants in greater Barcelona, Spain

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Objectives: This study aimed to report the prevalence and identify potential risk factors of chronic conditions among West African migrants living in the greater Barcelona area, Spain, and explore the relationship between years of residence in Spain and chronic disease burden.

Methods: This cross-sectional study included 436 adult African migrants who participated in a community-based hepatitis B virus (HBV) screening and vaccination program (HBV-COMSAVA) in the greater Barcelona area from 21 November 2020 to 22 January 2022. Data were analyzed using standard descriptive statistics and bivariable and multivariable logistic regression.

Results: HBV, non-communicable diseases (NCDs) and metabolic risk factors, and multimorbidity prevalence were 9.17, 20.87, and 4.13%, respectively. Being male or having been previously tested for HBV were associated with higher odds of HBV positivity. Associated risk factors for NCDs and metabolic risk factors included living in Spain for >5 years, being female, and being aged ≥50 years.

Conclusion: The high prevalence of chronic conditions in migrant populations supports a need for early detection strategies and tailored public health interventions that aim to reduce the disease burden imposed on migrants and on health systems in host countries.

KEYWORDS

migrants, hepatitis B virus, metabolic risk factors, multimorbidity, non-communicable chronic disease (NCD)

1. Introduction

As of January 2021, migrants made up about 5.3% of the European Union's (EU) total population with an estimated 23.7 million non-EU citizens living in the EU (1). Spain has the second highest number of resident non-nationals in the EU, with migrants accounting for over 10% (5.4 million people) of Spain's population, and the majority are non-EU citizens (1). Over the past decade, there has been a considerable increase in migration to Europe from countries in sub-Saharan Africa (2). Spain is host to around 1 million African migrants (3).

Host countries with large numbers of migrants must be prepared for the health needs of their incoming populations. Some migrants are disproportionately affected by certain infectious diseases due to a high prevalence of the infection in their country of birth (4, 5). Notably, migrant populations living in the EU/European Economic Area (EEA) who are from countries where hepatitis B virus (HBV) infection is highly endemic, such as in sub-Saharan Africa, are disproportionately affected by HBV (6). While only making up about 5% of the EU's population, migrants from countries where HBV is endemic account for an estimated 25% of all chronic HBV cases in the region (7).

Approximately 257–296 million people are living with chronic HBV infection globally (8, 9). About 1.4 million deaths per year are viral hepatitis related and, of these, nearly half of these deaths can be attributed to HBV alone (6). The prevalence of HBV surface antigen (HBsAg) in the general Spanish population is estimated to be 0.66% (10). However, among migrants who were born in intermediate (HBsAg 2–7%) and high endemic countries (HBsAg ≥8%) and live in the EU/EEA, the prevalence of chronic HBV infection is ∼6% (4). Based on these data, it is estimated that migrants from endemic countries account for almost 40% of all chronic HBV infected cases in Spain (10). One study found that in Spain, African migrants accounted for the highest proportion of HBV prevalence in the population (11). In addition, late presentation to viral hepatitis specialist care is frequent in Spain and 35% of HBV patients who present late to care are foreign-born (12). HBV poses a significant public health burden that can be reduced with vaccination, early screening, and treatment (13, 14).

Multimorbidity, the coexistence of two or more chronic conditions in the same individual, is also an increasingly important public health concern (15, 16), especially due to aging populations and the increase in non-communicable diseases (NCDs) globally (17). In general, NCDs account for 71% of annual global deaths, or 41 million mortalities (18, 19). Chronic conditions, including not only NCDs, but also metabolic risk factors such as obesity, hypertension, and high cholesterol, all contribute to the increase in multimorbidity (15). Furthermore, the burden of multimorbidity is greater in vulnerable populations such as migrants, thus worsening health inequalities (15). The estimated prevalence of multimorbidity among African migrants in Aragon, Spain, in 2010 was 11.7% (20).

Migrants may be at increased risk for overall poor health due to structural and sociocultural barriers which hinder their ability to access and navigate the health system in their host country (21). The issue of underutilization of health care services highlights the need for disease screening in migrant populations and the need for accurate and up-to-date epidemiological data for these populations to inform and implement appropriate public health measures. Data are especially lacking on the prevalence and associated risk factors of chronic conditions for African migrants living in Spain, which are key to the design of relevant targeted health interventions, from which this population could benefit. This study aimed to report the prevalence and identify potential risk factors of chronic conditions among African migrants living in Spain and explore the relationship between years of residence in Spain and chronic disease burden.

2. Methods

2.1. Study design

This research was part of the larger cross-sectional study and community-based hepatitis B screening and vaccination program (HBV-COMSAVA study). This intervention used point-of-care diagnostics in community and faith-based settings in the greater Barcelona area, Catalonia, Spain to identify West African migrants (adults ≥18 years), mainly from Ghana and Senegal, living with HBV. The main objective of the HBV-COMSAVA study was to link migrants to specialist care (22).

2.2. Study population

Convenience sampling was used and participants were recruited from study sites provided by community champions and the Association of Ghanaians in Catalonia (ASGC), The Coordinated Association of Senegalese in Catalonia (CASC), and The Cultural Association of African Muslims in Barcelona (CAAMB). These study sites were mainly located in places of worship and community spaces. Study sites that were affiliated with religious spaces (i.e., churches, mosques) allowed researchers to use ongoing religious services/gatherings in order to perform the intervention, posing a significant advantage for the implementation of an intervention directed at a difficult-to-reach population. Community leaders and champions, who were contacted by the study's community coordinators, made announcements to recruit participants, and those present on intervention days were invited to participate. Interventions took place every 2–4 weeks at different study sites throughout the greater Barcelona area. The inclusion criteria for participation in the study were being 18 years or older, providing written informed consent, and being in possession of a regional public health system health card (CatSalut card) or having received one through an expedited process for this project. Exclusion criteria included being unable to understand Spanish, Catalan, English or any other language used by the health care providers, and/or currently being treated for HBV infection.

2.3. Data collection

After meeting the inclusion criteria and providing informed consent, participants completed an epidemiological survey

consisting of questions regarding sociodemographic variables, HBV-associated risk factors, vaccination status, HBV vaccination criteria, and the presence of any other chronic or acute medical conditions. Once completed, participants were offered a rapid diagnostic test (RDT) (DETERMINE® HBsAg 2, Abbott Laboratories) to screen for HBsAg. This RDT meets the EU regulatory requirements and the WHO International HBsAg Standard with an analytical sensitivity of 0.1 IU/mL (23). A blood sample (140 µl per spot for total of 3 spots) was collected intravenously and spotted onto a plasma separation card (cobas® plasma separation card (PSC), Roche Diagnostics) for analysis in the laboratory. HBV viral load (HBV-DNA) and hepatitis D virus antibodies (anti-HDV) were analyzed among those who were HBsAg+ and HBV core antibodies (anti-HBc) to test for past resolved HBV infection were examined among those HBsAg–. PSCs were transported to Vall d'Hebron University Hospital Laboratory (Barcelona) for analysis 1–7 days after collection. Participants received the results of the RDT on the same day of the intervention. Those who were HBsAg+ were offered a referral to a specialist during their first visit. Laboratory results were communicated during follow-up visits at intervention sites and participants received either post-test-counseling or were offered vaccination against HBV depending on their laboratory results. All patient-reported data collected from the epidemiological survey, human-read RDT results, and laboratory reports from participant blood samples were recorded in an excel database using anonymous patient ID codes. Double entry was used to ensure the accuracy of values.

2.4. Variables

All variables were based on self-reported survey data except HBV infection status results, which were collected based on the human-read RDT result.

Sex was reported as female or male. Age was calculated by the reported year of birth. Age was recategorized into four groups: 18–29 years, 30–39 years, 40–49 years, and ≥50 years. Country of origin was reported by country name and recategorized for analysis into three groups: Ghana, Senegal, and Other African countries (Other). Number of children was reported as a continuous variable and recategorized for analysis into 3 groups: 0–2 children, 3–5 children, and ≥6 children. The survey question for the number of children was added on March 7, 2021, so data for this variable were only recorded for the last 281 participants.

Education status of participants was recorded as the highest level of education they had completed: no education, primary school completed, secondary school completed, university bachelor's degree, vocational/trade school, or university master's degree or higher. For analysis, education was recategorized as no schooling, primary completed, secondary completed, bachelor's degree or higher, and vocational/trade school. For employment, participants were asked to choose one of the following categories: full-time work (40 h per week), part-time work (<40 h per week), recently unemployed (<3 months), unemployed (3–12 months), unemployed (>12 months), autonomous worker, student, or other. For analysis, employment was recategorized as unemployed (non-student), employed, or student/other.

The number of years in Spain was calculated by participants' reported year of arrival to Spain. For analysis, number of years in Spain was categorized as 5 years or less and >5 years to distinguish between newly arrived and non-newly arrived migrants (4).

Body mass index (BMI) (kg/m^2) was calculated as a continuous variable based on self-reported height and weight data. For analysis, BMI was recategorized as underweight (<18.5 kg/m^2), normal weight (18.5–24.9 kg/m^2), overweight (25.0–29.9 kg/m^2), and obese (≥30.0 kg/m^2). The survey questions for height and weight were added March 21, 2021, so data for BMI calculation were only recorded for the last 261 participants. Data for HBV infection status were based on the RDT result, and when applicable, laboratory confirmation. Participants who tested positive for the presence of HBsAg were categorized as having an active HBV infection. Participants who tested negative for HBsAg were categorized as not having a current HBV infection. Participants were asked if they had any other illnesses to report and this information was used to determine if participants had any other chronic condition besides HBV. Chronic conditions were then categorized as a "NCD or metabolic risk factor" (including obesity, hypertension, and high cholesterol) or "other chronic condition." HIV, HCV, or an unspecified STI were categorized as other chronic conditions unless otherwise specified by participant.

Participants who reported unclear or unspecific ailments, such as "itchy eyes," were reclassified as having "no other condition" due to lack of clarity or connection to a specific condition. Participants who reported diseases for which they were already recovered were also reclassified as having no other condition. Participants who reported general symptoms such as back pain without a specific diagnosis were reclassified as having "other health problem." Multimorbidity was categorized based on the coexistence of two or more chronic conditions and included HBV, NCDs and metabolic risk factors, HCV, unspecified STI, and/or HIV and was recorded dichotomously as yes or no. Absence of multimorbidity was defined by the presence of only one or no chronic conditions.

Travel to Africa was recorded as yes or no based on participant's response to having traveled to the African continent in the last year or planning to travel in the next 12 months. Familial HBV diagnosis, maternal HBV diagnosis, and household HBV diagnosis were all recorded as yes, no, or not sure. HBV vaccination status and previous HBV testing were based on participants' answers to ever having been vaccinated for HBV or ever having been tested for HBV, respectively, and were also recorded as yes, no, or not sure. Ever being incarcerated, having tattoos or scarring, and ever having a surgery were recorded as yes or no.

2.5. Data adjustments

Of the 444 individuals surveyed as part of the HBV-COMSAVA intervention, eight participants were excluded from this analysis due to already being in treatment or care for HBV or having an inadequate blood sample for the RDT and/or laboratory results, resulting in a sample size of 436 participants (see Supplementary Figure 1).

2.6. Statistical procedures

The raw data were analyzed with StataCorp statistical software: Release 17 (24). Normal distributions of the quantitative variables were evaluated using histograms and Shapiro-Wilk Test. Baseline characteristics of participants were described and summarized. Missing values were accepted unless >5% of data were missing for a single variable. Means with standard deviation (SD) were reported for continuous variables with normal distribution while medians with 25 and 75 percentiles were reported for continuous variables with non-normal distributions. Frequencies and percentages were calculated for categorical variables. Proportions with 95% confidence intervals were measured to assess the prevalence of HBV and other chronic conditions. Bar charts were used to graphically represent the prevalence of HBV and other chronic conditions across different age groups, sex, and years since arrival in Spain.

Pearson's chi square test or Fisher's exact test where appropriate were used to compare proportions between chronic condition categories for each characteristic. The student's *T*-test was used to compare mean values for continuous variables with normal distribution and Mann Whitney-U test was used to compare means for continuous variables with non-normal distribution. Logistic regression models were applied to determine the associations between HBV, NCDs and metabolic risk factors, multimorbidity and variables of interest (years spent in Spain controlling for age, sex, and educational level if applicable). All variables that had exhibited an association with a *P* value of ≤0.1 in the bivariable analysis were also included in the multivariable analysis. A *P* value of <0.05 was considered statistically significant for all analyses.

3. Results

3.1. Description of study participants

Participants had a median age of 43 (range 19–78). The median number of years residing in Spain was 14 with the majority (337/436, 77.29%) having resided in Spain for more than 5 years. The majority of the study population was male (263/436, 60.32%), had completed secondary level of education (242/436, 55.50%), was employed (289/436, 66.28%), and had recent and/or planned travel to Africa (255/436, 58.49%). Participants were primarily from Ghana ($n = 320$; 73.39%) and Senegal ($n = 100$; 22.94%). The remaining 16 (3.67%) participants were from Mali ($n = 6$; 1.38%), Cameroon ($n = 2$; 0.46%), Niger ($n = 2$; 0.46%), Gambia ($n = 2$; 0.46%), Nigeria ($n = 1$; 0.23%), Benin ($n = 1$; 0.23%), South Africa ($n = 1$; 0.23%), and Egypt ($n = 1$; 0.23%) (Table 1).

3.2. Prevalence of chronic conditions and multimorbidity

A summary of the prevalence of chronic conditions is displayed in Figure 1. The overall prevalence of HBV and NCDs/metabolic risk factors in the population was 9.17% (95% CI 6.79–12.28%) and 20.87% (95% CI 17.30–24.95%), respectively. 1.61% (95% CI 0.77–3.34%) of the 436 participants reported having at least one chronic condition other than HBV or an NCD/metabolic risk factor: 1.61% (95% CI 0.77–3.34%) reported having an unspecified STI, 0.46% reported having HIV (95% CI 0.11–1.82%), and 0.23% reported having HCV (95% CI 0.03–1.62%). 4.13% (95% CI 2.61–6.46%) of all participants reported multimorbidity. HBV accounted for one of the two or more conditions among two thirds ($n = 6$) of participants with multimorbidity. The NCDs and metabolic risk factors reported among the 436 participants and their respective prevalence were hypertension 10.09% (95% CI 7.59–13.30%), obesity 8.05% (95% CI 5.29–12.05%), diabetes 3.67% (95% CI 2.26–5.91%), anemia 2.29% (95% CI 1.24–4.22%), asthma 1.38% (95% CI 0.62–3.04%), migraine 0.69% (95% CI 0.22–2.12%), stroke 0.46% (95% CI 0.11–1.82%), high cholesterol 0.23% (95% CI 0.03–1.62%), and chronic liver disease 0.23% (95% CI 0.03–1.62%).

The fully adjusted model for HBV suggests that males have an increased odds (odds ratio [OR] 3.12, 95% CI 1.34–7.23) of having HBV compared to females (Table 2). It was also observed that the odds of having HBV was higher in those who had previously been tested for HBV (OR 4.05, 95% CI 1.78–9.20) compared to those who had not been previously tested for HBV. There were no significant associations between HBV and years residing in Spain. There was also no significant association found between HBV and age or education level. The fully adjusted model for NCDs/metabolic risk factors suggests that people who have lived in Spain for more than 5 years had an increased odds (OR = 3.48; 95% CI: 1.36–8.88) of having an NCD or metabolic risk factor compared to those who have lived in Spain for 5 years or less. Females had an increased odds (OR = 2.09; 95% CI: 1.20–3.65) of having an NCD or metabolic risk factor compared to males and participants aged 50 and above had a significantly higher odds (OR = 3.83; 95% CI: 1.32–11.09) of having an NCD/metabolic risk factor compared to younger participants aged 18–29 years. There were no significant associations in the fully adjusted model for multimorbidity. Detailed results of the bivariable analysis are available in Supplementary Tables 1–3.

4. Discussion

The overall prevalence of HBV found in this study is much higher than the estimated overall HBV prevalence of 0.52% for Catalonia, Spain (25). This is consistent with studies that have found a higher prevalence among migrants, especially those from HBV endemic countries, than in the general European and Spanish population (7, 10). The prevalence of HBV for men was higher than for women in this study. While current literature supports that male sex is a risk factor for HBV prevalence (26), the differences in sex observed in this study could also be explained by the differences in health-seeking behavior among women and men and the exclusion criteria for participation in our study. In general, women have more health-seeking behavior, especially at the primary care level (27). The participants who were excluded for currently receiving HBV treatment were primarily women and may have been more recently tested (data not reported), perhaps due to antenatal screening in Spain. This hypothesis could be explored in future analyses accounting for how recently women and men were last tested for HBV.

Many of the participants in this sample would not be eligible for HBV treatment in their home countries, since in West Africa

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TABLE 1 Participants' characteristics ($N = 436$) overall and sorted by presence of chronic condition(s) (HBV-COMSAVA study, Spain, 2020–2022).

	Overall ($N = 436$)	HBV ($n = 40$)	NCD/metabolic risk factor ($n = 91$)	Multimorbidity ($n = 18$)	No chronic condition ($n = 182$)
Sex, *n* (%)					
Female	173 (39.68)	10 (25.00)	42 (46.15)	6 (33.33)	59 (32.42)
Male	263 (60.32)	30 (75.00)	49 (53.85)	12 (66.67)	123 (67.58)
Age in years, median (25–75%)	**43 (36–49)**	**40 (36–48.5)**	**47 (40–52)**	**49.5 (45–52)**	**42 (32–46)**
Age groups in years, *n* (%)					
18–29	61 (13.99)	4 (10.00)	6 (6.59)	1 (5.56)	32 (17.58)
30–39	89 (20.41)	15 (37.50)	14 (15.38)	2 (11.11)	46 (25.27)
40–49	191 (43.81)	14 (35.00)	38 (41.76)	6 (33.33)	78 (42.86)
≥50	94 (21.56)	7 (17.50)	32 (35.16)	9 (50.00)	26 (14.29)
Missing values	1 (0.23)	0 (0)	1 (1.10)	0 (0)	0 (0)
Country of origin, *n* (%)					
Ghana	320 (73.39)	31 (77.50)	56 (61.54)	12 (66.67)	112 (61.54)
Senegal	100 (22.94)	9 (22.50)	33 (36.26)	6 (33.33)	58 (31.87)
Other	16 (3.67)	0 (0)	2 (2.20)	0 (0)	12 (6.59)
Years in Spain, median (25–75%)	**14 (7–18)**	**13.5 (7–17)**	**17 (12–19)**	**17 (15–19)**	**14 (5.5–19)**
Years in Spain in groups, *n* (%)					
≤5	92 (21.10)	7 (17.50)	6 (6.59)	1 (5.56)	45 (24.73)
>5	337 (77.29)	31 (77.50)	83 (91.21)	17 (94.44)	135 (74.18)
Missing values	7 (1.61)	2 (5.00)	2 (2.20)	0 (0)	2 (1.10)
Number of children, median (25–75%)	**2 (1–3)**	**2 (2–3)**	**3 (1–3)**	**2 (1.5–3)**	**2 (1–3)**
Number of children in groups, *n* (%)					
0–2	135 (48.04)[a]	13 (61.90)[b]	34 (43.59)[c]	7 (43.75)[d]	89 (49.72)[e]
3–5	100 (35.59)[a]	6 (28.57)[b]	35 (44.87)[c]	5 (31.25)[d]	58 (32.40)[e]
>6	5 (1.78)[a]	0 (0)[b]	1 (1.28)[c]	0 (0)[d]	4 (2.23)[e]
Missing values	41 (14.59)[a]	2 (9.52)[b]	8 (10.26)[c]	4 (25.00)[d]	28 (15.64)[e]
Education, *n* (%)					
No schooling	42 (9.63)	5 (12.50)	14 (15.38)	3 (16.67)	21 (11.54)
Primary completed	87 (19.95)	11 (27.50)	22 (24.18)	7 (38.89)	39 (21.43)
Secondary completed	242 (55.50)	19 (47.50)	50 (54.95)	7 (38.89)	97 (53.30)
Bachelor's degree or higher	50 (11.47)	4 (10.00)	3 (3.30)	1 (5.56)	20 (10.99)
Vocational/trade school	15 (3.44)	1 (2.50)	2 (2.20)	0 (0)	5 (2.75)
Employment, *n* (%)					
Unemployed (non-student)	132 (30.28)	11 (27.50)	27 (29.67)	4 (22.22)	55 (30.22)
Employed	289 (66.28)	29 (72.50)	62 (68.13)	12 (66.67)	120 (65.93)
Student/Other	14 (3.21)	0 (0)	2 (2.20)	2 (11.11)	7 (3.85)
Missing values	1 (0.23)	0 (0)	0 (0)	0 (0)	0 (0)
BMI kg/m^2, median (25–75%)	**26.2 (23.5–29)**	**23.5 (22.1–29.1)**	**29.3 (24.7–30.8)**	**29.7 (26.4–30.1)**	**25.85 (23.6–27.5)**
BMI categories, *n* (%)					
Underweight (<18.5 kg/m^2)	3 (1.15)[f]	0 (0)[g]	1 (1.39)[h]	0 (0)[i]	2 (1.19)[j]

(Continued)

TABLE 1 (Continued)

	Overall ($N = 436$)	HBV ($n = 40$)	NCD/metabolic risk factor ($n = 91$)	Multimorbidity ($n = 18$)	No chronic condition ($n = 182$)
Normal weight (18.5–24.9 kg/m^2)	62 (23.75)[f]	9 (50.00)[g]	13 (18.06)[h]	2 (13.33)[i]	40 (23.81)[j]
Overweight (25.0–29.9 kg/m^2)	77 (29.50)[f]	3 (16.67)[g]	17 (23.61)[h]	5 (33.33)[i]	56 (33.33)[j]
Obese (≥30.0 kg/m^2)	21 (8.05)[f]	3 (16.67)[g]	21 (29.17)[h]	6 (40.00)[i]	0 (0)[j]
Missing values	98 (37.55)[f]	3 (16.67)[g]	20 (27.78)[h]	2 (13.33)[i]	70 (41.67)[j]
HBV related risk factors, *n* (%)					
Travel to Africa	255 (58.49)	26 (65.00)	61 (67.03)	14 (77.78)	117 (64.29)
Tattoos or scarring	7 (1.61)	0 (0)	2 (2.20)	1 (5.56)	4 (2.20)
Previous incarceration	10 (2.29)	0 (0)	2 (2.20)	0 (0)	6 (3.30)
Previous surgery	135 (30.96)	15 (37.50)	31 (34.07)	6 (33.33)	49 (26.92)
Familial HBV diagnosis	36 (8.26)	4 (10.00)	7 (7.69)	1 (5.56)	16 (8.79)
Maternal HBV diagnosis	5 (1.15)	2 (5.00)	2 (2.20)	0 (0)	0 (0)
Household HBV diagnosis	16 (3.67)	0 (0)	2 (2.20)	1 (5.56)	8 (4.40)
Previously vaccinated for HBV	46 (10.55)	4 (10.00)	9 (9.89)	1 (5.56)	19 (10.44)
Previously tested for HBV	79 (18.12)	15 (37.50)	18 (19.78)	6 (33.33)	28 (15.38)

Values are medians or percentages calculated at 95% confidence intervals. Number of children and BMI variables exclude the first 156 and 176 participants of the survey sample, respectively, for whom data was not collected. Reported HBV related risk factor variables' values represent number of "yes" responses.
[a]N=281; [b]N=21; [c]N=78; [d]N=16; [e] N=179;[f] N=261;[g] N=18; [h]N=72; [i]N=15; [j]N=168.
124 participants had missing data for one or more of the chronic condition variables and absence of chronic conditions could not be determined.
BMI, body mass index; HBV, hepatitis B virus; NCD, non-communicable disease.

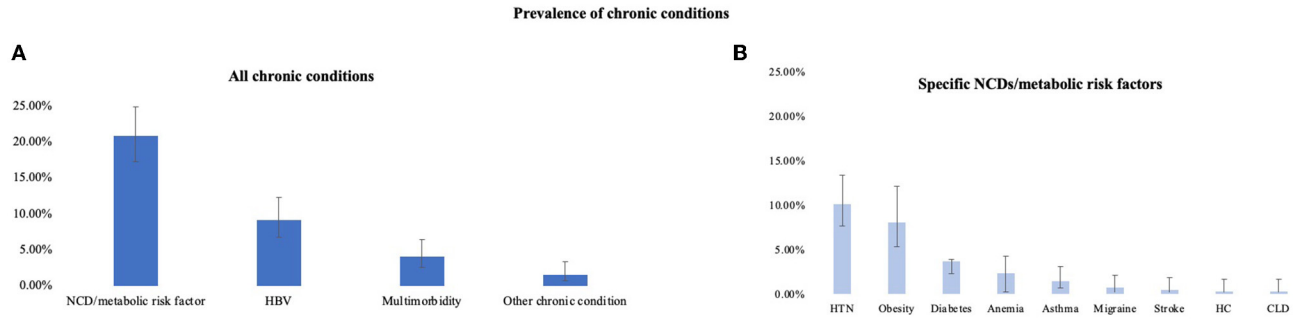

FIGURE 1
Overall prevalence of chronic conditions **(A)** and specific non-communicable diseases/metabolic risk factors **(B)** with 95% confidence intervals. NCD, non-communicable disease; HBV, hepatitis B virus; HTN, hypertension; HC, high cholesterol; CLD, chronic liver disease. Other chronic conditions included HIV, HCV, and unspecified STI. For obesity variable, $n = 262$. (HBV-COMSAVA study, Spain, 2020–2022).

fewer than 1 in 5 people with chronic HBV are eligible for treatment (28). Ineligibility for HBV treatment or previous loss to follow up may explain why previous HBV testing was found to be associated with HBV infection in this study. Participants may have received, but were currently unaware of, a previous HBV diagnosis and not in regular follow-up or treatment for HBV. Hence, they were not excluded from participating in this study.

Among the most prevalent NCDs/metabolic risk factors in this population were hypertension, obesity, and diabetes. Studies have shown that when migrants from non-Western countries migrate to Western countries, they may be more prone to such diseases in their new obesogenic environment (29, 30). Data also show that migrants coming from Africa to Europe are at a significantly increased risk for developing type 2 diabetes (31). The prevalence of NCDs/metabolic risk factors in this study population resembles the patterns seen in the general migrant population in Spain (20) and Ghanaian migrants in Europe (32): morbidity increases with length of time spent in Spain. These chronic conditions and migrants' years of residence in Spain should be carefully considered when planning screening and treatment interventions for migrant populations.

Age is a known risk factor for NCDs (33) and while participants aged 50 and above in this study population were at a greater risk of having an NCD or metabolic risk factor, prevention and control of chronic conditions must be considered for all age groups and genders. There are marked differences in mortality and morbidity between females and males for different NCDs and metabolic risk factors (34). One hypothesis for the observed increased odds of

TABLE 2 Results of the multivariable logistic regression models for quantifying independent effects of sub-group membership on risk of experiencing chronic conditions (HBV-COMSAVA study, Spain, 2020–2022).

Variables included in multivariate models	Hepatits B virus ($n = 40$)			NCD/metabolic risk factor ($n = 91$)			Multimorbidity ($n = 18$)		
	OR	95% CI	*P* value	OR	95% CI	*P* value	OR	95% CI	*P* value
Years in Spain									
≤5 years	1.00 (Ref)			1.00 (Ref)			1.00 (ref)		
>5 years	1.28	0.49–3.30	0.616	3.48	1.36–8.88	**0.009**	2.46	0.30–20.43	0.405
Sex									
Male	3.12	1.34–7.23	**0.008**	1.00 (Ref)			1.00 (ref)		
Female	1.00 (Ref)			2.09	1.20–3.65	**0.01**	0.89	0.31–2.53	0.825
Age									
18–29	1.00 (Ref)			1.00 (Ref)			1.00 (ref)		
30–39	2.31	0.66–8.07	0.19	0.96	0.32–2.88	0.939	0.99	0.08–11.79	0.997
40–49	0.85	0.25–2.93	0.794	1.69	0.63–4.54	0.3	1.51	0.17–13.52	0.711
≥50	0.96	0.24–3.91	0.954	3.83	1.32–11.09	**0.013**	5.18	0.58–45.93	0.14
Education									
No schooling	1.00 (Ref)								
Primary completed	0.95	0.29–3.15	0.937						
Secondary completed	0.52	0.17–1.56	0.242						
Bachelor's degree or higher	0.42	0.10–1.82	0.245						
Vocational/trade school	0.47	0.04–5.03	0.534						
Previously Tested for HBV									
No	1.00 (Ref)								
Yes	4.05	1.78–9.20	**0.001**						
Not sure	1.27	0.45–3.64	0.65						

Statistically significant variables (at level $\alpha < 0.05$) are highlighted in bold. The minimal sufficient adjustment sets applied to this analysis for estimating the total effect of years in Spain on HBV were age, education level, and sex. The minimal sufficient adjustment sets applied to this analysis for estimating the total effect of years in Spain on NCD and metabolic risk factors and on multimorbidity were age, and sex.
CI, confidence interval; OR, odds ratio; NCD, non-communicable disease.

NCDs/metabolic risk factors among women in this study is that women in this population may have been more likely to have an NCD/metabolic risk factor diagnosis due to their previous health-seeking behavior. Additionally, obesity was accounted for in the definition of NCDs/metabolic risk factors, which is highly prevalent in the Ghanaian population, especially among women (17, 35), and could have also contributed to this observed difference.

The prevalence of multimorbidity (4.13%) was relatively low in the study population compared to other studies that have found a prevalence of up to 50% in African migrants living in Europe (17). However, this study was limited by the fact that multimorbidity could not be determined for participants who had missing data for one or more chronic condition categories. There were no significantly associated risk factors to multimorbidity found in this study likely due to having such a limited sample of participants ($n = 18$) with multimorbidity who had information available. Results did show that out of the 18 participants who had multimorbidity, HBV accounted for one of the two or more chronic conditions among six participants (33%). The fact that these participants already had a diagnosed chronic condition highlights the possible missed opportunity for a previous HBV diagnosis during their health system utilization.

4.1. Implications for public health policy

Participants who have been in Spain for more than 5 years had a significantly higher odds of having an NCD/metabolic risk factor compared to newly arrived migrants in this study. Multimorbidity and a high prevalence of HBV and NCDs/metabolic risk factors found in this population suggests that health system utilization is critical upon migrants' initial arrival to Spain. Early detection of chronic conditions can possibly slow progression of disease, reduce mortality, and reduce the burden on health systems that would otherwise result from late detection of chronic conditions. Therefore, interventions should aim to increase linkage to care among newly arrived migrants who may have undiagnosed and/or asymptomatic chronic conditions that will benefit from early

intervention and management. When linked to care, especially at the primary care level, it is also important that routine screenings for chronic conditions include screenings for both NCDs/metabolic risk factors and HBV as to make efficient use of migrants' health system utilization, avoid possibly overlooking certain conditions during their visits, and to ensure health and health care equity for this population.

4.2. Implications for future research

Future studies, with a larger sample size and study population, could offer more robust data into the burden of chronic conditions on African migrants and their health system utilization in Spain. Public health research should also consider relevant risk factors when designing and evaluating community-based interventions for similar populations.

4.3. Limitations

This study had several possible limitations. Firstly, people who were already receiving treatment for HBV were not eligible to participate in the HBV-COMSAVA study. This may have resulted in an underestimation of the prevalence of HBV infection in this population. Since participants were recruited by convenience sampling, this cohort may not be representative and the results of this study may not be generalizable to other points in time or to other West African migrant populations, especially those living outside of the greater Barcelona area. Further studies utilizing random sampling or a cohort study design with longitudinal follow-up rather than a cross-sectional design could provide more robust data on prevalence rates among this population.

Furthermore, the prevalence of NCDs/metabolic risk factors and the prevalence of multimorbidity do not account for potential obesity in 196 participants who were not asked for height and weight information for BMI calculation since these variables were not initially included in the study questionnaire. Additionally, self-reporting of chronic conditions cannot account for patients with undiagnosed conditions. For these reasons, NCDs/metabolic risk factors and multimorbidity prevalence may have been underestimated in this cohort. Also, all survey questions were self-reported and questions about participant histories may have been subject to measurement error bias regarding height and weight data, self-reporting bias, recall bias, and/or social desirability bias.

4.4. Conclusion

This study adds to the limited data available regarding the chronic disease burden in African migrants living in Spain. This study found the prevalence of HBV, NCDs/metabolic risk factors, and multimorbidity were 9.17%, 20.87%, and 4.13%, respectively. Being male or having been previously tested for HBV were associated with higher odds of HBV positivity. Being female, being aged 50 or above, and having lived in Spain for more than 5 years were associated risk factors for having an NCD/metabolic risk factor. These results offer valuable information for designing and evaluating community-based interventions. Specifically, these results highlight the need for early detection strategies and tailored public health interventions that aim to increase healthcare utilization among migrants, reduce the burden of chronic conditions in migrant populations, and reduce the burden on health systems in migrants' host countries.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by Ethical Committee of the Hospital Clínic de Barcelona, Barcelona, Spain (n. HCB/2020/1036). The patients/participants provided their written informed consent to participate in this study.

Author contributions

CP and JL conceived the study and finalized the study with input from MM. Data collection was carried out by CP, MM, DN, and LS. Laboratory analyses were carried out by AS under the supervision of FR-F. Patients were seen by MB, SL, SR-T, JP, and CL. MM wrote the first draft of the manuscript with input from CP. All authors contributed to subsequent drafts of the manuscript and approved it for submission.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships

that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2023.1142672/full#supplementary-material

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"We are in the forgotten corner!" a qualitative study of experiences and challenges among Chinese older women at the onset of acute myocardial infarction

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Background: Acute myocardial infarction (AMI) is a common and serious cardiovascular disease (CVD) that is one of the leading causes of death among women globally and in China. However, there are sex-associated differences and inequalities in the detection and management of AMI, especially in older people. There is little research demonstrating how challenges and barriers affect older women's help-seeking behavior and health-related procedures in China.

Purpose: The objective of this study was to explore the experiences of older women with AMI, focusing on their perception, challenges, and coping strategies at the onset of AMI in Wuhan, China.

Methods: This study utilized a qualitative research design approach and conducted semi-structured, in-depth, and audio-recorded interviews with 18 women aged 65–84 years, purposively selected from two tertiary hospitals in Wuhan City from November 2021 to April 2022.

Results: Interpretative Phenomenological Analysis (IPA) was used in this study to analyze the data on 18 participants and three major themes were generated: disease perception disorder, negative coping strategies, and barriers due to social-environmental contexts.

Conclusion: To reduce older women's delay in seeking help, healthcare professionals should provide public health education that emphasizes sex-related disparities, and age-specific knowledge-attitude aspects to high-risk groups. Policy-based and health administration recommendations, including e-health information support, access to care, and social-environmental factors, should be highlighted to promote women's health behavior.

KEYWORDS

myocardial infarction, gender, experience, challenges, older people, qualitative

Introduction

Acute myocardial infarction (AMI) is an important cause of death globally, causing over 7 million deaths globally each year (1). The morbidity of AMI in China was lower than in Western countries in the past, but changes in social movement and lifestyle have caused a 7.5% increase in cardiovascular disease prevalence in China (2). Additionally, China will experience overall growth and aging of its adult population in the coming decades. According to the results of the Seventh National Population Census in China in 2020, 13.5% of the population is aged 65 years old or above. By 2030, the population is predicted to reach 1.46 billion, with 16% of Chinese citizens being aged 65 years old or above (3). These risk factors significantly increase the incidence of morbidity and disease burden of MI in China (4–6).

In patients with AMI, symptoms and their interpretation are important early indicators of the need to seek medical care. Older people often have atypical clinical manifestations, diversified symptoms, and higher mortality, which make them prone to be misdiagnosed and underdiagnosed, especially in the female population (7, 8). Studies have shown that women's risk of dying during the first 2 weeks after a heart attack is double that of men (9, 10), and delay in seeking medical help (>2 h) is more than threefold higher in women aged ≥65 years compared to other adult women (10, 11).

One meta-analysis research used a qualitative thematic synthesis approach on 21 articles to synthesize the experiences of patients with AMI with delays in seeking treatment and found that decision-making in seeking medical help is a complex social and psychological process. This process included interpreting and evaluating symptoms, which were influenced by cognitive, emotional, and cultural aspects (12). The interpretation of symptoms could influence their behavior of seeking help, and the patients who considered their symptoms to be serious, urgent, and caused by cardiac events tended to seek medical treatment earlier (12–14). Female patients, on the other hand, often lacked familiarity with the symptoms associated with AMI and experienced confusion over the symptoms, which were factors that could be a major barrier to seeking care (13–15).

Dreyer et al. conducted a meta-synthesis of 17 articles on patients' experience after AMI and found that participants had to navigate the emotional reaction, but lacked professional guidance to help them cope with the psychosocial changes in their lives (16). Limited qualitative studies have shown that women adopt more passive coping strategies than men, such as depressive reactions, denial, and minimizing the impact of the disease (17–19). In addition, some research on the medical-seeking decision experiences of patients with AMI did not focus on the female population and few studies have explored the individual nature and inner thoughts of older women in particular (12, 16, 18, 19).

Many older Chinese women prioritize taking care of their partners and children over their own health status, despite having critical chronic diseases. Moreover, the majority of Chinese women undertake the double burden of household duties and work and often interpret symptoms as fatigue from overwork rather than as a painless manifestation of AMI; therefore, they tend to delay seeking treatment, which might cause a pre-hospital delay (10, 20, 21). In addition, studies have pointed out that older women in China tend to seek medical advice from friends and neighbors rather than healthcare professionals or have online consultations (9, 10, 22). Due to China entering an aging society in the year 2000, an increasing number of older people have faced increasing challenges and barriers in the adoption of health care access in the Internet era (23), therefore, psychosocial processes can influence the decision about seeking medical help, and sex-related, age-specific, ethnic, and cultural backgrounds may be significant factors.

Some Chinese researchers studied female patients' knowledge, attitudes, beliefs, and responses to AMI symptoms, and the limited research used qualitative methods to explore the age-specific female experience of AMI, focusing on the perceptions, challenges, thought processes, and coping strategies used by older women in mainland China. Given these issues and using a sample of Chinese older women with AMI, this study aimed to address the following questions: How did Chinese older women describe their experiences and challenges at the early stages of AMI? What kind of factors and barriers could affect their decision-making process in seeking medical care?

Methodology

Design and sample

This study adopted Leventhal's common sense model (CSM) as the theoretical framework, which illustrated that patients could form a preliminary cognitive representation after they were aware of disease threat and health perception, and formulated corresponding action plans to cope based on cognitive representation (24). It was used to understand the interviewees' awareness, emotional response, and behavior regarding health information and experience of coping with illness. As little information about the topic is available in China, a qualitative method with a descriptive phenomenological approach was used to explore the experiences, perceptions, and challenges in older women during the early stages of AMI under the background of the information age.

The target population was inpatients in cardiovascular wards from two tertiary hospitals affiliated with a university in the central part of China. Participants were recruited through purposive sampling. The inclusion criteria were: (1) age ≥ 65 years, (2) women with a medical diagnosis of AMI, (3) mentally competent for communication, (4) able to understand and read Mandarin Chinese, and (5) approximately 24–48 h post admission.

Data collection

A semi-structured interview was held with the participants privately in a single room. The researcher utilized open-ended and reflective questions to probe participants' experiences that pertained to some of the awareness, thought processes, responses, and coping strategies of women with AMI. The following questions were utilized: What were you doing when you felt uncomfortable? What did you think when the symptoms happened? What factors affected your decision to seek help for AMI symptoms? What challenges and barriers did you experience while going to see a doctor? Could you describe your experience of admission to the hospital? What do you know about acute myocardial infarction?

The sequence of the questions was not the same for each participant, depending on the individual interview process and the answers given by the participants. The interview varied according to the issues emerging from the data as the interviews and analysis progressed.

The interviews took 40–55 min and were audio-recorded with the express permission of the participants. Immediately following each interview, contextual information was recorded, such as the participant's manner of speaking and non-verbal behavior. The researcher transcribed each audio recording verbatim.

Data analysis

Interpretative Phenomenological Analysis (IPA) was used in this study to analyze the data (25). IPA focuses on the complexity and process of individual experience and aims to explore how people perceive, understand, and construct health and disease, which is one of the common research methods in phenomenology. It was suitable for understanding individual experiences from the perspective of specific groups in a specific context.

The analysis steps included: (1) Extensively recording open annotated texts, (2) identifying themes from the preliminary annotations, (3) extracting information and naming topics, (4) identifying inter-theme associations, (5) writing characteristic reports and starting the next case analysis, and (6) identifying thematic patterns in individual cases.

After repeated and careful examination of the participants' transcripts by two researchers, major categories and key themes were developed and defined. The interviews were conducted until unique and new themes were no longer identified (26). Each theme was coded and each code was compared with others to identify differences and similarities in all the data. Saturation occurred with the 16th interview, in which all levels of coding were complete and no new theme emerged. Two other interviews were done to ensure saturation.

Quality control

Guba and Lincoln proposed that the trustworthiness and rigor of qualitative research can be measured by four criteria: credibility, dependability, confirmability, and transferability (27). To ensure credibility, one researcher in this study was a nurse with many years of experience in the cardiology department. The researcher obtained the trust of female patients while providing care to them every day; thus, interviews were formed under the relationship of trust, and the credibility and accuracy of the data were greatly improved. In the interview process, the researchers recorded the interview content completely and transcribed it as soon as possible after the interview to form a preliminary description. The transcript would be returned to the female patient for verification and preservation. To enhance dependability, NVivo 11 was adopted to manage the data to facilitate the audit trail. To ensure confirmability, the researchers repeatedly checked and rechecked statements with the interviewees, for example, "Do you mean..." was used to avoid the subjective intervention of researchers during the interview. In this way, the interview data could present as closely as possible the opinions and reasonings of the interviewees. Detailed study procedures, methods, and main characteristics of participants were provided to enhance the transferability of findings across contexts. The interview outline was used to elicit the feelings and experiences of female participants during the early stages of AMI, and the description content was further explored to obtain the essential description.

Ethical consideration

Ethical approval (WHU-2021-YF0010) was acquired by the institutional review board of Wuhan University and its affiliated teaching hospitals before the study. Following site approval from the Department of Cardiology, the researcher invited eligible female patients to participate in the study on an individual and voluntary basis and explained the objective and methods of the study. The patients had the right to withdraw from the study at any time. The audio recording did not begin until the patient's oral and written consent was obtained. The interview was held in a private room to maintain privacy. Confidentiality was assured by anonymously coding all data by numbers. Tapes and transcripts were kept in locked files, which only two researchers could access.

Results

Description of the participants

A total of 18 participants were interviewed, with ages ranging from 65–84 years, with a mean of 70.22 years (SD 4.98). Three participants (16.67%) had received a tertiary diploma and above, six (33.33%) had completed high school education, four (22.22%) had completed middle school education, and five (27.78%) had obtained only a primary school education (see Table 1). All of them were retired, but two were still working full-time in the family business. Among them, two participants were smokers, one drank alcohol every day, and the others had never smoked or drunk alcohol. Of the participants, 4 were widows and lived alone, and 14 lived with their husbands or family members.

Three major themes were generated from the participants' narration and the data analysis, namely, disease perception disorder, negative coping strategies, and barriers to social-environmental context. Several subthemes were also illustrated with quotes (see Table 2).

Disease perception disorder

Failure to recognize atypical symptoms

From their own recollection, the majority of the participants had experienced atypical symptoms, such as nausea, vomiting, weakness, fatigue, sweating, dizziness, dyspnea, jaw pain, back pain, and chest discomfort, but they contributed these signs to gastrointestinal or psychosomatic problems and did not believe these symptoms were associated with a heart attack. One informant (N. 2) said: *"I went to the drug store at once and bought the antacids when I feel sick, vomited, and sweated, I thought I might take some unsanitary food this morning, so I took the medication and went to bed because I felt tired at that time …*

TABLE 1 Basic information of interviewees.

Patient number	Age	Educational background	Marital status	Living with	Delay in hours
1	66	Tertiary	Married	Husband and family member	3.4
2	67	High school	Married	Husband	5.6
3	84	Primary school	Widow	Living alone	13.8
4	72	Middle school	Widow	Living alone	7.9
5	65	Tertiary	Married	Husband	14.3
6	68	High school	Married	Husband	23.1
7	69	High school	Married	Husband	18.9
8	73	Primary school	Widow	Living alone	19.6
9	70	Primary school	Married	Husband	21.4
10	68	Middle school	Married	Husband	16.2
11	70	High school	Married	Husband	9.3
12	72	Primary school	Married	Husband	6.7
13	75	Primary school	Married	Husband	15.4
14	65	Bachelor degree	Married	Husband and family member	21.6
15	68	Middle school	Married	Husband	19.9
16	80	Primary school	Widow	Living alone	35.8
17	69	High school	Married	Husband	24.0
18	72	High school	Married	Husband and family member	15.8

I thought I would be ok after good rest"[*sic*]. Many informants stated that they felt discomfort at the onset of their symptoms, perceiving that "something was wrong," but they did not immediately recognize that discomfort as a heart problem and that they should see a doctor as soon as possible. Another informant, a 72-year-old (N. 12) said*: "I had toothache for nearly 2 days, I did not want to eat anything, the dental problem is a common health problem in old people, my daughter visited me by chance at that day and decided to take me to see a dentist, to my surprise, I was told I had AMI rather than the dental problem*" [*sic*].

Unawareness of cardiac risk

In all, 83.3% of participants said that they never thought they would have a heart attack, even among healthcare workers. One informant (N. 1) said: "I was a retired nurse in a stomatology hospital. I took my health condition seriously; I did physical checkups annually especially the examination of breast cancer and uterine myoma…you know, women were at high risk of these diseases. But I never thought that I would have a heart attack because I am a female and I never smoke, I have a good habit of diet and I do physical exercise every day, my figure is fitness, so I believed I must be tired when I was short of breath and had heart palpitation due to heavy workload"[*sic*]. During data collection and analysis, the study found that many participants lacked awareness about the impact of coronary heart disease (CHD) on women and held stereotypical views that heart attack patients should be overweight, smokers, and middle-aged age men. One participant (N. 6) told the author that she could not trust the physician in the cardiac care unit (CCU) because young physicians might make the wrong diagnosis and that everyone knew AMI was a male disease. She said: "You know, we often heard about well-known actresses or female singers who died from breast cancer or cervical cancer, but we rarely heard about them dying from cardiac attack, which is a male-dominated disease" [*sic*].

Negative coping strategies

Denial

Denial perhaps is one of the most commonly used psychological mechanisms for coping with serious threats and with strong emotional stress. Of the 18 women who took part in the interviews, half of them stated that at the onset of their chest discomfort, they initially denied that symptoms might signify anything serious or could relate to heart problems. *One informant (N. 10) said, "I feel something was wrong, I had a sensation of something pressing on my chest all day, I guess it was going to rain, I decided not to think about it and waited for the symptom disappear, so I had a hot bath and drank some milk and went to bed"* [*sic*]. *Another informant (N. 9) said: "my brother asked me to go to the hospital, he has had two experiences of heart attacks before and he thought my symptom is similar to his, but I do not think so, why me? It is impossible for me to have a coronary disease … I could not accept that I had a heart problem, I will be well after good rest, I think …"* [*sic*]. Some informants told the interviewer that they had not believed what the physician said to them at all at first and that they thought the physician took their symptoms to be more serious than they were. However, they finally believed and accepted that they had had a heart attack after several blood examinations and EKG results.

When cardiac symptoms persisted, a few informants recognized something was wrong, or that their symptoms might be related to the heart, but they used denial and avoidance as coping strategies. Many of the women reported that they often used coping strategies, such as wishing or praying that symptoms would go away, trying to relax, pretending nothing was wrong, and trying not to think about the symptoms when they first noticed their symptoms. *One 65-year-old woman (N. 5) said: "I knew it is possible for a woman has heart disease, but being a woman, it is more likely to get gynecological problems than*

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TABLE 2 Extracting information and naming themes and sub-themes.

Theme 1 Disease perception disorder	
Sub-themes	**Quotes**
Failure to recognize the atypical symptoms	*"I went to the drug store at once and bought the antacids when I feel sick, vomited, and sweated; I thought I might take some unsanitary food this morning."(N. 2)* [*sic*] *"I had toothache for nearly 2 days, I did not want to eat anything, the dental problem is a common health problem in old people… to my surprise, I was told I had AMI rather than the dental problem."(N. 12)* [*sic*]
Unawareness of cardiac risk	*"I never thought that I would have a heart attack because I am a female and I never smoke."(N. 1)* [*sic*] *"We often heard about well-known actresses or female singers who died from breast cancer or cervical cancer, but we rarely heard about them dying from cardiac attack."(N. 6)* [*sic*]
Theme 2 negative coping strategies	
Denial	*"My brother had two experiences of heart attacks before and he thought my symptom is similar to his, but I do not think so, why me? It is impossible for me to have a coronary disease … I could not accept that I had a heart problem."(N. 9)* [*sic*] *"I feel something was wrong, I had a sensation of something pressing on my chest all day, I decided not to think about it and waited for the symptom disappear."(N. 10)* [*sic*]
Incorrect self-help behavior	*"I was sure it was indigestion; I had the same symptom 2 weeks ago… stomached, nausea and diaphoresis, I asked my husband to go to the drug store and buy some promoting digestion medicine for me."(N. 17)* [*sic*]
Ambivalence	*"Although I felt uncomfortable, I did not want to bother others."(N. 8)* [*sic*] *"I do not know how to solve this problem; I am not sure what happened to me.… I could not let my family drop in a mess." (N. 13)* [*sic*]
Theme 3 barriers due to social-environmental contexts	
Lacking professional information support	*"I telephoned my friend when I felt dizziness and sweating.… I followed her advice and waited for several hours, but it did not work…, I should see a doctor earlier." (N. 7)* [*sic*] *"My sister told me she recovered soon after taking this medication; so I went to the drug store with her and bought the same medication, in fact, the medication has no effect on me, I still feel palpitation and weakness." (N. 16)* [*sic*]
Obstacle to online medical services	*"My daughter told me she often registers and consults for the physician online, but I could not use WeChat or web-based platforms like that… Maybe I would receive treatment early if I could finish the online consultation." (N. 11)* [*sic*] *"I do not dare to see the doctor without my son or daughter-in-law; I had to rely on their help. I have to wait until they are free to take me to the hospital."(N. 8)* [*sic*]
Prioritizing family responsibility over seeking help	*"I feel bad yesterday morning, but I did not tell my family member. … Therefore, I told myself I have to tolerate uncomfortably. My family will drop into a mess if my health condition became deteriorated." (N. 18)* [*sic*] *"Why I went to see the doctor so late? … I must take on family and household responsibilities, and I do not want to be a burden on my family." (N. 14)* [*sic*]

have a heart attack. The number of females got heart attacks is few; I thought I will not become one of them, my mother does not have it, and my family members do not have this kind of disease. Therefore, I told myself I was not that sick when I feel chest discomfort, I attributed the discomfort to tiredness and stress these days. The symptoms would go after good relaxation" [*sic*].

Incorrect self-help behavior

In the present study, 72.2% of patients stated that they decided not to immediately seek professional medical care, preferring self-medication instead at the onset of their symptoms. One interviewee (N. 17) said: "*I was sure it was indigestion; I had the same symptom 2 weeks ago… stomached, nausea and diaphoresis, I asked my husband to go to the drug store and buy some promoting digestion medicine for me*" [*sic*]. There were sex-related differences in the symptoms of AMI, and the symptoms of older female patients were atypical, including fatigue, back pain, loss of appetite, palpitation, and dizziness, and self-treatment was diverse, ineffective, and delayed the patients from seeking medical help. Two interviewees had body massages to relieve back pain and fatigue; three interviewees chose to drink red tea to solve ingestion problems and fatigue, and others took painkillers and drank milk to treat toothache and stomachache.

Ambivalence

Though most of the interviewees felt uncomfortable and doubtful when the prodromal symptoms appeared, they were hesitant to see a doctor and tried to delay medical treatment as much as possible to avoid bothering other family members' work and routines. *One informant (N. 8) said: "Although I felt uncomfortable, I did not want to bother others, I live alone, my daughter is busy and has two children to take care of, I would feel sorry for my daughter if she takes care of me rather than her children, but I had a strong bad feeling, I should see a doctor*" [*sic*]. Female patients expressed in the interview that they were more concerned with family responsibilities and obligations than the importance of their own health and tried to keep a balance between the undertaker of family affairs and the role of the care receiver. *One 75-year-old woman (N. 13) said: "What can I do? I do not know how to solve this problem; I am not sure what happened to me. My husband is 81 years old, he will be anxious if he knew I was uncomfortable. We only have one son who worked in another city that is far from here over 500*

kilometers. I could not let my family drop in a mess, maybe it is a false alarm" [*sic*].

Barriers due to social-environmental contexts

Lacking professional information support

Although it is convenient for the participants who live in a city to see a doctor because there are many clinics and community hospitals available in China, Chinese people, especially retired women, traditionally often share health information and seek advice from family members, and friends rather than health professionals when they have an ailment. One informant with type 2 diabetes (N. 7) said: *"I telephoned my friend when I felt dizziness and sweating, she is also a diabetes patient, and she told me I had hypoglycemia and suggest that I should take orange juice or eat a few biscuits. I followed her advice and waited for several hours, but it did not work…actually, I should see a doctor earlier, there is a community hospital nearby my house, I go there by walk for no more than 10 min*" [*sic*]. Another interviewee (N. 16) stated: *"My sister told me she recovered soon after taking this kind of medication; her symptom was similar to me, so I went to the drug store with her and bought the same medication, but, in fact, the medication has not effect on me at all, I still feel palpitation and weakness"* [*sic*].

Obstacle to online medical service

Most large teaching hospitals in China have developed online registration booking systems to provide convenience and quick medical service for clients. However, many older people face difficulties using electronic payment and online registration services. One informant (N. 11) stated: *"My daughter told me she often registers and consults for the physician online, it is save-time and efficient for medical advice and treatment, but I could not use WeChat or web-based platforms like that… this is hard for us older people. Maybe I would receive treatment early if I could finish the online consultation*" [*sic*]. Another 72-year-old woman (N. 4) said: *"I went to the hospital and found I just sit around and do nothing, the nurse asked me to show the electronic registration information, but I did not know how to perform it on my cell phone, so I sit there and waited for the nurse to help me, but many older people need this kind of help, I had to wait and do nothing"* [*sic*]. Some participants complained that hospitals' online registration system is so complex that they could not go to the hospital by themselves. One older lady (N. 8) said: *"I do not dare to see the doctor without my son or daughter-in-law, I had to rely on their help, but they are very busy. I have to wait until they are free to take me to the hospital"* [*sic*].

Prioritizing family responsibility over seeking help

During the interview, most of the informants (77.8%) expressed a strong notion that their work and family role function was influenced by their health status. One 72-year-old woman (N. 18) said: *"Actually, I feel bad yesterday morning, but I did not tell my family member. I have to take care of my husband, he had a stroke 3 years ago, and I also have to do the cooking for my granddaughter, she is studying in middle school and she has lunch at my house every day, so I told myself I have to tolerate uncomfortably. My son and daughter-in-law are very busy; my family will drop into a mess if my health condition became deteriorated"* [*sic*]. Most of the participants expressed that they were not willing to bother others with their health problems because of their own and others' role expectations of family responsibilities. A 65-year-old woman (N. 14) said: *"Why I went to see the doctor so late? You see, this is the end of the year, and my husband is a part-time faculty in college, he has a lot of work to do, a lot of annual summaries and reports to finish. I could not disturb him at that time. My little son is going to have a master entry examination this month which is a very significant moment for him; I must take on family and household responsibilities, and I do not want to be a burden on my family"* [*sic*].

Discussion

Older women's delay in seeking medical help for AMI

According to the results of the Global Burden of Disease Study 2019 (28), cardiovascular disease is the leading cause of death among women, accounting for 35% of all deaths among women. Approximately 25% of women died of CHD in the US, and 50% of women were more likely than men to be initially misdiagnosed at the onset of heart attack symptoms (29). The hospitalization rate of female patients with AMI in China has increased nearly four-fold from 2001 to 2011 (30), and the incidence of in-hospital cardiac death was significantly higher in female patients than in male counterparts (15, 31). The total ratio of major adverse cardiac events (MACE) and mortality during hospital was higher in the older female group than in other adult female groups (10, 15, 30). Cardiovascular disease in women is called a silent killer, it remains underestimated, under-recognized, and under-diagnosed globally and especially in China (2). Reducing pre-hospital delay, early diagnosis, and optimal treatment are widely recognized as critical steps in decreasing mortality from AMI. In this study, the time between the onset of AMI symptoms and admission to the hospital ranged from 3.4 h to 35.8 h, and the mean delay time was 16.26 ± 7.94 h. The result of the study indicated that delays in seeking care in older female participants were related to not recognizing atypical symptoms, denying initial symptoms, holding the incorrect perception of the disease, and inappropriate self-treatment, which is consistent with other studies (14, 32, 33).

Age- and sex-related education programs focus on the knowledge-attitude-behavior aspect

Based on the report from the Lancet Women and Cardiovascular Disease Commission, some significant under-recognized risks, including depression, perceived stress, lower economic status, health literacy, and sociocultural role disproportionately influenced by the sex of the patient, contribute to CVD in women (2). Women's experiences surrounding the onset of AMI symptoms and the decision-making process related to seeking medical help were influenced by several factors, such as psychosocial context and cognitive-emotional response to the symptoms (2, 12, 18, 19, 32). Research has indicated that most women are more likely to believe they are more vulnerable to breast cancer than cardiac disease, whereas the truth is that there is a 31% likelihood that a woman may experience cardiac disease in her life while only a 2.8% likelihood of

her developing cancer (34). In the interviews conducted in the present study, 66.7% of participants reported a difference between the symptoms they experienced and the symptoms expected. The perception that heart disease is a male-dominant health problem is reinforced by the media in China, which often choose middle-aged men as target people in advertisements to arouse public concern about cardiac disease. In addition, as a result of the influence of traditional Chinese culture, breast cancer or gynecological health problems are often thought of as a greater threat to women than heart attacks, and some health professionals and patients still tend to underestimate and under-recognize the cardiac risk in women (32). The result of this research demonstrated that knowledge gaps and cognitive differences in detection, prevention, and access to care for women still exist nowadays (2, 7), which is consistent with the results of other studies (16–19).

Social-environmental factors being involved in the decision about seeking treatment as well as cultural differences might be an aspect influencing health behavior. Very few women are full-time housewives in China, and while most Chinese women have the same workload as men, they spend an extra 2–3 h performing household chores, which is approximately 43.9% more time than men spend in these activities, and 85.3% of women have reported excessive workload and working stress (9, 20, 21). In Chinese traditional culture, as an old famous saying states that "women uphold half of the sky." Chinese women work just as hard as men and have been smoking more than before, with many women interpreting fatigue, weakness, loss of appetite, and palpitation as a result of overworking rather than as painless atypical manifestations at the onset of AMI, which causes a delay in the decision-making time for seeking medical care (32). Some participants said in the interview that they had to take on heavier household and working responsibilities after retirement, meet others' role expectations, and neglect their own ailments or tolerate the discomfort when they were at the onset of symptoms. Sutantri et al. (19) found that their sample of women avoided telling relatives about their physical discomfort out of concern for others and for fear of not being allowed to undertake what they perceived as their normal household roles.

Most participants in the interview expressed that they lacked information on cardiovascular disease in the female population and the majority of them obtained information from friends, relatives, advertisements, and television. Chinese media often choose men for representations of typical crushing chest pain in TV or advertisements, which could mislead awareness and perception of heart disease among the female population. Media plays a significant role in highlighting factors and behaviors that affect health outcomes. Research suggested that women still have worse outcomes than men after heart attacks and the highest rates of mortality shift from men to women especially those with lower social-demographic indexes. In addition, women were more likely to be susceptible to health resource disparities, access to care, and continuity of treatment than men (5, 35, 36).

In the present study, only one participant directly called a health professional and called up emergency medical service (EMS), whereas the other participants tended to seek advice from family members or friends. Zhang et al. (9) undertook a study of 803 patients with AMI who were admitted to 21 hospitals in China and discovered that although guidelines strongly recommend the use of EMS by patients with AMI, only 39.5% of patients called up the EMS at the onset of symptoms and only 13.1% of female patients utilized EMS, which is one of the reasons of the pre-hospital delay in female patients. Yin et al. (37) used face-to-face individual interviews in Guangdong Province to explore patient-level and system-level barriers associated with delay in AMI treatment and found patient-level barriers included poor knowledge in recognizing AMI symptoms and not calling EMS when symptoms occurred. Future intervention strategies are imperative to strengthen publicity and health education, promote MI patients' health behavior by using EMS timely, and increase EMS capacity to improve health outcomes.

Help the older population adopt mobile health technology

Adequate health literacy is related to detecting and managing disease risk and contributes to good health behavior and utilization of healthcare services. With the advent of the information age, e-health literacy is becoming more imperative. E-health literacy refers to the ability of individuals to utilize emerging information and communication technology to improve health outcomes and access to healthcare services. The survey by Li et al. (22) showed that the qualified rate of e-health literacy among 1,201 older adults was 11.1% and that inadequate e-health literacy contributed to poor health outcomes and low utilization of healthcare services.

Almost every participant in the interview process of the present study mentioned the difficulties and challenges they encountered in completing medical service procedures online, such as appointment booking, service guidance, and report checking. These measures were considered very convenient, time-saving, and efficient in the younger patients group, but for the older population, it was a big challenge. With mobile technology, most tertiary hospitals in China are trying to improve smart systems of medical service, registration, and treatment to decrease people gathering, reduce waiting time, and improve the medical service experience. Online registration has become the mainstream way to make appointment bookings including the use of hospitals' mobile apps, WeChat official accounts, and other online booking systems, but it can be a barrier for older people who might not be as familiar with smartphones as younger people (23). In the study conducted by Zhu et al. (38), the authors suggested that the development of the Internet had brought great convenience to seek medical treatment for general clients, but not for older people, those with more health issues, and the most frequent users of health services who do not have access to the Internet. The "inconvenience" brought to the older group by the appointment network in hospitals is a typical manifestation of the "digital divide" or "technology discrimination" (23).

Poor health literacy is a common public health problem in developing countries, but it also happens in developed countries. An investigation conducted in Germany demonstrated lower health literacy and less use of health care services in women than in men with cardiovascular disease (39). Another study indicated that the patient's sex was a predictor for poor health literacy at an older age and that it is necessary to ensure women improve self-care, modify risk behavior, and adhere to treatment (40, 41). Thus, it is imperative to promote culturally tailored education and standardized health information practices to detect and manage cardiovascular disease among older women.

Given the increasing difficulties and inconveniences of access to mobile healthcare services that some older people face, policymakers and health professionals should develop measures to optimize the medical care process for the older group. First, hospital administration should reserve a certain number of offline registration appointments and provide offline health services for older people, especially those who seek medical treatment alone, and open telephone appointments, develop devices and hospital access methods that are deemed more friendly to the older population, which is conducive to solving the difficulties and building on age-friendly society (37). Moreover, the experts in health software services should consider age-related needs and regulate the digital products for the older group, such as adding voice guidelines and decreasing manual complexity to improve user experience and convenience. Third, volunteers should strengthen community-based education for mobile health technology for older residents. This is a strong recommendation to encourage young people to provide bottom-up intergenerational digital feedback to older people to narrow the digital gap faced by them.

Conclusion

In conclusion, this study explored the experiences, perceptions, and barriers among the older female population when having an AMI in China. The findings of this study indicated that older women had to meet the challenges of knowledge-attitude-behavior aspects. Women were more likely to experience health inequality than men due to social, cultural, and economic factors. By exploring the patient-level barriers and unmet needs from the perspectives of older women, this study provided richer and more insightful evidence for the future development of interventions to reduce the burden of cardiovascular disease in women. Efforts should be focused on helping health professionals promote educational programs and culturally tailored communication mechanisms that can address age-specific, gender-related strategies that target older women with cardiovascular disease risk factors to reduce care-seeking delay, improve public e-health literacy and behavior, and promote women's health quality.

Limitations

This study has a few limitations. First, the interviews were carried out in two hospitals in one big city in China, which possibly does not reflect cultural diversity. Furthermore, due to the characteristics of qualitative research, the limited sample size may not be representative of all older women with AMI in China. Further research needs to utilize mixed research methods to examine the direct and indirect effect of sex-related, psychosocial factors on older women with MI and to develop and evaluate the intervention strategies on knowledge, perception, and attitude on the behavior of seeking treatment.

Data availability statement

The datasets presented in this article are not readily available because they may contain information that could compromise research participants' privacy and consent. Requests to access the datasets should be directed to XL, luoxw187@126.com.

Ethics statement

The studies involving human participants were reviewed and approved by Wuhan University (WHU-2021-YF0010). The participants provided their written informed consent to participate in this study.

Author contributions

HY: conceptualization, methodology, validation, formal analysis, and writing – original draft. HL: conceptualization, methodology, investigation, and formal analysis. ZA: formal analysis and validation. JZ: methodology, investigation, and formal analysis. XM: conceptualization, resources, and validation. XL: methodology and conceptualization. XZ: methodology and writing – review and editing. All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Intersectional analysis of inequalities in self-reported breast cancer screening attendance using supervised machine learning and PROGRESS-Plus framework

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Background: Breast cancer is a critical public health concern in Spain, and organized screening programs have been in place since the 1990s to reduce its incidence. However, despite the bi-annual invitation for breast cancer screening (BCS) for women aged 45–69, significant attendance inequalities persist among different population groups. This study employs a quantitative intersectional perspective to identify intersectional positions at risk of not undergoing breast cancer screening in Spain.

Methods: Women were selected from the 2020 European Health Interview Survey in Spain, which surveyed the adult population (>15 years old) living in private households ($N = 22,072$; 59% response rate). Inequality indicators based on the PROGRESS-Plus framework were used to disentangle existing social intersections. To identify intersectional groups, decision tree models, including classification and regression trees (CARTs), chi-squared automatic interaction detector (CHAID), conditional inference rees (CITs), and C5.0, along with an ensemble algorithm, extreme gradient boosting (XGBoost), were applied.

Results: XGBoost (AUC 78.8%) identified regional differences (Autonomous Community) as the most important factor for classifying BCS attendance, followed by education, age, and marital status. The C5.0 model (balanced accuracy 81.1%) highlighted that the relative importance of individual characteristics, such as education, marital status, or age, for attendance differs based on women's place of residence and their degree of interaction. The highest risk of not attending BCS was observed among illiterate older women in lower social classes who were born in Spain, were residing in Asturias, Cantabria, Basque Country, Castile and León, Extremadura, Galicia, Madrid, Murcia, La Rioja, or Valencian Community, and were married, divorced, or widowed. Subsequently, the risk of not attending BCS extends to three other groups of women: women living in Ceuta and Melilla; single or legally separated women living in the rest of Spain; and women not born in Spain who were married, divorced, or widowed and not residing in Ceuta or Melilla.

Conclusion: The combined use of decision trees and ensemble algorithms can be a valuable tool in identifying intersectional positions at a higher risk of not utilizing public resources and, thus, can aid substantially in developing targeted interventions to increase BCS attendance.

KEYWORDS

healthcare access, breast cancer screening, health inequalities, intersectionality, decision trees, supervised machine learning, PROGRESS-Plus framework, Spain

1 Introduction

In the majority of EU countries, universal health insurance and, in theory, universal access to healthcare are in place. However, while many have achieved universal health coverage for a broad range of services, access to these services is not equally experienced by all citizens (1).

The Conceptual Framework of Access to Healthcare developed by Levesque et al. presents a comprehensive multidimensional approach to understanding and improving health service accessibility that combines individual- and system-related variables (2). In this article, we focus on an individual-level accessibility outcome, such as attendance at organized breast cancer screening programs, and examine groups at the intersections of individual-, system-, and environment-level inequality dimensions to identify those at the highest risk for non-attendance.

In 2020, breast cancer was the most diagnosed cancer among women, with 2.3 million cases, and the most prevalent, with 7.8 million women still living after a diagnosis within the past 5 years, globally (3). According to the European Cancer Information System (ECIS), breast cancer accounted for 28.7% of all cancers in women in the EU-27 countries in 2020, with an estimated 355,457 new cases and an age-standardized mortality rate (ASR) of 142.8 per 100,000 inhabitants (4). In Spain, the context for this study, breast cancer constitutes 30.7% of all cancers in women, with 110,946 new cases detected in 2020. The ASR for breast cancer is 132 per 100,000, followed by colorectal cancer with an ASR of 58.4 per 100,000 (4).

The importance of early breast cancer detection has been on the European agenda since 1980. The European Commission has urged Member States to establish preventive organized screening programs (OSPs) that bi-annually invite women aged 50–69 years for breast cancer screening (BCS). Additionally, women aged 45–49 years and 70–74 years should be conditionally screened every 2–3 years and 3 years, respectively (5). Over time, Member States have implemented OSPs with age ranges ranging from 40 to 74 years (6).

In 1990, Spain established OSPs, making it one of the first European countries to do so. However, due to the fact that some competencies of the Spanish healthcare system are allocated at the level of Autonomous Communities (regions), there were substantial differences between regions in invitation schedules: Some regions implemented a bi-annual regimen for women aged 45–69, some only for age groups 50–69, and there were differences with regards to the starting points as well—for example, Navarre was the first region implementing the program in 1990, followed by Catalonia, Castilla-La Mancha, Castile and León, Catalonia, Valencian Community, and Galicia in 1992. Ceuta and Melilla, on the other hand, only started their program in 2005 (7). The national attendance rate has steadily increased over the years, with 72.6% of targeted women attending their last medical appointment and 93.13% undergoing screening at least once in their lifetime in 2020. (8). Although this is a small proportion (6.87%), there is a large number of invited women who did not seek care, despite having knowledge of their age-related risks and available healthcare services.

Studies have shown that attendance inequality exists in BCS, with non-attendance not being uniformly distributed among the targeted population. In a recent international systematic review, Mottram et al. found that migrant women, women of lower socioeconomic status, non-homeowners, and those who previously experienced false-positive results had the lowest attendance rate (9). Recent studies in Spain have found that being married, having Spanish nationality, and having higher education are positive predictors of screening participation (10). Similarly, Serral et al. stated that socioeconomic status and country of origin are the strongest discriminating factors for screening attendance in Spain (11). Moreover, Martín-López et al. reported that holding Spanish nationality, being married, and having a high educational and income level are positively associated with BCS attendance (12). However, so far and to the authors' knowledge, no study has assessed these sociodemographic variables alongside the regional importance of non-attendance rates. In decentralized healthcare systems such as the Spanish system, where the concentration of health professionals in certain autonomous regions is approximately twice that of others, it is crucial to assess the influence of regional disparities on healthcare accessibility (13, 14).

Moreover, previous studies have examined dimensions of inequality as independent predictors of non-attendance. However, adopting an *intersectional* framework is necessary to understand the complexity of attending breast cancer screening by analyzing social and demographic risk factors beyond independent predictors.

The theory of intersectionality, developed in 1991 by Kimberlé Crenshaw in the context of unfair legal processes for Black women, posits that discrimination and oppression result from the intersection of multiple aspects of identity (e.g., gender, ethnicity) and related experiences (15). This theoretical framework is used in several disciplines today, with a broader range of variables that embody social power structures (e.g., sexuality, age, and income) (16). Inequalities in health-related outcomes, such as screening behavior, can be disentangled by adopting a non-additive, intersecting approach (17). In other words, experiences of discrimination by individuals who lay at the intersection of several axes of inequalities cannot be assessed and understood only by summing up the oppression suffered by these two variables independently.

Although traditionally examined in qualitative studies, recent years have witnessed a significant increase in the use of quantitative methods for intersectionality research (18). In this study, relatively simple regression analyses with interaction terms or intersection variables are more frequently used; more complex and less frequently used approaches include analyses such as decomposition analysis or decision trees (18). The latter refers to machine learning techniques that allow a non-parametric, data-driven exploration of intersectional heterogeneity in the data. In this study, variables potentially discriminating between groups varying in their estimated prevalence of a health outcome, such as PROGRESS-Plus characteristics, can

be included in the analysis without the risk of overfitting the model (19). Even at the risk of non-replicative arbitrary data splits, decision trees allow for any interaction, which helps, on the one hand, with variable selection and reduction and, on the other hand, identifying subgroups for potential interventions (20, 21).

Only a few public health studies have used decision trees to explore sociodemographic inequalities. Mena et al. used classification and regression trees (CARTs) and conditional inference trees (CITs) to identify groups with a higher prevalence of non-daily vegetable intake (22). Eagle et al. employed chi-squared automatic interaction detection trees (CHAID) to explore the associations between race and ethnicity, sex, depression, and concussion history with reported suicide attempts among adolescents in the US (23). Delgado-Gallegos et al. used C5.0 to assess perceived stress in healthcare professionals attending to COVID-19 cases in Mexico (24). These studies suggest that decision trees are a viable and helpful tool to identify the intersectional groups at high risk for specific outcomes, but so far, only a few studies have employed decision trees for studying sociodemographic inequalities in attending breast cancer screening.

Freitas et al. used CHAID to examine individual and environmental factors that predict breast cancer screening practices among women aged 45–69 in Portugal (25), but have not adopted a decidedly intersectional perspective. To the author's knowledge, no study in Spain has addressed inequality in breast cancer screening from an intersectional perspective or using machine learning techniques. Thus, according to national and regional breast cancer screening guidelines and based on the intersections of PROGRESS-Plus characteristics, this study aims to identify the intersectional positions of women more at risk of not undergoing breast cancer screening in Spain.

2 Materials and methods

2.1 European health interview survey

We used the cross-sectional data from the third wave of the European Health Interview Survey (EHIS) conducted in Spain in 2019 and 2020 to identify intersectional groups. The sample size of the survey was 22,072 respondents, corresponding to 59% of the invited participants ($N = 22{,}072$; 59% response rate). The survey, legally binding from the second wave onwards, is conducted every 5 years (every 6 years since 2019) and targets the population over 15 years old living in private households. Its main objective is to gather data on the population's health status, the utilization of health services, and determinants of health in a harmonized and comparable manner at the European level (b). The survey is framed within the European Commission's (EC) Regulation 1338/2008, and the current legally binding EC Regulation describing the survey's definitions is EC 2018/255 of 19 February 2018 (26, 27).

2.2 Ethical consideration

No ethical approval is required for this study as it is a secondary analysis of de-identified publicly available data.

2.3 Primary outcome

The primary outcome of this study was self-reported breast cancer screening attendance at some point during their lifetime via mammography for women aged 45–69 in 7 out of 19 Autonomous Communities (Castilla-La Mancha, Castile and León, Valencian Community, La Rioja, Navarre, Ceuta, and Melilla) and for women aged 50–69 in the rest of Autonomous Communities. Possible answers to these questions were: yes, no, unknown, or unanswered. Answers were dichotomized, removing those few who responded unknown or unanswered to avoid incorporating uncertainty on whether the respondent reported never attending BCS (no = 0, yes = 1).

2.4 Explanatory variables

The explanatory variables used in this research are based on the PROGRESS-Plus framework (28). Their use to disentangle social inequalities has been extensively discussed (29) and used (30). For this study, we categorized existing indicators of the survey into the PROGRESS-Plus categories and used them as potential predictors of non-attendance at BCS.

Place of Residence was determined through two different variables: the size of the municipality and the specific Autonomous Community. The first variable was composed of the following seven categories: less than 10,000 inhabitants, 10,000–20,000 inhabitants, 20,000–50,000 inhabitants, 50,000–100,000 inhabitants, more than 100,000 inhabitants, capital of the province, or more than 500,000 inhabitants. As mentioned above, the specific Autonomous Community also serves as a proxy for the time period of the implementation of BCS programs and the density of health professionals in the region.

Race, ethnicity, culture, and language were measured by the respondents' country of origin. The information provided by this variable in the *EHIS* was whether the participants were born in Spain or another country. Thus, the variable was employed as a binary variable (Spain = 1 and other = 2).

Occupation was operationalized through the respondents' current working situation. The derived categorical variable had the following categories: paid employment, unemployed, retired, unable to work, (unpaid) household work, and others. The "others" category is a merged category that includes *EHIS* classification such as unable to work, studying, and others, as the two first categories had very few participants, 17 and 1, respectively.

Sex was not included as an explanatory variable but rather as a requirement needed for including participants in the analysis: to be a female. *Gender* and *religion* dimensions were not included in the present research, as the *EHIS* did not comprise any questions covering gender identification or religious preferences.

Education was measured following the CNED14 classification, the Spanish adaptation of ISCED-2011 (31). The variables employed had the following categories: illiterate, uncompleted primary education, completed primary education, first-stage high school, finished high school, intermediate vocational training, superior vocational training, and university degree.

Socioeconomic status was operationalized by the type of occupation. The variable's classification was obtained based on the Spanish Society of Epidemiology classification developed in 1995 and

revised in 2012. This grouping comprises 6 groups, with 1 being the highest social class and 6 being the lowest (32).

Social capital was not explicitly included in the dataset; however, we used two proxy variables: marital status (single, married, legally separated/divorced, or widowed; indicating the availability of spousal support) and type of household (alone, with a partner, with a partner and children, alone with children, or others; indicating the availability of family support).

The *Plus* dimension of the PROGRESS-Plus framework was proposed to extend the social determinants of health that could potentially be discriminating features. Among these contextually dependent factors, characteristics that attract discrimination, features of relationships, and time-dependent relationships have been highlighted (33). In this study, we assessed characteristics that attract discrimination through the Global Activity Limitations Indicator (GALI) and age (34). The GALI self-reported measure is conceived by assessing the degree of limitation experienced in the last 6 months, with the possible answers being severely limited, mildly limited, or not limited. Age is a categorical variable comprising women aged 45–69 in quintiles (45–49 years old, 50–54 years old, 55–59 years old, 60–54 years old, and 65–69 years old). While one would anticipate a proportional relationship between age and BCS attendance (i.e., older women being invited to BCS more times in their lives than younger women), this variable was included to assess its potential interactions with other PROGRESS-Plus variables. Specifically, it aimed to examine whether distinct social determinants of health intersect in different age groups.

As a final point, none of the categories of the explanatory variables were collapsed (e.g., illiterate and uncompleted primary education); Instead, they were included in the model individually with all categories. This approach was chosen because decision tree algorithms permit a high level of granularity and the ability to capture interactions and potential intersections among the various categories (35).

2.5 Analytic approach

Descriptive analytics, frequencies, and percentages were calculated for all variables. The statistical significance between participants who attended BCS and those who did not was tested using a chi-squared test for all variables.

For this study, a complete case analysis was conducted when missing data were present. The total sample size was restricted to women aged 45–69 in 7 out of 19 Autonomous Communities (Castilla-La Mancha, Castile and León, Valencian Community, La Rioja, Navarre, Ceuta, and Melilla) and to 50–69 years in the rest of Autonomous Communities ($n = 4{,}180$). Among these women, those who did not provide information on whether they ever underwent mammography ($n = 8$) were excluded, and those who did not provide their marital status ($n = 21$) were excluded. Hence, the final total sample size of the study was 4,151 participants.

We used decision trees to identify the groups of women most at risk of not attending BCS. There is scarce literature that suggests which decision trees better operate on diverse health outcomes. CART bases its splitting decision on the lowest Gini impurity (or entropy) coefficient of every possible split (21). It is often criticized for not providing statistical significance measures and being biased toward variables with many categories. CIT was developed to overcome some of CART's limitations. CIT employs a formal statistical hypothesis for building the decision trees and avoids variable selection bias by dividing the selection process into two steps (36). CHAID was the first decision tree developed based on statistical significance tests, in which all covariates are tested against the outcome, and the one with the highest association is selected as the splitting variable. The limitation of CHAID is that it computes only categorical variables and is based on the chi-squared test (37). C5.0 is a non-parametric method that uses the entropy of the imputed variables to generate splits. Therefore, nodes are generated based on the data split that produces a higher information gain (i.e., the entropy of the data split is the lowest, meaning the homogeneity among the included cases is the highest) and therefore appears to be more advantageous for classification (38). After C5.0 generates a vast tree, it applies the binomial confidence limit method to every subtree for pruning through a high predicted error rate. Moreover, C5.0 uses adaptive boosting (39) and winnowing in the growing process (40, 41).

In the present study, the four most commonly used decision trees were implemented using R packages "caret" (42) for exploratively hypertuning the models and "rpart" (CART) (43), "chaid" (CHAID) (44), "partykit" (CIT) (20), and "C50" (C5.0) (40) for outputting the final model in R version 4.2.3.

Decision trees that use classification algorithms employ several metrics derived from a confusion matrix to evaluate their performance. In the case of a binary outcome, the confusion matrix is a 2×2 table that illustrates the total number of true positives (TP – hit), true negatives (TN – correct rejection), false negatives (FN – type II error), and false positives (FP – type I error) when comparing the predicted positive (PP) and predicted negative (PN) cases to the actual positive (P) and actual negative (N) cases. Measures such as balanced accuracy, recall, precision, and F1 score (Table 1) can then be calculated and used for model performance evaluation (45).

Despite decision trees being reliable tools for intersectional subgroup identification, they are unstable given their dependence on the data used to train them and, thus, posing the risk of overfitting. Small changes in the training data could lead to differences in decision tree construction; hence, the implementation of ensemble algorithms is recommended (46). There are several ensemble algorithms that employ different procedures, such as bagging (Random Forest), boosting (AdaBoost), and bagging and boosting (extreme gradient boosting). Following the results of previous research (47–49), we decided to use extreme gradient boosting (XGBoost) to increase the internal validation and robustness of the decision trees.

TABLE 1 Informative metrics derived from the confusion matrix for model's performance evaluation.

Evaluation metrics	Equation
Balanced accuracy	$\frac{\frac{TP}{P} + \frac{TN}{N}}{2}$
Recall (sensitivity)	$\frac{TP}{P}$
Precision	$\frac{TP}{PP}$
F1 score	$\frac{2TP}{2TP + FP + FN}$

The algorithm was implemented using the package "xgboost" (49) in R version 4.2.3.

3 Results

3.1 Descriptive statistics of the sample

A summary of the descriptive statistics of the sample can be found in Table 2. Association chi-squared tests suggest marginal associations between each independent variable and the outcome, except for municipality size. The total sample size is 4,151. Of those, 3,886 attended BCS during the last 2 years, while 285 did not. As expected, the youngest group, women aged 45–49 years, attended less in their lifetime (18.34% – never attended) than older women ($\chi^2 = 76.93$, df = 4, $p < 0.001$). Women not born in Spain (14.78%) attended less BCS compared to those born in Spain ($\chi^2 = 35.54$, df = 1, $p < 0.001$). Illiterate women (43.75%) ($\chi^2 = 74.94$, df = 7, $p < 0.001$) and women in the lowest social class (10.51%) ($\chi^2 = 38.00$, df = 6, $p < 0.001$) had the smallest number of attendances at BCS. Regarding the place of residence, women living in municipalities with 10,000–20,000 inhabitants (8.82%) ($\chi^2 = 16.95$, df = 6, $p < 0.151$) and women living in Melilla (37.14%) ($\chi^2 = 157.26$, df = 18, $p < 0.001$) had the lowest attendance at BCS. Finally, legally separated women (13.39%) ($\chi^2 = 68.11$, df = 4, $p < 0.001$), women living alone with children (8.21%) ($\chi^2 = 27.8$, df = 4, $p < 0.001$), women in a working situation labeled as other (10.90%) ($\chi^2 = 26.92$, df = 4, $p < 0.001$), and severely limited women (12.44%) ($\chi^2 = 13.15$, df = 2, $p < 0.0106$) participated in BCS the least among their PROGRESS-Plus dimension.

3.2 Data analysis: pre-processing steps

Several pre-processing steps were taken to prepare the data to be analyzed. First, a complete case analysis was conducted, as only 29 cases had missing data on any variable. Second, to improve external validity, data were randomly split into a training subset ($N = 3{,}321$, 80% of the entire dataset) and a testing subset ($N = 830$, 20% of the entire dataset), with stratification of the outcome (i.e., to respect the distribution of classes in both subsets). Furthermore, balance sampling methods were applied to the training data given the imbalanced nature of the dependent variable (93.13% ever attended BCS, 6.87% never attended). Several studies have demonstrated that model performance improves when resampling the training data in highly imbalanced datasets (50–52). Four balanced sampling techniques that minimize the majority class (undersampling), maximize the minority class (oversampling), or minimize the majority class and maximize the minority class (SMOTE and ROSE) were tested (Table 3). Oversampling outperformed the other sampling techniques, estimated through the area under the curve (AUC) of logistic regression (LR).

3.3 Data analysis: explanation of the tree

We tested several decision trees, CART, CIT, CHAID, and C5.0, to the oversampled training data. C5.0 outperformed the others with a balanced accuracy of 81.1%, recall of 80.7%, precision of 24.3%, and F1 score of 0.374. See Supplementary material 1 for more details and Figure 1; Table 4 for the final C5.0 decision tree.

The best tree identified the variables Autonomous Communities, origin, marital status, age, education, socioeconomic class, origin, and type of household as relevant in explaining attendance and non-attendance to BCS. The first splitting point, the root node, is found in Autonomous Communities, where women living in Ceuta or Melilla form a subgroup (Node 1, 464 cases /71 no-cases), and the rest of Spain further split. The second split is found in marital status, where single or separated women create a subgroup (Node 2, 1,112/585), and married, divorced, and widowed women further split. The third node relates to the respondent's origin country: women born outside Spain form a subgroup (Node 3, 280/163), and women born in Spain proceed to split. Women born in Spain, married, divorced, or widowed, and not residing in Ceuta or Melilla are additionally divided based on being 55 years of age or older. The youngest group is further split based on the level of education, forming two final leaves: less than high school education or professional education (Node 4, 496/334) and greater than high school education except for professional education (Node 5, 93/221). The oldest group is fragmented based on the socioeconomic class of the respondents, where those belonging to the highest two social classes form a subgroup (Node 6, 30/312), and the rest is additionally divided based on the place of residence. The sixth split divides the abovementioned group into those living in the Autonomous Communities of Navarre, Aragon, Canary Islands, or Catalonia (Node 7, 0/316), those living in Andalusia, Balearic Islands, or Castilla-La Mancha, and the rest of Spain. Women living in Andalusia, Balearic Islands, or Castilla-La Mancha are further separated based on the type of household they live in: alone, with a partner, or with a partner and children (Node 8, 307/243), and those living alone with children or other household constellations (Node 9, 7/48). Finally, women living in Asturias, Cantabria, Castile and León, Valencian Community, Extremadura, Galicia, Madrid, Murcia, Basque Country, or La Rioja, from middle and low social classes, aged 55 years or older, born in Spain, and married, divorced, or widowed, are lastly split based on their level of education: illiterate (Node 10, 42/2) and primary education or greater (Node 11, 270/792).

For more robust information and internal validation of the decision tree, extreme gradient boosting was performed. XGBoost sequentially trains multiple decision trees (bagging), where each tree endeavors to correct the classification errors of the precious one by assigning specific weights to each tree and its leaves (boosting) (49). The parameters used to build the ensemble algorithm were a learning rate of 0.1 (low learning rate to be more robust to overfitting), a maximum number of boosting iterations of 53, and a learning objective of logistic regression for binary classification. XGBoost assessed the importance of the variables when building the boosted trees through the information gain criteria. In essence, this algorithm informs which variables were more significant in constructing the decision trees and therefore has a higher predictive power in the model. With an AUC of 78.80%, the algorithm resolved that Autonomous Community followed by education, age, and marital status are the most important variables for predicting whether targeted women in Spain will attend BCS or not. Following with less than 50% relative importance are origin, social class, GALI, population density, working situation, and type of household (Figure 2).

TABLE 2 Descriptive PROGRESS-Plus characteristics on the attendance to BCS among targeted women in Spain based on the 2020 EHIS.

	Attended BCS (*N* = 3,866)	Never attended BCS (*N* = 285)	Total (*N* = 4,151)	*p*-value
Age quintiles (years)				
45–49	187 (4.8%)	42 (14.7%)	229 (5.5%)	<0.001
50–54	865 (22.4%)	93 (32.6%)	958 (23.1%)	
55–59	982 (25.4%)	63 (22.1%)	1,045 (25.2%)	
60–64	956 (24.7%)	48 (16.8%)	1,004 (24.2%)	
65–69	876 (22.7%)	39 (13.7%)	915 (22.0%)	
Country of origin				
Spain	3,572 (92.4%)	234 (82.1%)	3,806 (91.7%)	<0.001
Other	294 (7.6%)	51 (17.9%)	345 (8.3%)	
Educational group				
Illiterate	19 (0.5%)	13 (4.6%)	32 (0.8%)	<0.001
Uncompleted primary education	186 (4.8%)	23 (8.1%)	209 (5.0%)	
Completed primary education	720 (18.6%)	63 (22.1%)	783 (18.9%)	
First-stage high school	976 (25.2%)	75 (26.3%)	1,051 (25.3%)	
Completed high school	533 (13.8%)	30 (10.5%)	563 (13.6%)	
Intermediate vocational training	331 (8.6%)	18 (6.3%)	349 (8.4%)	
Superior vocational training	266 (6.9%)	22 (7.7%)	288 (6.9%)	
University degree	835 (21.6%)	41 (14.4%)	876 (21.1%)	
Socioeconomic position				
1 (high)	427 (11.0%)	17 (6.0%)	444 (10.7%)	<0.001
2	333 (8.6%)	14 (4.9%)	347 (8.4%)	
3	851 (22.0%)	47 (16.5%)	898 (21.6%)	
4	420 (10.9%)	21 (7.4%)	441 (10.6%)	
5	1,104 (28.6%)	101 (35.4%)	1,205 (29.0%)	
6 (low)	545 (14.1%)	64 (22.5%)	609 (14.7%)	
Not classifiable	186 (4.8%)	21 (7.4%)	207 (5.0%)	
Size of the municipality (people)				
<10,000	484 (12.5%)	34 (11.9%)	518 (12.5%)	0.151
10,000–20,000	920 (23.8%)	89 (31.2%)	1,009 (24.3%)	
20,000–50,000	314 (8.1%)	15 (5.3%)	329 (7.9%)	
50,000–100,000	350 (9.1%)	19 (6.7%)	369 (8.9%)	
>100,000	590 (15.3%)	56 (19.6%)	646 (15.6%)	
Province Capital	436 (11.3%)	25 (8.8%)	461 (11.1%)	
>500,000	772 (20.0%)	47 (16.5%)	819 (19.7%)	
Autonomous community				
Andalusia	443 (11.5%)	52 (18.2%)	495 (11.9%)	<0.001
Aragon	154 (4.0%)	2 (0.7%)	156 (3.8%)	
Asturias	176 (4.6%)	13 (4.6%)	189 (4.6%)	
Balearic Islands	61 (1.6%)	8 (2.8%)	69 (1.7%)	
Canary Islands	212 (5.5%)	12 (4.2%)	224 (5.4%)	
Cantabria	165 (4.3%)	13 (4.6%)	178 (4.3%)	
Castile and León	188 (4.9%)	14 (4.9%)	202 (4.9%)	
Castilla-La Mancha	228 (5.9%)	19 (6.7%)	247 (6.0%)	
Catalonia	356 (9.2%)	7 (2.5%)	363 (8.7%)	

(Continued)

TABLE 2 (Continued)

	Attended BCS (*N* = 3,866)	Never attended BCS (*N* = 285)	Total (*N* = 4,151)	*p*-value
Valencian Community	393 (10.2%)	28 (9.8%)	421 (10.1%)	
Extremadura	149 (3.9%)	8 (2.8%)	157 (3.8%)	
Galicia	217 (5.6%)	15 (5.3%)	232 (5.6%)	
Madrid	384 (9.9%)	20 (7.0%)	404 (9.7%)	
Murcia	144 (3.7%)	9 (3.2%)	153 (3.7%)	
Navarre	170 (4.4%)	7 (2.5%)	177 (4.3%)	
Basque Country	192 (5.0%)	12 (4.2%)	204 (4.9%)	
La Rioja	140 (3.6%)	8 (2.8%)	148 (3.6%)	
Ceuta	50 (1.3%)	12 (4.2%)	62 (1.5%)	
Melilla	44 (1.1%)	26 (9.1%)	70 (1.7%)	
Marital status				
Single	548 (14.2%)	83 (29.1%)	631 (15.2%)	<0.001
Married	2,269 (58.7%)	122 (42.8%)	2,391 (57.6%)	
Widowed	460 (11.9%)	27 (9.5%)	487 (11.7%)	
Legally separated	194 (5.0%)	30 (10.5%)	224 (5.4%)	
Divorced	395 (10.2%)	23 (8.1%)	418 (10.1%)	
Type of household				
Alone	1,024 (26.5%)	87 (30.5%)	1,111 (26.8%)	<0.001
With partner	1,130 (29.2%)	49 (17.2%)	1,179 (28.4%)	
With a partner and children	918 (23.7%)	66 (23.2%)	984 (23.7%)	
Alone with children	556 (14.4%)	65 (22.8%)	621 (15.0%)	
Other	238 (6.2%)	18 (6.3%)	256 (6.2%)	
Working situation				
In paid employment	1742 (45.1%)	129 (45.3%)	1,871 (45.1%)	<0.001
Unemployed	355 (9.2%)	37 (13.0%)	392 (9.4%)	
Retired	903 (23.4%)	34 (11.9%)	937 (22.6%)	
Household work (unpaid)	727 (18.8%)	68 (23.9%)	795 (19.2%)	
Others	139 (3.6%)	17 (6.0%)	156 (3.8%)	
Experienced limitation				
Severely limited	176 (4.6%)	25 (8.8%)	201 (4.8%)	0.0106
Mildly limited	960 (24.8%)	55 (19.3%)	1,015 (24.5%)	
Not limited	2,730 (70.6%)	205 (71.9%)	2,935 (70.7%)	

* The outcome is a binarized variable that measures whether the respondent never attended breast cancer screening (yes = 0, no = 1).

TABLE 3 Performance of balance sampling techniques on the training dataset.

Balancing technique	Never attended BCS	Attended BCS	Total	AUC (LR)
Oversampling	3,101	3,087	6,188	0.714
Undersampling	234	236	470	0.691
ROSE sampling	1,677	1,644	3,321	0.701
SMOTE sampling	3,087	3,087	6,174	0.708

4 Discussion

In this study, we employed decision trees to identify intersectional groups of women at the highest risk for never attending breast cancer screening and ensemble algorithms to give more robustness to the classification model. Autonomous Community, education, age, and marital status, were reported as the most critical variables for classifying attendance at BCS among women aged 45–69 in Spain.

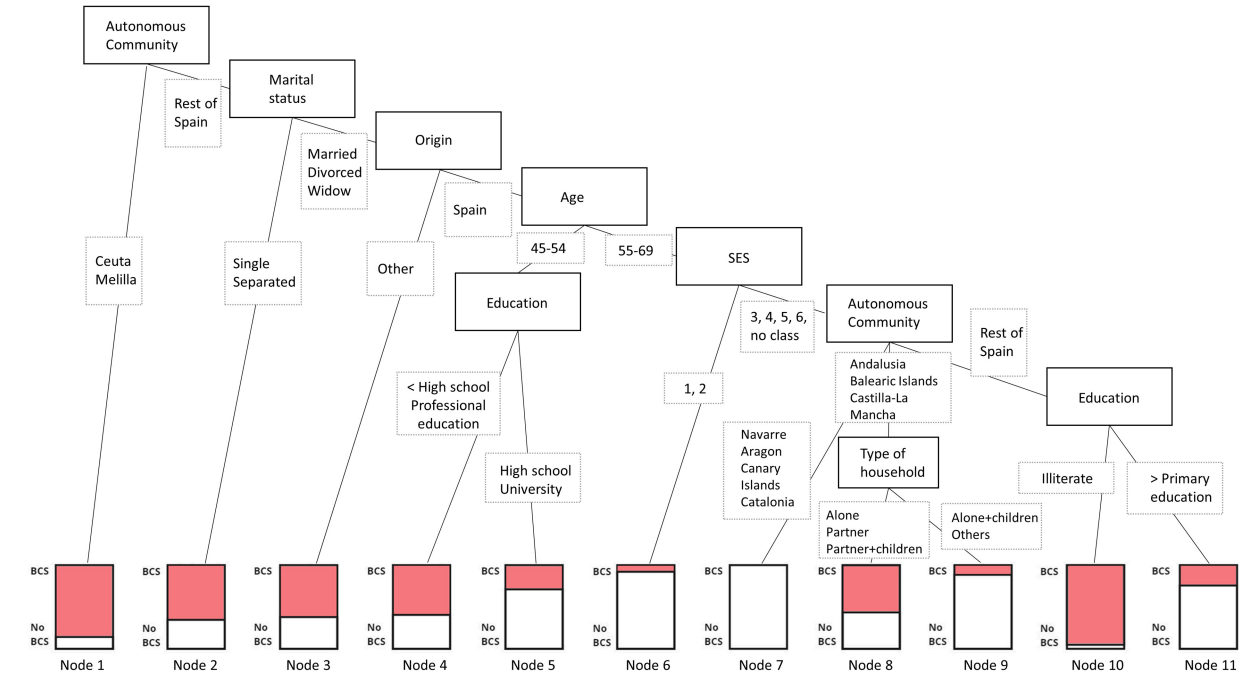

FIGURE 1
C5.0 decision tree assessing intersectional social positions most at risk of not attending BCS.

TABLE 4 Description of the intersectional social positions (nodes) at risk of not attending BCS from the C5.0 decision tree.

Rank	Intersectional social positions	Node number
1	Illiterate women living in Asturias, Cantabria, Castile and León, Valencian Community, Extremadura, Galicia, Madrid, Murcia Basque Country or La Rioja, from middle and low social classes, aged 55 or older, born in Spain, married, divorced, or widowed	10
2	Women living in Ceuta or Melilla	1
3	Single or separated women not living in Ceuta or Melilla	2
4	Married, divorced, or widowed women born outside Spain and not living in Ceuta or Melilla	3
5	Married, divorced, or widowed women, born outside Spain and not living in Ceuta or Melilla, younger than 55 years of age with less than high school education or professional education	4
6	Married, divorced, or widowed women, living alone, with a partner, or with a partner and children, born outside Spain, older than 55 years of age, belonging to social classes 3–6, living in the Autonomous Communities of Andalusia, Balearic Islands, or Castilla-La Mancha	8
7	Married, divorced, or widowed women, born outside Spain and not living in Ceuta or Melilla, younger than 55 years of age with more than high school education (except professional education)	5
8	Women living in Asturias, Cantabria, Castile and León, Valencian Community, Extremadura, Galicia, Madrid, Murcia Basque Country or La Rioja, from middle and low social classes, with primary education or greater, aged 55 years or older, born in Spain, married, divorced, or widowed	11
9	Married, divorced, or widowed women, living alone with children or other household constellations, born outside Spain, older than 55 years of age, belonging to social classes 3–6, living in the Autonomous Communities of Andalusia, Balearic Islands, or Castilla-La Mancha	9
10	Married, divorced, or widowed women, born outside Spain and not living in Ceuta or Melilla, older than 55 years of age, belonging to the highest two social class groups	6
11	Married, divorced, or widowed women born outside Spain, older than 55 years of age, belonging to social classes 3–6, living in the Autonomous Communities of Navarre, Aragon, Canary Islands, or Catalonia	7

While all Autonomous Communities have now adopted the OSP, it is worth noting that Ceuta and Melilla were the last to implement in 2006, and these were the regions where the lowest number of targeted women attended screenings (53). In addition, these regions are those with the lowest density of health professionals (2.5/1,000 inhabitants) in Spain (14). Moreover, given the enclave of these cities in Morocco,

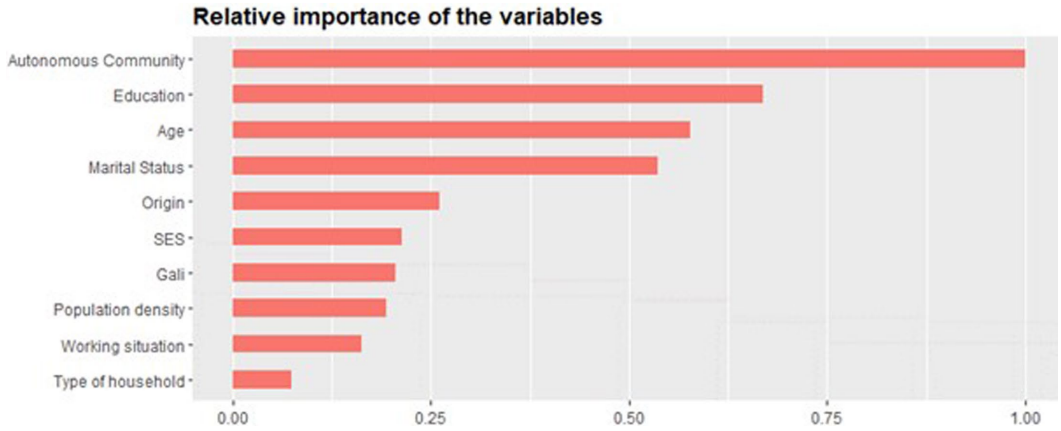

FIGURE 2
Variables' relative importance in the XGBoost model for predicting BCS attendance.

many inhabitants define themselves as Muslim, and several studies have observed that Muslim women have a lower attendance at BCS (54). Finally, the average level of education of women in these regions is significantly lower than in the rest of Spain (8).

Autonomous Communities, such as Navarre (1990) and Catalonia (1992), where OSPs were first implemented sustain higher screening attendance (7, 53). Indeed, our analysis enhances the importance of the intersections of individual and system levels of inequality. While women in higher social classes tend to attend BCS more than those in low and middle social classes (9), our analysis shows that women born in Spain, married, divorced, or widowed, not living in Ceuta or Melilla from the two highest social classes, have a slightly higher risk of not attending BCS compared to women born in Spain, married, divorced, or widowed, with middle and low social class, living specifically in Navarre, Aragon, Canary Islands, and Catalonia. These Spanish regions are thus strongly protective factors for BCS attendance, potentially over individual-level variables such as social class.

Among women born in Spain, married, divorced, or widowed, not living in Ceuta or Melilla, and younger than 55 years of age, their education level determines their risk of not attending BCS. Women with lower education have been at higher risk of not attending BCS compared to those with higher education (12, 55). However, among women older than 55 years of age, social class is the determinant variable. In this case, those in the two highest social classes are a subgroup with the second lowest predicted risk of not attending BCS. The non-linear nature of the interactions permitted in decision trees allows for the emergence of such divergences.

Another unexpected intersectional result of this analysis is the intersection between marital status and origin. Women not living in Ceuta and Melilla, single or separated, and who are married, divorced, or widowed with a migration background have a similarly high risk of not attending BCS. Single and separated women have a higher risk of not attending BCS than women with migration backgrounds who are married, divorced, or widowed. In other words, in this study, the origin of women plays a decisive role only for those who are not single or separated. Although contradictory to previous studies (11, 56, 57), marital status plays a more prominent role than migration background. These results are reinforced by the variable importance rank for building the model, where marital status has double the importance of origin.

Finally, the intersectional subgroup with the highest risk of not attending BCS, Node 10, encompassed women with very low educational levels in the Autonomous Communities of Asturias, Cantabria, Basque Country, Castile and León, Extremadura, Galicia, Madrid, Murcia, La Rioja, and Valencian Community. Although this subgroup intersects with the privileged position of other variables, such as marital status, age, and origin, being illiterate strongly determines their risk of not attending BCS. These results align with an earlier study showing that education is essential for BCS attendance (55). The present study contributes to and strengthens this statement showing that, although lying at the intersection of several protective factors, intersecting with low levels of education is pernicious. Furthermore, such social inequalities will persist if the responsible public health institutions do not address them. Molina-Barceló et al. found that most of the Autonomous Communities of this subgroup, Asturias, Castile and León, Extremadura, Madrid, and Murcia, did not develop interventions to decrease inequalities in the uptake of BCS in the last decade (58).

Although our results are specific to the Spanish healthcare system, some aspects might have implications beyond Spain. When healthcare competencies such as the allocation of financial resources, organization of territorial coverage, or development and implementation of preventive programs are delegated to regional authorities, disparities in access to healthcare services may emerge (13). This study identified the Autonomous Community as the most pivotal variable for predicting whether a woman aged 45–69 years old in Spain will attend BCS. Indeed, the Spanish Federation of Breast Cancer has, for several years, been advocating for greater interregional political cohesion to enhance equitable access to breast cancer prevention and treatment (59). Regions with lower economic means, such as Ceuta and Melilla, have invested less in addressing social inequalities compared to wealthier regions, such as Navarre or Catalonia, ultimately enlarging inequities within and between regions (58). Regional differences in the use of health services and their correlation to the socioeconomic level of the regions have been previously found in Spain (60). While a trend toward narrowing this gap has been observed, Autonomous Communities in the south and

northwest of the country continue to exhibit worse health indicators than those in the north and northeast. This is particularly notable in regions such as Ceuta, Melilla, Canary Islands, and Andalusia (61).

4.1 Strengths and limitations

Supervised machine learning techniques, specifically decision trees and the presented ensemble algorithm, allow for a non-parametric and non-linear explanation of the relationship between explanatory variables and the outcome. Thus, unlike the classic statistical analysis, where including many potential predictors could lead to overfitting the model, machine learning techniques allow for a more comprehensive inclusion of all available PROGRESS-Plus variables in the dataset. Multicollinearity deriving from potentially correlated predictors is not an issue in machine learning approaches since decision trees split based on an individual variable at each node, and ensemble algorithms further mitigate the risk by outputting the average importance of each variable. In this study, machine learning algorithms allowed an inductive exploration of intersecting social determinants of health in women. At last, no predictive value is tested; instead, variables are evaluated as potential predictors for building the classification models (35).

The study is not without limitations. No causal inference can be drawn due to the cross-sectional design of the survey. Moreover, response and common-method bias may occur due to the nature of the self-reported survey. In fact, the response rate of *EHiS* wave 3 was 59%, emphasizing the need for caution when drawing conclusions from studies using this dataset. Previous researchers have speculated that the *EHiS* suffers from underestimating inequalities in access to screening programs (58). Along these lines, the nature of the target population in the survey—people living in private households—could potentially reveal details about individuals living in less advantaged housing situations, such as public or institutional housing. Furthermore, although the presented decision tree outperformed others, it is relatively large and outputs both simple and highly dimensional intersectional positions. Therefore, the large dimensionality of some subgroups might challenge the usability of their content. Indeed, the present analysis ought to enhance the understanding of the intersectional importance of different variables and describe those most at risk of not attending the BCS. Finding the balance between algorithm performance and public health interpretability and usability is essential in health prevention.

Finally, secondary data intrinsically limit the included variables and their categorization. The dimension of race/ethnicity could only be estimated based on the respondent's country of origin, which does not fully capture the experience of discrimination that women might experience. An extensive body of literature shows how race/ethnicity is often a proxy for convergence factors such as experiences of discrimination, social mobility, and a lack of financial opportunities (62).

5 Conclusion

The present study pinpointed the intersectional positions of women at risk of not undergoing breast cancer screening in Spain. In our analyses, decision trees combined with an ensemble algorithm show that the importance of individual characteristics, such as education, marital status, or age, diverges based on the place of residence and their interaction. Particular attention ought to be placed on women living in specific regions: Ceuta and Melilla, single or legally separated women living in the rest of Spain, women not born in Spain, not residing in Ceuta or Melilla who are married, divorced, or widowed, and finally, illiterate women in lower social classes who are living in Asturias, Cantabria, Basque Country, Castile and León, Extremadura, Galicia, Madrid, Murcia, La Rioja, or Valencian Community at the protective intersection with marital status, age, and origin.

Beyond the Spanish context, applying a quantitative intersectionality framework that applies a comprehensive set of individual, system, and environmental indicators of inequality can greatly assist in the creation of health prevention programs that strive for equitable access to healthcare services.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

Ethical approval was not required for the study involving humans in accordance with the local legislation and institutional requirements. Written informed consent to participate in this study was not required from the participants or the participants' legal guardians/next of kin in accordance with the national legislation and the institutional requirements.

Author contributions

NP: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Visualization, Writing – original draft, Writing – review & editing. BS: Conceptualization, Supervision, Validation, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Gender-based violence and associated factors among female sex workers in Ethiopia. Evidence from The National Bio-behavioral Survey, 2020

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Background: Gender-based violence (GBV) is usually defined as unequal power relations between men and women, which poses a widespread public health problem. The study evaluated the prevalence and factors associated with GBV among female sex workers (FSWs) in Ethiopia.

Method: We used cross-sectional bio-behavioral data collected using respondent-driven sampling (RDS) in 2020 from 16 towns in Ethiopia. Descriptive statistics was analyzed to summarize the study population characteristics and prevalence of GBV, and a multilevel logistic regression model was applied to identify associated factors for GBV. A p-value of ≤ 0.05 was used as a threshold for statistical significance.

Result: Of 6,085 participants, 28.1% had experienced GBV during the last 12 months, among which 12.7% and 22.3% experienced physical and sexual violence, respectively. FSWs aged 15–24, and 25–34 than those 35 years or more, had a non-paying than paying partners, had 31–60, 61–90, and over 91 than those had less than 30 paying partners, ever had anal sex than those not, condom failure than those not, mobile female sex workers when compared with those not mobile at different town; 3–5 and ≥ 6 years than those less than 3 years stayed in selling sex, street-based, and multiple places selling sex than those used other venues were significantly associated with GBV.

Conclusion: Gender-based violence is a substantial problem among FSWs in Ethiopia, with significant implications for program planning on prevention and response to mitigate the occurrence and impact of GBV among FSWs.

KEYWORDS

female sex workers, gender-based violence, sexual violence, physical violence, Perpetrators and victims

Background

The United Nations defines GBV as any act of violence that results in or is likely to result in physical, sexual, or psychological harm or suffering to women, including threats of such acts, coercion, or arbitrary deprivation of liberty, whether occurring in public or in private life (1). The definition emphasizes that violence is a manifestation of historically unequal power relations between men and women, which have led to the domination over and discrimination against women by men that causes various health problems.

Female sex workers are at heightened risk for GBV (2, 3). Gender-based violence among female sex workers may cause a widespread public health problem including the acquisition of HIV and other sexually transmitted infections (STIs) through unprotected sex and forced sex, physical injury, and psychological trauma. An increasing body of evidence suggests that sexual violence among FSWs may be associated with individual and interpersonal characteristics and a broad range of environmental factors (4–6).

Reports indicate that the prevalence of GBV at the workplace among FSWs varies from 14 to 54% globally (3, 4, 6). Sexual and/or physical GBV was 75% in Latin America and the Caribbean (7), whereas GBV among mobile FSWs in India was 30.5% (8). Physical violence was reported in 65% of some studies (5, 7, 9). A study from South India indicated that the overall GBV among FSWs was 24%, of which 33% and 7% were exposed to physical and sexual violence, respectively (8). In comparison, sexual violence was reported to be 16.9% in Iran (9). Different reports from five Southern African countries show that physical and sexual violence among FSWs in the past 12 months was as high as 70% (10). This figure was 87%, 82%, and 40% in Kenya, Uganda, and Tanzania, respectively (11–13). In Ethiopia, the studies conducted in specific areas indicated that the overall workplace sexual violence was 28%, and the highest prevalence of 75.6% was reported at Mekele town among this population group (14, 15).

Female sex workers use different settings and venues for selling sex where GBV could be committed. The most common settings reported include homes, workplaces such as bars, and on the street (5, 16). The perpetrators of GBV vary by their type of relationship and setting, which was approximately 63.8% with clients in the Caribbean and 18.7% with brothel management in Nigeria (17). The other different factors such as migration to meet new clients (18, 19), stigma, discrimination, or harassment, and changes in work environments increase the exposure of FSWs to GBV (18–21).

Indeed, the majority of these studies identified that individual-level risk factors associated with physical or sexual violence among FSWs were limited to small geographic areas and did not take into account interpersonal and environmental factors beyond individual control that may play significant roles in GBV. Therefore, this study aimed to determine the magnitude of GBV and associated factors related to individual, interpersonal, and environmental factors by considering the cluster effect across towns in Ethiopia.

Abbreviations: FSW, female sex worker; GBV, gender-based violence; HIV, human immunodeficiency virus; NHSBS, National HIV and other STIs Bio-Behavioral Survey; RDS, respondent-driven sampling; STI, sexually transmitted disease; SNNPR, south nations and nationalities people region.

Materials and methods

A cross-sectional survey using a respondent-driven sampling process was conducted from 2019 to 2020 to identify the prevalence of HIV and other STIs, and GBV among FSWs in 16 cities and towns of Ethiopia. The study population was FSWs who had had sex for money or goods in the capital cities (Addis Ababa, Hawassa, Bahir Dar, Harar, Gambella, and Dire Dawa) of six administrative regions and ten sub-national major towns (Adama, Jimma, Nekemte, and Shashemane; Arba Minch, Dilla, and Mizan; Gondar and Kombolcha; and Logia), which could represent the population groups in Ethiopia.

Sampling procedures

The sample size was determined by a single population proportion formula, assuming a 95% confidence interval, $\alpha = 0.05$, margin of error (d) = 35%, and proportion (p) = 2% (22), and a design effect of 1.5 with a replacement for non-responders was used. The minimum desired sample size of FSWs in the 6 regional capitals and 10 major towns with a 10% contingency was 6,085 FSWs. This was allocated to the 16 sites proportionate to population size (Table 1).

The participants were included in the study by respondent-driven sampling (RDS) method. The RDS technique was started by identifying seeds or initial participants. The "seeds" were selected based on the type of sex worker, age category, and geographic location. The number of seeds for each site was determined based on the result of the formative assessment. Accordingly, five seeds for each site that had less than 450 sample sizes, 6–8 seeds for each site that had between 450 and 900 sample sizes, and 12 for 1,250 sample sizes were recruited. Then, FSWs with a known social network were given three coupons so that

TABLE 1 Sample sizes and seed distribution by study sites and the National HIV and Other STI Bio-Behavioral Survey, Ethiopia, 2019–2020 (N = 6,085).

Study site	Sample size	Seeds	Study site	Sample size	Seeds
Addis Ababa	1101	13	Dilla	251	5
Jimma	254	5	Dire Dawa	434	5
Adama	676	8	Logia/ Semera	251	5
Arba Minch	251	5	Bahir Dar	372	8
Hawassa	522	8	Gonder	250	5
Kombolcha/ Dessie	251	5	Nekemte	257	5
Gambella	468	6	Shashemane	250	5
Mizan	255	5	Harar	242	5
Total				6085	98

they could invite their friends or other FSW contacts that were in their network. The coupon was active from the day the coupon was given by the potential recruiter and expired after 2 weeks or when the study was completed. Coupons that were damaged, not readable, photocopied, had no seal/stamp on them, or were not the original ones were declared not valid to avoid desirability bias. Each participant who visited the study site brought the coupon that was identified by number and by who referred them. Based on these criteria, each new participant was given coupons and asked to recruit three additional acquaintances. This process continued until the desired sample size was achieved and the RDS equilibrium was attained. The respondents gave their informed consent to participate in the study. A total of 98 seeds were used for the enrollment of a total of 6,085 FSWs from the 16 study sites, and all 6,085 participated in the study. The majority of the study participants were recruited from seeds that generated two to six waves. A maximum of 16 waves were attained.

Inclusion criteria

Across all 16 study sites, participants were eligible for the study if they were 15 years or older, reported having sex in exchange for money, goods, services, or drugs with more than one client within 12 months before the interviews, and lived or worked in the city/town where the study was conducted.

Definitions of terms

Khat is a shrub (*Catha edulis*) of the staff-tree family that is cultivated in the Middle East and Africa for its leaves and buds which are the source of a habituating stimulant when chewed or used as a tea (23).

Condom failure is the situation when the condom tears off or partially or completely slips off the penis or is removed from the penis during sexual intercourse (24).

Study variables

The outcome (dependent) variable was GBV experienced by FSWs. The independent variables were individual [(**socio-demographic factors**: age, educational status, marital status, income, and residence), alcohol consumption, chewing khat, and duration since engagement in sex work], **interpersonal with partners** (number and type of partner, ever had anal sex, and condom failure), and **environmental** (change of place in the last 6 months, number of cities FSWs practiced selling sex and practiced venue, FSWs' mobility, and place of sex work).

Data collection

A standard National HIV and other STIs Bio-Behavioral Survey (NHSBS) questionnaire includes questions on demographic characteristics, history of sexual and other risk behaviors, and GBV (25). A response plan was made to refer FSWs who reported recent GBV victims to the concerned body to get the necessary counseling and support services. The data were collected using the Open Data Kit (ODK) software on a tablet.

Data analysis

The RDS recruitment process (tree of recruitment), evaluation of the RDS assumptions, and generation of weights were all done using R statistical software. The entire dataset was combined with the RDS weights using the RDS-II function before being exported for additional analysis. The frequency in their raw, median, inter-quartile range (IQR), and RDS-adjusted forms was computed using STATA software. The ODK software's data were exported to MS Excel, cleaned up, and then imported into STATA Verssion16 for analysis.

Owing to the different geographic areas, GBV prevalence and the associated factors could be influenced by the differences in site (city/town)-level factors. A multilevel logistic regression analysis was considered to assess for variation by town and identify their association with the independent variables. This analysis used a two-level multilevel fixed-effect logistic regression model. Level 1 variables were all the independent variables categorized as individual-level variables and level 2 variables were the towns. To measure the impact of the level 2 variables (town) in the multilevel regression model, we used intra-class correlation (ICC), and the between-town variation accounted for a portion of the total variation in the response variable. The effects of individual-level predictors were quantified by the estimates from the fixed-effect part of the model with a p-value less than 0.05 at 95% CI that did not include one.

Ethical considerations

The study protocol and procedures were approved by the Research Ethics Committee of the Ethiopian Public Health Institute (Ethics reference number: EPHI-IRB-108-2018). FSWs were invited to participate in the study after receiving a brief introduction to the aims of the study and the potential risks and benefits of participating in the study. Those who provided verbal informed consent were interviewed one-on-one in a private room by trained interviewers. The collected data were kept confidentially and secured in the Ethiopian Public Health Institute's database.

Results

Socio-demographic and other related characteristics

In total, 6,085 FSWs were recruited from the 16 survey sites. The median age of participants was 25.0 IQR of ±8 years [22, 30]. More than four-fifths (82.7%) of them were literate (attended primary school and above). A majority (85%) consumed alcohol, and approximately 62.9% of them chewed *Catha edulis* (khat) (Table 1). Nearly two-thirds (61.5%) of them had up to 60 paying partners in the last 6 months, and most (81%) stayed in the same town in the past 12 months before the survey (Table 2).

Prevalence of types of gender-based violence

Among the 6,085 FSWs aged 15 years and above who participated in the study, over a quarter (1710) [28.1%; 95% CI (26.99, 29.25)] had experienced physical or sexual violence or both types in the last 12 months before the survey, of which 1,354 [22.3%; 95% CI (21.23, 23.31)] and 771 [12.7%; 95% CI (11.86, 13.53)] experienced physical violence and sexual violence, respectively (Table 3).

Gender-based violence perpetrators and victims reported to the police

Nearly four-fifth (77.9%) of the perpetrators who committed GBV were paying partners followed by non-paying partners other than regular non-paying partners (10.5%) (Figure 1). Only 20% of the victims reported to the police (Figure 2).

Gender-based violence and associated factors

The results on the multilevel fixed-effect logistic regression model diagnosis show that the model fitted well for the data over the standard logistic regression to assess determinants for GBV ($X^2 = 174.66$, $p < 0.001$). The results of the ICC of the two multilevel models revealed that approximately 8.0% of the variations in the likelihood of GBV were explained by the variation among the towns in Ethiopia. As we can see from the 95% CI [0.04, 0.15], the variation among the towns was statistically significant, and hence any estimation without considering this effect will result in a biased estimate (Table 4).

The fixed effect of the multilevel logistic regression analysis indicated that age groups 5–24 and 25–34 years [AOR = 1.35; 95% (1.07, 1.69); $p = 0.01$] and [AOR = 1.44; 95% CI (1.20, 1.81); $p < 0.001$] than age group 35 years or more have shown an association with GBV among FSWs. Concerning partners' characteristics; having a non-paying partner [AOR = 1.58; 95% CI (1.38, 1.80); $p < 0.001$] than paying; number of paying partners having 31–60, 61–90; and ≥ 91 which were [AOR = 1.24; 95% CI (1.04, 1.47); $p = 0.016$], [AOR = 1.32; 95% CI (1.07, 1.64); $p = 0.011$)], and [AOR = 1.48; 95% CI (1.24, 1.77); $p < 0.001$] than with less than 30, respectively, have shown association with GBV among FSWs. It also indicated that the trend of GBV among FSWs increased with an increase in the number of paying partners. Related to sexual act, those FSWs who ever had on the other side, sexual acts ever had anal sex [AOR = 2.05; 95% CI (1.64, 2.55); $p < 0.001$] than those not; condom failure [AOR = 2.33; 95% CI (2.05, 2.65); $p < 0.001$] than those not, and number of years 3–5, and 6 years or more [AOR = 1.21; 95% CI (1.05, 1.41)] and [AOR = 1.34; 95% CI (1.15, 1.75); $p = 0.002$) than those stayed less than 3 years in selling sex, respectively, were associated with FSWs GBV.

Regarding the environment in which FSWs reside and sell sex; changing place or mobile than those not in the last 6 months [AOR = 1.39; 95% CI (1.20, 1.60); $p < 0.001$]; the number of cities two and three or more FSWs stayed and selling sex [AOR = 1.46; 95% CI (1.23, 1.75); $p < 0.00$] and [AOR = 1.42; 95% CI (1.11, 1.82); $p = 0.006$], respectively, than those stayed at one town/city, sex work in the street and multiple places [AOR = 1.42; 95% CI (1.28, 1.83); $p < 0.001$] and [AOR = 1.53 95% CI (1.29, 1.86); $p = 0.001$] than those use other venue, respectively, were associated with GBV among FSWs.

Discussion

The overall prevalence of GBV experienced among FSWs in our study was 28.1%, which falls within the range of globally reported GBV prevalence among this population group (4). The prevalence of GBV among FSWs by our study was approximately a third of that reported by studies conducted in Mombasa, Kampala, and Mekele (11, 12, 15) and less than half of that reported from Latin America and the Caribbean, Nigeria, Zambia, and Tanzania (7, 12, 13, 17). On the other hand, our finding was almost similar to what had been reported from south India (30.5%) and the finding from a meta-analysis of isolated studies in Ethiopia (16), while it was higher than what was reported by a study in Iran and the Middle East (6). These variations could be due to the variations in sociocultural differences between the countries and/or the continents.

The physical violence and the sexual violence among FSWs in our study were 22.3% and 12.8%, respectively. The prevalence of physical violence among FSWs was similar to what had been reported by the study conducted in Mombasa, Kenya, but was two times more than the finding from South India (8, 11), three times more than the prevalence reported by Tanzania (13), and two times less than what was reported by the study from Nigeria (17). On the other hand, sexual violence in our study showed a similar finding to the study conducted in South India among mobile FSWs but three times less than the findings from Nigeria and Tanzania and five times less than what was reported from North Karnataka in South India (9, 13, 17).

The wide variation in the prevalence and type of gender-based violence among FSWs across countries indicates specific individual characteristics and contextual factors need to be understood to design prevention and response interventions. Among the FSWs in the study, we documented that age, having non-paying partners and number of paying partners in the 6 months preceding data collection, having ever had anal sex, mobility of FSWs, number of towns where they practiced selling sex, number of years the FSWs stayed in selling sex, and the venue at which selling sex was practiced were associated with violence.

Our finding on prevalence and predictors of sexual violence among FSWs concurs with the report from a study conducted in Northern Ethiopia, which showed that FSWs in the younger age group had a higher rate of violence than the older age category (15). In contrast, a study in Nigeria identified more violence among older FSWs than the younger age group (17). This might be explained as the older age group FSWs could have more awareness of it and experience in escaping from perpetrators, while the differences could be due to sociocultural and other drivers of GBV among FSWs in the two countries. Among other factors associated with FSWs, GBV in our study was having non-paying partners in the last 6 months. This was similar to the findings from North Karnataka in South India, which examined determinants of GBV among FSWs in an intimate partner relationship (9). Similar to the study conducted in Zambia, our study

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TABLE 2 Socio-demographics and other related characteristics of female sex workers in Ethiopia ($N = 6,085$).

Variables	Frequency	%
Age		
15–24	2,595	42.7
25–34	2,671	43.9
≥ 35	819	13.5
Educational status		
No formal education	1,054	17.3
Primary school	3,560	58.5
Secondary school and above	1,471	24.2
Income due to selling sex/month in dollars		
< 86 $	1778	29.2
86–171.99 $	2066	34.0
>172–259 $	1,175	19.3
≥ 259 $	1,066	17.5
Catha edulis (khat) chewing		
No	2,258	37.1
Yes	3,827	62.9
Alcohol and drug use		
No	915	15.0
Yes	5,170	85.0
Currently, do you have a regular non-paying partner?		
No	4,347	71.4
Yes	1738	28.6
Number of non-paying partners in the last 6 months		
Never	4,347	71.4
Only one	1,404	23.1
2 and more	334	5.5
Number of paying partners in the last months		
4–30	2,308	37.9
31–60	1,436	23.6
61–90	696	11.4
≥ 91	1,645	27.0
Ever had anal sex		
No	5,659	93.0
Yes	426	7.0
Condom failure		
No	4,260	70.0
Yes	1825	30.0
Condom Use		
Consistent	5,119	84.1
Inconsistent	966	15.9
FSWs** movement/change of place in 6 months		
No	4,572	75.1
Yes	1,513	24.9

(Continued)

TABLE 2 (Continued)

Variables	Frequency	%
Number of cities where the FSWs moved and practiced selling sex		
One town	4,933	81.1
Two town	776	12.8
Three or more towns	374	6.1
Years lived in current city/place		
< 5	2,308	37.9
5–10	1,559	25.6
≥ 11	2,218	36.5
Number of years as sex worker		
< 3	2,343	38.5
3–5	2,202	36.2
≥ 6	1,537	25.3
Venue		
Bar/Hotel	1,132	18.6
Street	1,221	20.1
Multiple	3,040	49.9
Others	692	11.4

FSWs** movement/change place is when FSWs change their place of work from town to town to meet more clients or their clients.

TABLE 3 Prevalence and types of violence among female sex workers in Ethiopia ($N = 6,085$).

Characteristics	Categories	(*n*)	% (95% CI)
Violence among female sex workers in the last 12 months before the survey	Yes	1710	28.1 (26.99, 29.25)
	No	4,375	71.9 (70.75, 73.01)
Physical violence in the last 12 months before the survey	Yes	1,354	22.3 (21.23, 23.31)
	No	4,731	77.8 (76.89, 78.78)
Sexual violence in the last 12 months before the survey	Yes	771	12.7 (11.86, 13.53)
	No	5,314	87.3 (86.47, 88.14)

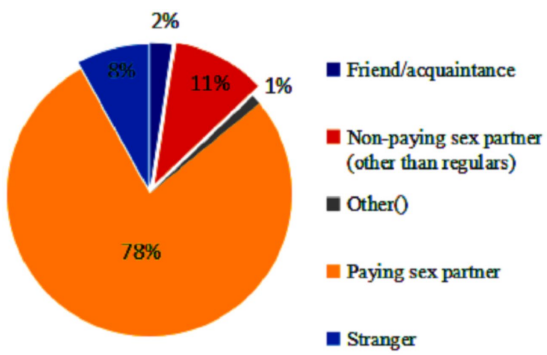

FIGURE 1
Perpetrators of violence.

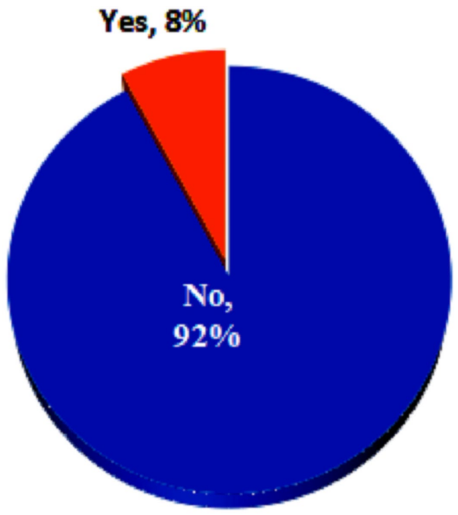

FIGURE 2
Victims reported to the police.

showed that the number of paying partners in the last 6 months was associated with GBV among FSWs, while having more than nine paying partner by our study has half less GBV among FSWs than the finding from Zambia (12).

TABLE 4 Bivariate and multivariate logistic regression analyses of gender-based violence and associated factors among female sex workers.

Characteristics	Not violated	Violated	COR (95% CI)	*p*-value	AOR (95% CI)	*p*-value
Age						
15–24	1891 (73)	701 (27)	1.36 (1.11, 1.65)	0.002	1.35 (1.07, 1.69)	0.010**
25–34	1844 (69.2)	822 (30.8)	1.58 (1.31, 1.91)	<0.001*	1.44 (1.20, 1.81)	<0.001**
35+	635 (77.9)	180 (22.1)	1		1	
Educational status						
Not attended school	754 (71.7)	297 (28.3)	1.14 (0.9. 1.14)	0.268		
Primary school	2,551 (71.7)	1,005 (28.3)	1.04 (0.86, 1.25)	0.685		
Secondary and above	1,065 (72.6)	401 (27.4)	1			
Income from selling sex						
< 86 $	1,359 (76.8)	411 (23.2)	1.16 (0.99, 1.36)	0.059		
86–172 $	1,496 (72.5)	567 (27.5)	1.37 (1.14, 1.64)	0.001*		
172.4–259 $	812 (69.1)	363 (30.9)	1.34 (1.12, 1.63)	0.002*		
≥ 259 $	703 (66)	362 (34)	1			
Catha edulis (khat) chewing						
No	1794 (79.6)	459 (20.4)	1			
Yes	2,576 (67.4)	1,244 (32.6)	1.78 (1.47, 2.17)	< 0.001*		
Alcohol use						
No	725 (79.6)	186 (20.4)	1		1	
Yes	3,645 (70.6)	1,517 (29.4)	1.42 (1.19, 1.69)	<0.001*	1.17 (0.97, 1.41)	0.103
Had non-paying partner in the last 6 months						
No	3,300 (76.1)	1,038 (23.9)	1		1	
Yes	1,070 (61.7)	665 (38.3)	1.84 (1.62, 2.09)	<0.001*	1.58 (1.38, 1.80)	<0.001**
Number of paying partners in the last 6 months						
≤30	1775 (77.1)	527 (22.9)	1		1	
31–60	1,028 (71.7)	405 (28.3)	1.32 (1.12, 1.56)	0.001	1.24 (1.04, 1.47)	0.016**
61-90	482 (69.3)	214 (30.7)	1.42 (1.15, 1.74)	0.001	1.32 (1.07, 1.64)	0.011
≥ 91	1,085 (66.1)	557 (33.9)	1.74 (1.47, 2.05)	<0.001*	1.48 (1.24,)1.77	<0.001**
Ever had anal sex						
No	4,168 (73.8)	1,479 (26.2)	1		1	
Yes	202 (47.4)	224 (52.6)	2.77 (2.25, 3.41)	<0.001*	2.05 (1.64, 2.55)	<0.001**
Condom failure						
No	3,326 (78.2)	927 (21.8)	1		1	
Yes	1,044 (57.4)	776 (42.6)	2.62 (2.32, 2.97)	<0.001*	2.33 (2.05, 2.65)	<0.001**
FSWs' change of place in the last 6 months						
No	3,427 (75.2)	1,133 (24.8)	1		1	
Yes	943 (62.3)	570 (37.7)	1.74 (1.53, 1.99)	<0.001*	1.39 (1.20, 1.60)	<0.001**
Number of cities/towns FSWs practiced selling sex						
One town	3,691 (75.0)	1,230 (25.0)	1		1	
Two towns	469 (60.4)	307 (39.6)	1.87 (1.58, 2.20)	<0.001*	1.46 (1.23, 1.75)	<0.001**
Three or more towns	208 (55.6)	166 (44.4)	2.04 (1.62, 2.58)	<0.001*	1.42 (1.11, 1.82)	0.006**
Number of years as a sex worker						
Less than 3 years	976 (71.6)	388 (28.4)	1		1	
4+ years	3,394 (72.1)	1,315 (27.9)	1.43 (1.23, 1.66)	<0.001	1.34 (1.15, 1.75)	0.002**
Venue						

(Continued)

TABLE 4 (Continued)

Characteristics	Not violated	Violated	COR (95% CI)	*p*-value	AOR (95% CI)	*p*-value
Bar/Hotel	808 (71.7)	319 (28.3)	1		1	
Street	958 (78.6)	261 (21.4)	1.37 (1.12, 1.68)	0.002	1.42 (1.28, 1.83)	<0.001**
Multiple	2056 (67.7)	980 (32.3)	1.59 (1.35, 1.90)	<0.001	1.53 (1.29, 1.86)	0.001**
Others	548 (79.3)	143 (20.7)	0.88 (0.69, 1.13)	0.313	0.92 (0.71, 1.19)	0.524
Random effects						
Towns/cities					0.27 (0.13, 0.57)	
ICC**					0.08 (0.04, 0.15)	
LR testvs. logistic model**						
Chibar2 = 174.66 **						
p-value = 0.000						

**—shows variables shown significant association at the stated p-value.

We also found that FSWs who ever practiced anal sex experienced GBV more often than their counterparts, which was similar to what was reported by the African Sex Work Alliance among FSWs in Nairobi but two times more than that was reported by the study conducted at Kampala (12). Regarding FSW mobility and the number of cities and towns where they practiced selling sex in association with GBV, the finding from our study was similar to the findings from the study conducted in India and Northern Vietnam (20, 21).

This study also identified an association between GBV and the number of years of selling sex (more than 3 years) sex by FSWs. This finding corroborated the similarity with the finding from a study conducted in Northern Ethiopia (19). Concurring with the findings from the Ethiopia National Survey on FSWs (16), the venue type where the FSWs used to sell sex was significantly associated with violence in our study. This indicated that there are still similarities in trends of venues where FSWs used to pickup their partners. Unlike previous studies (14–16), other socio-demographic and individual factors including educational status, income, and chewing *Catha edulis* (khat) were not associated with GBV among FSWSs in our study.

Limitations

As the findings from this study relied on self-reported measures, there might be social desirability and recall biases. These need to be considered in the interpretation of the results as well. The strength of the study was the nationally representative number of FSWs from cities and towns that participated, the respondent-driven sampling method (RDS) including eligible participants, and the multilevel logistic regression analysis that was applied to manage the individual level and intra-class correlation (ICC) between-town variation.

Conclusion and recommendation

The findings from this study revealed that violence among FSWs is high in Ethiopia. It also indicated that GBV among FSWs in Ethiopia is associated with socio-demographic factors, partner characteristics, and the environment where they practice sex selling. The study results have important implications for policy and program planning, prevention, and response to mitigate the occurrence and impact of GBV among FSWs.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Ethiopian Public Health Institute IRB. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

LN developed the concept of the study and contributed to the analysis, manuscript development, and submission. JA contributed to data analysis. SA was involved in manuscript development and review. JB, BB, FW, WB, and AH participated in manuscript development. SL carried out the manuscript review. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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Exploring gender disparities in the disease and economic tobacco-attributable burden in Latin America

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Introduction: Tobacco use has significant health consequences in Latin America, and while studies have examined the overall impact, the gender-specific effects have not been thoroughly researched. Understanding these differences is crucial for effective tobacco control policies. The objective of this study was to explore the differences in tobacco-attributable disease and economic burden between men and women in Argentina, Brazil, Chile, Colombia, Costa Rica, Ecuador, Mexico, and Peru.

Methods: We used a previously validated economic model to quantify the impact of tobacco-related illnesses, including morbidity, mortality, healthcare costs, productivity losses, informal care expenses, and DALYs, by gender and age. We utilized data from national surveys, records, studies, and expert opinions to populate the model.

Results: In 2020, there were 351,000 smoking-attributable deaths. Men accounted for 69% and women 31%. Ecuador and Mexico had the highest male-to-female death ratio, while Peru and Chile had the smallest disparities. 2.3 million tobacco-related disease events occurred, with 65% in men and 35% in women. Ecuador and Mexico had higher disease rates among men, while Peru had a more balanced ratio. Regarding DALYs, men lost 6.3 million due to tobacco, while women lost 3.3 million, primarily from COPD, cardiovascular disease, and cancer. Brazil and Mexico had the highest DALY losses for both genders. Costa Rica had a lower male-to-female tobacco use prevalence ratio but ranked second in deaths, disease events, and DALYs attributed to tobacco. Colombia had a unique pattern with a male-to-female death ratio of 2.08 but a higher ratio for disease events. The health systems spent $22.8 billion to treat tobacco-attributable diseases, with a male-to-female cost ratio 2.15. Ecuador showed the greatest gender cost difference, while Peru had the lowest. Productivity loss due to tobacco was $16.2 billion, with Ecuador and Mexico exhibiting the highest gender disparities and Peru the lowest. Informal care costs amounted to $10.8 billion, with men incurring higher costs in Ecuador, Costa Rica, and Mexico.

Discussion: Tobacco causes significant health and economic burdens in Latin America, with gender-based differences. There is a need for gender-disaggregated data to improve tobacco control policies.

KEYWORDS

gender, burden of disease, tobacco use, health disparities, Latin America

Introduction

Tobacco use is the leading preventable cause of disease and premature death worldwide (1). In the Americas, the prevalence of smoking is higher for men (21.3%) than for women (11.3%) in 2020 (2, 3). Data shows that the trend of tobacco use is declining; however, tobacco use among women is decreasing at a much slower rate than among men (3). At present, the difference in smoking prevalence between males and females is smallest in the Americas and Europe when compared to other regions of the world (3, 4). In addition, there is evidence of a high prevalence of female smoking among adolescents aged 13–15 years, even at the European level (2, 3).

A significant body of evidence shows the differences between men and women in tobacco use and how these differences could contribute to several diseases (5, 6). Recent research has revealed that female smokers face a significantly higher risk of acute coronary syndrome with obstructive coronary artery disease compared to their male counterparts (7, 8). In contrast, smoking has been associated with intracranial calcifications of the internal carotid artery in men with ischemic stroke, while hypertension and diabetes were identified as strong risk factors in women (9) When it comes to lung cancer, some studies indicate that women may be more susceptible to lung carcinogens than men and may develop cancer even with lower levels of cigarette use (10). On the other hand, although chronic obstructive pulmonary disease (COPD) has long been considered a male disease, several studies have shown that women report more symptoms of dyspnea, cough, and decreased forced expiratory volume, even when they have a similar pack-years history of smoking (11).

The differential negative impact to tobacco uses by gender goes beyond health outcomes. The chronic and globally progressive nature of tobacco-attributable diseases is associated with a continuous increase in the utilization of healthcare-related resources, impacting not only patients and their families but also society as a whole (12, 13). In Latin America in particular, smoking generates $34 billion in direct medical costs each year, representing a significant portion of that subregion's healthcare budgets (14). In addition, there are studies that suggest that tobacco use has a significant impact on social costs, which could further deepen gender gaps if we look behind the numbers (15–17). This situation may have an unequal impact on financial protection based on gender, due to disparities in earnings and labor opportunities between genders (18). It is well known that there is significant economic inequality in the region and, the efforts to reduce poverty have not equally benefited men and women, nor have they progressed at the same pace. In 2021, according to the femininity index for every 100 men living in poor households in the region, there were 116 women facing a similar situation (19). Furthermore, socially prescribed gender roles assign women as the main ones responsible for family care. It is estimated that approximately 90% of women in Latin American countries engage in unpaid health care and household chores, dedicating twice as much time to these family responsibilities compared to men (20). These aspects significantly expand the scope of understanding the gender-based implications of social costs associated with tobacco, emphasizing their importance in informing policy decisions, as well as, the understanding of the differential effects of tobacco control policies by subpopulations (21–23).

For a long time, tobacco control overlooked the importance of analyzing tobacco use from a gender perspective. This can be attributed to the limited attention given to integrating gender considerations in research, policies, and programs, thus impeding progress in this domain (24). Recently, the World Health Organization (WHO) and the parties to the Framework Convention on Tobacco Control recognized the imperative need of recommendations to address gender-specific risks associated with tobacco. These recommendations encompass a range of actions such as augmenting funding for gender-specific research and advocacy, using sex-disaggregated data, implementing affordable tobacco control programs, addressing the connection between women's liberation and tobacco use, and focusing on education for women and girls. These measures are crucial for effectively tackling the globalization of smoking-related challenges (24, 25).

The estimates and projections for the entire region of the Americas carried out by the WHO indicate that the association of smoking is greater in men (2, 26), which can also be reflected from the economic perspective. However, these data often mask large differences in men and women between and within countries. Therefore, disease burden and cost analyses are valuable in informing the diverse impact of tobacco-attributable diseases and thus helping decision makers to allocate resources and implement tobacco control measures and public policies at the optimal time.

The aim of this study was to explore the differences between men and women in the health and economic burden attributable to smoking in Argentina, Brazil, Chile, Colombia, Costa Rica, Ecuador, Mexico, and Peru. These countries lead the economic income of the region and represent 80% of the Latin American population.

Methods

This study is based on an economic model already published and previously validated in 13 countries. The economic model is a state transition or probabilistic Markov microsimulation (first-order Monte Carlo technique) that considers the natural history, direct medical costs, indirect costs, and, quality losses associated with the main tobacco-attributable diseases (coronary and noncoronary heart disease, cerebrovascular disease, COPD, pneumonia, influenza, lung cancer, and nine other neoplasms) (27, 28). Its characteristics, components, validation, and applications are described in previous publications (16, 27, 29–31). In the model, adult people (35 years and over) are followed in hypothetical cohorts, and individual annual risks of disease incidence, disease progression, and death are estimated based on demographic characteristics of the population, smoking status, previous clinical conditions, and underlying risk equations to present aggregated results on mortality, disease events, quality of life, health care costs and, indirect costs (lost productivity). It is relevant to emphasize that the hypothetical cohort was chosen to commence at the age of 35 because it is from this age onwards that chronic diseases related to smoking begin to be observed. Furthermore, the hypothetical cohort was selected to represent the adult population of Latin America, which has an average age of around 35 years. This decision not only mirrors the epidemiological reality but also enables a more precise capture of the impacts of this habit on health as the population ages.

Additionally, the selection of this hypothetical cohort was made to accurately depict the adult population of Latin America, where the average age is approximately 35 years. This approach ensures that the model's results are more applicable and representative for the region by considering the specific demographic characteristics of the population under study (32). Most of the data is disaggregated by sex and the risk of the events is estimated from the baseline risk in non-smokers multiplied by the age, sex, and condition-specific relative risks (RR) for smokers and ex-smokers (33). The main characteristics of the model are shown in Figure 1.

Information sources

Data to populate the model were obtained from a literature review that used MEDLINE, LILACS, Embase, EconLit, Google (for gray literature), and Google Scholar. Public statistics and country-representative surveys were the main sources of information on demographics, mortality rates, and smoking prevalence by sex, and age. Research teams from participating countries provided additional information from local sources on civil registrations, vital statistics, and hospital databases, and validated the epidemiological parameters used. The data included is available in Table 1.

The direct medical costs associated with tobacco-related diseases were estimated using a mixed-method approach based on data availability. In cases where cost data was available, the micro cost method was applied, which involves calculating the cost of resources required for diagnosis, treatment, and follow-up and weighting them by usage rates for each disease related to tobacco use. However, for certain diseases, expert consultations and Delphi panels were employed to estimate the cost of treatment. Our report presents the average direct medical costs from a third-party payer perspective. Macroeconomic parameters, such as gross domestic product (GDP) and health expenditure, were extracted from data banks of multilateral organizations. The costs of labor productivity loss attributable to tobacco use were estimated considering the premature death of working-age individuals and the decrease in individuals' labor productivity due to a health condition (absenteeism). To estimate the cost component associated with premature death, we applied the Value of a Statistical Life formula (34). For the absenteeism cost component, we adopted an indirect estimation criterion, assuming that individuals' work productivity decreased proportionally to the reduction of quality of life attributed to that condition (35). To estimate both cost components, we calculated individuals' labor income (by sex) through a Mincer equation (36) using representative household surveys, and the legal retirement age by sex in each country (37). For further details see Pinto et al. (16). The costs of time use of informal caregivers (those who provide care to family members without receiving remuneration or economic compensation for it) was estimated through the proxy good approach using information from Espinola et al. (20, 38). We estimated the costs in local currency units. Then, we converted to 2020 US dollars (USD) using the average exchange rates for each local currency, which were obtained from the web page of each Central Bank. (39–45)

The epidemiological data utilized to populate the model were gathered for the year 2020, and the key inputs are outlined in Table 1 and the Supplementary material. Notably, we observed an imbalance in the gender distribution among individuals over 35 years of age in 2020 across the eight countries under study. Despite there being more women than men in this age group, tobacco use is more prevalent among men, with variations observed among countries. For instance, in Ecuador, the ratio is five men to every woman using tobacco, whereas in Chile, the ratio is 1.34 men to every woman (Table 1). On another note, when examining the data on the relative risks of smokers versus non-smokers, it becomes evident that female smokers generally exhibit a higher relative risk than men, except for lung cancer, where men have almost twice the relative risk of women. Conversely, the data on the relative risks of smokers versus former smokers indicates that male smokers tend to have a higher relative risk compared to female smokers, except

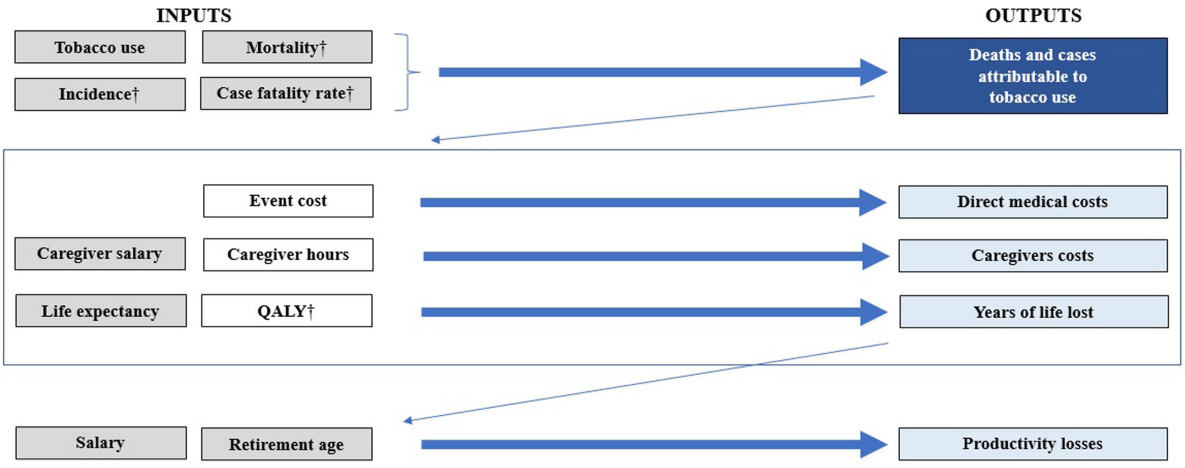

FIGURE 1
The burden of disease model structure and availability of data by sex. In gray the inputs that are differentiated between men and women. In dark blue the results that fully contemplate the differentiation between men and women. In clear light blue those who contemplate it at least partially. †Of related diseases with tobacco use. QALY, quality-adjusted life-year.

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TABLE 1 Annual burden of mortality, disease incidence and DALYs attributable to tobacco by sex and country for 2020.

Country	Chile	Peru	Brazil	Argentina	Costa Rica	Mexico	Colombia	Ecuador	Total
Total population									
Over 35 years old	9,771,671	13,390,445	98,134,446	20,404,023	2,299,805	51,796,845	21,977,761	6,335,146	236,441,488
Men	48%	49%	47%	47%	49%	47%	47%	49%	48%
Woman	52%	51%	53%	53%	51%	53%	53%	51%	52%
Ratio	0.92	0.96	0.89	0.89	0.96	0.89	0.89	0.96	0.92
Tobacco use									
Men	26%	29%	16%	16%	10%	21%	11%	15%	18%
Woman	19%	18%	9%	7%	4%	6%	3%	3%	9%
Ratio	1.37	1.61	1.78	2.29	2.50	3.50	3.67	5.00	2.09
Death attributable to tobacco use									
Men	11,594	12,853	110,961	31,023	1,719	48,141	20,500	5,447	242,238
Women	7,496	9,503	51,023	13,776	460	15,136	9,859	1,377	108,630
Ratio	1.55	1.35	2.17	2.25	3.74	3.18	2.08	3.96	2.23
Diseases events atributable to tobacco use									
Men	78,938	75,307	739,425	149,471	13,476	355,346	114,810	44,499	1,571,272
Women	53,290	61,343	421,470	83,042	3,643	105,985	63,509	10,086	802,368
Ratio	1.48	1.23	1.75	1.80	3.70	3.35	1.81	4.41	1.96
DALYs atributable to tobacco use									
Men	320,859	359,037	3,025,355	744,303	46,726	1,188,361	504,249	146,530	6,335,421
Women	223,393	292,910	1,632,548	399,061	14,230	411,942	255,428	41,808	3,271,320
Ratio	1.44	1.23	1.85	1.87	3.28	2.88	1.97	3.50	1.94

for stroke (1/0.89, a 1.25-fold lower risk) and COPD, where the risk is similar. As for the 'basal mortality rate due to diseases associated with tobacco use,' in most countries, mortality is higher in men than in women. This rate represents overall mortality before factoring in additional risk factors and specifically pertains to mortality caused by diseases associated with tobacco use. (32) However, for certain conditions such as other heart and cardiovascular diseases (Chile, Costa Rica, Colombia, Ecuador, and Mexico), stroke (Chile, Costa Rica, Colombia, Mexico, and Peru), and pneumonia/influenza (Argentina, Brazil, Chile, and Colombia), there is higher mortality in women than in men. Additionally, there is greater mortality from lung cancer and AMI in women than in men in Colombia (Supplementary Tables S1, S2).

Estimation of the smoking-attributable disease burden

The main outcomes of the model were deaths, disease events, healthy years of life lost due to premature death and disability, and disease costs by sex in each country. The disease burden was estimated as the difference in outcomes between the results predicted by the model for each country under current smoking prevalence and a hypothetical cohort of individuals who never smoked. Passive smoking and perinatal effects were estimated to impose an additional burden of 13·6% (men) and 12% (women) (46).

Model calibration and validation process

Disease-specific mortality rates for sex were compared to local statistics in each country. Predicted rates within 10% of references were considered acceptable. With larger deviations, risk equations were calibrated. The model was externally validated against other epidemiological and clinical studies not used for equation estimation and development.

Results

In Table 1, we present the results of the tobacco-attributable disease burden by sex in 2020. Overall, the study estimated a total of 351,000 smoking-attributable deaths in the eight countries. Among these deaths, approximately 69% were of men, while 31% were of women. This resulted in a male-to-female death ratio of 2.23, indicating that men experienced more than twice as many deaths compared to women due to tobacco use. Among the countries with the highest male–female mortality rates are Ecuador and Mexico, with ratios of 3.96 and 3.18, respectively. On the other hand, Peru and Chile had the smallest disparities in deaths between men and women, with ratios of 1.35 and 1.55, respectively. The variations observed between countries can be attributed to differences in the prevalence of smoking between men and women, although the relationship is not strictly linear.

The model projected an annual estimate of 2.3 million disease events directly related to tobacco use. This distribution between genders reflects the patterns of death observed. Among these, about 1.5 million (65%) were projected to occur in men, while approximately 800,000 (35%) were estimated to occur in women. Ecuador and Mexico exhibited more tobacco-attributable disease events per year among men compared to women. Ecuador, for example, showed a ratio of 4.41 disease events in men for each one in women (Table 2).

In terms of disability-adjusted life years (DALYs), the results highlight those men experienced a loss of 6.3 million DALYs due to tobacco-related premature mortality and disability, while women registered half of that figure with 3.3 million. The main drivers of these numbers were COPD, cardiovascular disease, and cancer. Brazil and Mexico emerged as the countries with the highest DALY loss for both sexes, underscoring the profound impact of tobacco-related health outcomes (Supplementary Table S3).

Particularly interesting is the case of Costa Rica, where the prevalence ratio of tobacco use between men and women (2.5) appears lower compared to Ecuador (5) and Mexico (3.5). However, it stands out with the second-highest ratios in terms of deaths, disease events, and DALYs attributable to tobacco, positioning itself between Ecuador and Mexico. Conversely, Colombia presents an interesting scenario with a tobacco use prevalence of 11% among men and 3% among women, resulting in a ratio of 3.67. Its male-to-female death ratio attributed to tobacco is 2.08, marking it as the third-lowest ratio among the eight countries. Nonetheless, when it comes to tobacco-attributed disease occurrences, Colombia demonstrates a higher ratio compared to the other nations (Figure 2).

Additionally, Table 3 shows the results of the economic burden attributable to tobacco by sex in 2020. We estimated that the health systems in these eight countries spent $22.8 billion in direct medical costs due to tobacco use. Of this total, $15.5 billion was spent by men and $7.2 billion by women. This represents a male-to-female ratio of 2.15. Ecuador had the greatest disparity in costs between men and women, with $5.14 spent on men for every dollar spent on women, while Peru was the country with the lowest difference in cost between men and women (1.29 dollars for every dollar in women).

The economic burden of tobacco-attributable productivity loss was estimated at $16.2 billion, with $12.3 billion in men and $3.9 billion in women. Among the analyzed cost categories, this cost exhibited the most significant difference by sex, consistently observed across countries. Ecuador and Mexico presented the greatest lost productivity costs, with 5.3 billion and 5.0 billion dollars lost in productivity in men for every dollar lost in productivity in women, respectively. Conversely, Peru has the lowest ratio of productivity loss costs for men to women among the countries examined. Informal care costs represented an additional burden of $10.8 billion, with $6.9 billion for caring for a man and $3.9 billion for caring for a woman. This means that men generate higher informal care costs than women. These differences are particularly marked in Ecuador, Costa Rica, and Mexico, where $4.45, $3.78, and $3.34 are spent to care for a man for every dollar spent to care for a woman, respectively.

Discussion

Despite WHO estimates indicating a decrease in the prevalence of smoking in the Americas region, smoking remains one of the main causes of disease and economic burden in men and women, with large differences between and within countries. Our study estimates that almost a thousand people die every day because of tobacco use in these eight countries, and annually it causes more than 2 million disease events, including cardiovascular events, cancer, stroke, COPD, and other diseases. Men—being more likely than women to smoke—are also two times more likely to die from smoking, and to have disease events attributable to tobacco use. However, the study shows significant heterogeneity among the countries analyzed in the region. In some countries (Ecuador, Costa Rica, and Mexico) the deaths and cases in men are more than 3 times higher than women. Although this aspect is associated with a higher prevalence in the countries, the relationship is not completely linear.

The differences in tobacco prevalence rates and associated health burden by sex clearly illustrate that differences in tobacco use are not necessarily determined by sex differences in relation to the psychopharmacological properties of nicotine or other tobacco components, and that social opinions play an important role in determining the smoking rates, possibly related to differences in gender equality between countries. (47, 48) To such an extent that the WHO points out that in countries where women are more empowered, smoking rates for women are higher than those for men, regardless of income inequality. (48) Similarly, other social determinants, such as ethnic origin and socioeconomic position, play an important role during the first years of life, when health behaviors and risk factors are formed, up to adolescence and adulthood. (24, 49) Specifically, related to gender, an example would be the products designed by the tobacco industry, such as "light" cigarettes marketed specifically for women, they are smoked with greater intensity and have higher yields of nitrosamines, which is responsible for the increase in lung cancer in women. Another example would be the gender bias in the diagnosis of COPD, men are more likely to be diagnosed with COPD than women with the same symptoms, delaying their diagnosis. (47, 48) So we can mention that the differences between men and women in tobacco consumption and its impact are crossed by various socioeconomic and cultural factors that can explain the differences between countries, and within a country.

In addition, our study shows the gender difference in the economic burden attributable to tobacco use. In 2020, tobacco use causes $49.8 billion in economic losses in the eight countries. Of this total, direct costs accounted for 46%, productivity loss costs represented 33% and informal care represented 22%. The analysis by gender showed that the highest proportion of direct and indirect costs were generated by men. The greatest difference between men and women is observed in the costs of lost productivity, more than 3 times, even though the model does not consider differences according to participation in the labor market. This disparity not only correlates with increased mortality and morbidity rates among males but also underscores the disparity in labor income by gender. It is known that the prevalence of tobacco use is higher in lower-income households, (50) and society is experiencing a situation known as the feminization of poverty. (19) Therefore, the loss of employment or falling ill for a female head of household can be financially more catastrophic than for a male head of household. (51) On the other hand, the study reveals that 22% of the overall cost corresponds to expenditures on informal care. It is widely recognized that women predominantly assume the role of informal caregivers, further exacerbating their disadvantaged position. (20) Furthermore, when analyzing between

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TABLE 2 Annual burden of mortality and disease incidence attributable to tobacco by sex, country, and specific diseases for 2020.

Country	Chile	Peru	Brazil	Argentina	Costa Rica	Mexico	Colombia	Ecuador	Total
Deaths									
Cardiovascular disease									
Men	2,042	1,493	24,271	7,853	433	15,580	5,357	1,222	58,251
Women	944	759	8,908	2,193	86	3,950	2,595	229	19,664
Ratio	2.16	1.97	2.72	3.58	5.03	3.94	2.06	5.34	2.96
Stroke									
Men	772	912	6,159	1,371	69	2,996	1,057	360	13,696
Women	472	626	3,882	804	25	1,097	598	111	7,615
Ratio	1.64	1.46	1.59	1.71	2.76	2.73	1.77	3.24	1.80
Lung cancer									
Men	1,986	1,324	15,903	6,018	198	3,647	2,891	484	32,451
Women	1,217	1,097	8,540	2,573	56	1,475	1,446	196	16,600
Ratio	1.63	1.21	1.86	2.34	3.54	2.47	2.00	2.47	1.95
Pneumonia/influenza									
Men	425	1,684	8,882	2,683	83	3,232	594	438	18,021
Women	268	1,190	3,319	1,245	14	848	189	76	7,149
Ratio	1.59	1.42	2.68	2.16	5.93	3.81	3.14	5.76	2.52
*Other cancers**									
Men	2,149	1,991	20,757	4,325	278	4,680	2,790	739	37,709
Women	891	1,098	4,926	1,427	54	1,169	794	159	10,518
Ratio	2.41	1.81	4.21	3.03	5.15	4.00	3.51	4.65	3.59
Passive smoking									
Men	1,388	1,539	13,284	3,714	206	5,763	2,454	652	29,000
Women	803	1,018	5,467	1,476	49	1,622	1,056	148	11,639
Ratio	1.73	1.51	2.43	2.52	4.20	3.55	2.32	4.41	2.49
COPD									
Men	2,832	3,910	21,705	5,059	452	12,243	5,357	1,552	53,110
Women	2,901	3,715	15,981	4,058	176	4,975	3,181	458	35,445
Ratio	0.98	1.05	1.36	1.25	2.57	2.46	1.68	3.39	1.50
Diseases events									
Cardiovascular disease									
Men	29,325	11,986	335,780	51,211	6,879	145,769	38,189	17,817	636,956
Women	13,569	7,306	157,284	16,324	1,047	25,337	20,812	2,280	243,959
Ratio	2.16	1.64	2.13	3.14	6.57	5.75	1.83	7.81	2.61
Stroke									
Men	8,001	6,006	31,618	7,355	269	25,669	10,156	2,988	92,062
Women	4,579	4,649	21,119	4,049	103	9,058	6,480	857	50,894
Ratio	1.75	1.29	1.50	1.82	2.61	2.83	1.57	3.49	1.81
Lung cancer									
Men	2,219	1,455	16,940	6,557	254	4,224	3,088	527	35,264
Women	1,458	1,275	9,186	2,981	68	1,836	1,565	228	18,597
Ratio	1.52	1.14	1.84	2.20	3.74	2.30	1.97	2.31	1.90
Pneumonia/influenza									
Men	3,444	13,385	77,596	20,235	581	32,518	4,764	3,830	156,353

(Continued)

TABLE 2 (Continued)

Country	Chile	Peru	Brazil	Argentina	Costa Rica	Mexico	Colombia	Ecuador	Total
Women	2,067	10,784	37,382	12,452	192	11,427	2,072	918	77,294
Ratio	1.67	1.24	2.08	1.63	3.03	2.85	2.30	4.17	2.02
*Other cancers**									
Men	3,448	3,056	32,411	7,433	478	7,118	4,357	1,069	59,370
Women	1,398	1,789	7,850	2,221	90	1,884	1,231	253	16,716
Ratio	2.47	1.71	4.13	3.35	5.31	3.78	3.54	4.23	3.55
COPD									
Men	32,501	39,419	245,080	56,680	5,015	140,048	54,256	18,268	591,267
Women	30,219	35,540	188,649	45,015	2,143	56,443	31,349	5,550	394,908
Ratio	1.08	1.11	1.30	1.26	2.34	2.48	1.73	3.29	1.50

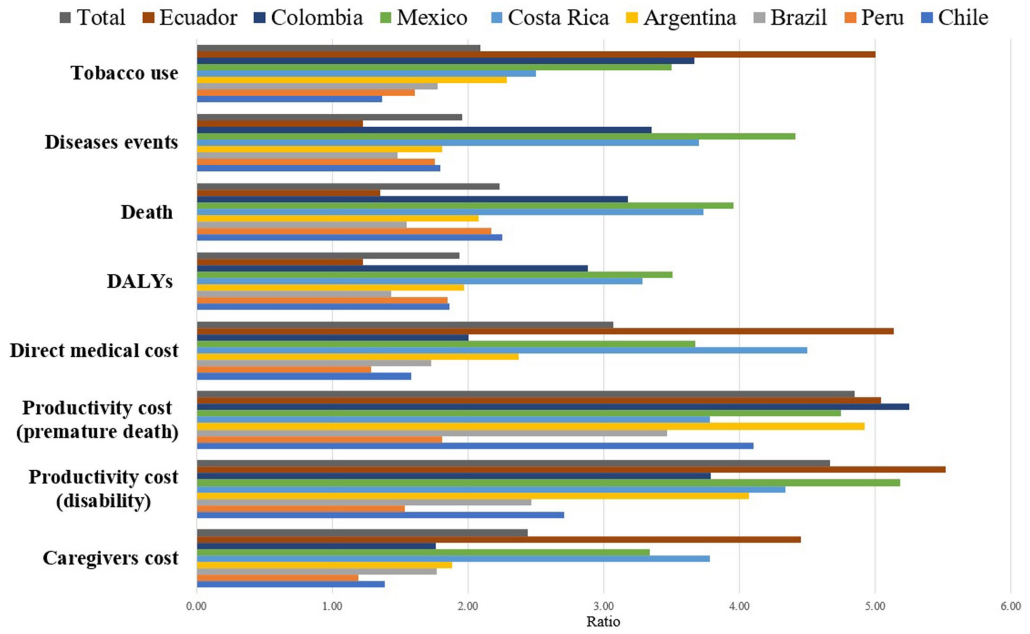

FIGURE 2
Ratios of men/women in tobacco use and the associated disease and economic burdens by country for the year 2020.

countries, a significant heterogeneity in both direct and indirect costs can be observed, which further highlights the existing inequalities within the region.

The scope of the analysis was limited by data limitations. First, the information presented in this study is based on the available sex-disaggregated data, acknowledging its limitations. It is crucial to recognize that relying solely on sex-specific data may restrict a comprehensive understanding of the intricate relationship between gender dynamics and their impact on the research findings. Gender encompasses various social, cultural, and individual factors that extend beyond biological sex and can influence health outcomes and behaviors. Consequently, the interpretations and conclusions drawn from this analysis may not fully capture the nuanced interactions between gender and the subject matter under investigation. To enhance the depth and accuracy of future research, efforts should be made to collect and report both sex and gender-disaggregated data. Second, the data on health spending were not available by disease, sex, and age, so we were unable to perform a more detailed analysis of direct cost; although we use the best available information and apply a uniform and replicable method, the availability and quality of epidemiological and cost information in Latin America is heterogeneous, and this could have led to an underestimation or overestimation of the direct cost. Although all the main costs have been considered, the caregiver cost data is not disaggregated by sex, since we do not have information on the sex and age of the caregiver. However, there are several studies that show that informal care is mainly carried out by women. Third, although our study did not include all Latin American countries, the countries analyzed comprise 80% of the population and represent a diverse sample. Despite these limitations, our study provides a comprehensive and robust estimate of the health and financial burden of smoking in Latin America and shows a huge tobacco-attributable burden, which is likely a

TABLE 3 Annual economic burden attributable to tobacco by sex and country for 2020 (USD millions).

Country	Chile	Perú	Brazil	Argentina	Costa Rica	México	Colombia	Ecuador	TOTAL
Direct medical cost									
Men	1,198,735,774	683,401,917	5,921,380,002	1,957,452,356	233,312,455	4,222,520,742	780,666,475	548,870,177	15,546,339,898
Women	756,254,016	531,802,466	3,426,030,681	823,617,858	51,824,272	1,148,300,627	388,961,213	106,865,913	7,233,657,046
Ratio	1.59	1.29	1.73	2.38	4.50	3.68	2.01	5.14	2.15
Productivity cost (early death)									
Men	327,300,700	198,124,120	2,694,105,227	556,032,944	37,098,478	878,008,000	205,570,417	100,504,334	4,996,744,219
Women	79,763,464	109,304,663	777,722,681	112,939,471	9,810,365	184,896,939	39,173,112	19,917,657	1,333,528,352
Ratio	4.10	1.81	3.46	4.92	3.78	4.75	5.25	5.05	3.75
Productivity cost (disability)									
Men	527,746,658	259,544,149	3,885,387,260	643,137,177	79,950,884	1,389,582,989	300,452,179	198,990,057	7,284,791,354
Women	194,640,187	168,784,352	1,572,989,227	157,970,662	18,419,472	268,211,161	79,372,283	36,078,400	2,496,465,743
Ratio	2.71	1.54	2.47	4.07	4.34	5.18	3.79	5.52	2.92
Caregivers cost									
Men	655,832,930	380,948,275	3,847,047,539	697,604,326	79,106,691	710,139,143	331,215,745	254,939,143	6,956,833,791
Women	471,732,409	319,194,077	2,176,609,904	370,288,995	20,931,537	212,562,854	187,788,713	57,282,072	3,816,390,560
Ratio	1.39	1.19	1.77	1.88	3.78	3.34	1.76	4.45	1.82

conservative estimate as data on the burden were not available from secondhand smoke.

This study makes visible the need to generate more evidence based on gender and diversity to develop more sensitive research focused on the differential needs of women who are affected by tobacco use. Understanding and incorporating both sex and gender perspectives in research design, data collection, analysis, and interpretation can lead to more comprehensive and accurate findings, ultimately contributing to better-informed policies and interventions. At the same time, we hope that this analysis expands future research, considering the contextual differences in the different countries of the Latin American region from a sensitive perspective that shows the differences in the burden of tobacco use between men and women and including advances in issues of gender in the region.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

AA: Conceptualization, Investigation, Methodology, Project administration, Supervision, Validation, Visualization, Formal analysis, Writing – original draft. EL: Visualization, Writing – original draft, Formal analysis, Investigation, Methodology. AC: Data curation, Formal analysis, Visualization, Writing – review & editing. FR-C: Data curation, Writing – review & editing. FA: Conceptualization, Methodology, Supervision, Validation, Writing – review & editing. AB: Conceptualization, Methodology, Supervision, Validation, Writing – review & editing. LP: Data curation, Writing – review & editing, Visualization. AP: Conceptualization, Methodology, Validation, Writing – review & editing. AP-R: Conceptualization, Methodology, Supervision, Validation, Writing – review & editing. NE: Formal analysis, Methodology, Validation, Writing – review & editing, Conceptualization, Supervision.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

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Sex differentials in the prevalence of behavioral risk factors and non-communicable diseases in adult populations of West Kazakhstan

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Introduction: The prevalence of non-communicable diseases (NCDs) is increasing worldwide. Several modifiable risk factors, such as smoking, alcohol drinking, physical inactivity, and obesity, have been linked to the development of NCDs in both genders. Understanding the prevalence of these risk factors and their associated factors is crucial for effective intervention planning in adult populations. This study aimed to provide an overview of the prevalence and associated factors of these risk behaviors among different genders of adults in West Kazakhstan.

Methods: A cross-sectional study was conducted in four regions of West Kazakhstan. A stratified multistage sampling technique was utilized to obtain a representative sample size of 4,800 participants aged 18 -69 years. Trained researchers administered face-to-face interviews using validated questionnaires to gather information pertaining to sociodemographic characteristics, smoking habits, alcohol drinking, dietary patterns, physical activity levels, body mass index (BMI), and prevalent diseases.

Results: This study, which included 4,800 participants from West Kazakhstan, revealed some striking numerical findings. The overall prevalence rates of behavioral risk factors and metabolic conditions were as follows: smoking was 13.6% (95%CI: 3.2–24.0%), alcohol drinking was 47.0% (27.7–66.3%), current obesity was 22.3% (9.0–35.6%), and physical inactivity was 80.7% (55.4–106.0%). In addition, the overall prevalence rates of metabolic conditions were 25.6% (11.3–39.9%) for hypertension, 7.5% (0.2–15.2%) for diabetes, 11.8% (2.1–21.5%) for high cholesterol, and 13.0% (2.8–23.2%) for cardiovascular diseases. Additionally, a higher prevalence of high cholesterol was observed in men, and a greater prevalence of heart disease was identified in women. Multinomial logistic regression revealed that physical inactivity was associated with hypertension, diabetes, and heart disease, while obesity was linked to hypertension, high cholesterol, and heart disease.

Discussion: This study in West Kazakhstan identified variations in the prevalence of behavioral risk factors and NCDs, highlighting gender, age, and regional disparities. Notably, men showed higher rates of smoking and alcohol drinking, while women exhibited a greater prevalence of physical inactivity and obesity. Gender and regional differences were evident, with the West Kazakhstan region standing out for distinct

patterns. Tailored interventions are crucial to address these disparities and enhance public health in the region.

KEYWORDS

behavioral risk factors, non-communicable diseases, sex differentials, cardiovascular disease, diabetes, hypertension, high cholesterol

1 Introduction

Among middle-aged and older adults, the global concern of lifestyle-related risk factors, including smoking, alcohol drinking, poor nutrition, physical inactivity, and obesity, is paramount (1). Kazakhstan, which is undergoing dynamic societal shifts post-Soviet Union dissolution, experiences challenges linked to urbanization and changing dietary patterns (2). These shifts, notably increased processed food consumption, raise concerns about obesity and non-communicable diseases (NCDs).

Understanding the prevalence of risk factors among middle-aged and older adults in Kazakhstan is imperative due to their contributions to NCDs (3). These factors significantly impact quality of life, functional ability, and independence (4). The country, with its rich cultural heritage and rapid urbanization, faces unique health challenges, including complex dietary practices (2).

Factors such as smoking, excessive alcohol drinking, physical inactivity, and obesity contribute to NCDs in both genders (5). This study aims to systematically investigate these factors among adult populations in West Kazakhstan, focusing on patterns, gender disparities, and regional variations. The objective of this study is to inform targeted public health interventions and improve well-being.

Aligned with the World Health Organization (WHO) recommendations on physical activity and sedentary behavior (WHO guidelines on physical activity and sedentary behavior; WHO: Geneva, Switzerland, 2020), our research explores lifestyle choices, emphasizing sex differentials in middle-aged and older adults in West Kazakhstan.

Kazakhstan's diverse population and rapid urbanization pose unique health challenges. This study aims to provide a holistic view of health challenges, exploring cultural and socioeconomic determinants influencing behaviors and their impact on the health system.

The study aims to investigate the prevalence and determinants of key behavioral risk factors, such as smoking, alcohol drinking, physical inactivity, and obesity, among adults in West Kazakhstan. By adopting a sex-differential perspective, we aim to uncover patterns and regional variations in these behaviors. This research is significant not only for filling knowledge gaps but also for guiding evidence-based interventions. Our ultimate goal is to promote healthier aging and reduce the burden of NCDs in the region.

2 Materials and methods

2.1 Ethical issues

The research protocol received ethical approval from the Local Ethics Committee of S.D. Asfendiyarov Kazakh National Medical University, Almaty, Republic of Kazakhstan, under protocol number 12 (118) dated 28 September 2021. Additionally, this study obtained ethical approval from the Central Bioethics Commission of the Ministry of Healthcare of the Republic of Kazakhstan, as indicated by protocol number 14, dated 24 November 2021. The study was duly registered on ClinicalTrials.gov under identifier NCT05122832. All methodologies adhered to relevant ethical and procedural guidelines, and informed consent was appropriately obtained from all study participants or their legal representatives.

2.2 Study design and population

This cross-sectional study consisted of a representative sample of people aged 18–69 years in the general population of the population of West Kazakhstan regions for the period October 2021 to May 2022 from four regions.

In this study, a total of 4,800 participants were surveyed, and their characteristics are presented in Tables 1, 2. The participants were categorized based on their regions of residence, and the prevalence rates of various health-related behaviors and conditions were assessed.

This demographically representative study of the adult populace employed a stratified sampling method, categorized according to Western regions of Kazakhstan, with the primary objective of attaining precise prevalence estimations for health-related indicators across the entirety of West Kazakhstan's administrative regions. In each regional stratum, a total of 1,200 individuals aged between 18 and 69 years were subjected to examination, spanning four distinct regions: Aktobe region, Atyrau region, Mangistau region, and West Kazakhstan region. The sampling strategy within each stratum (region) adopted a two-tiered cluster sampling framework. In the initial phase, 30 primary sampling areas (PSAs), or clusters, were meticulously chosen. Subsequently, a comprehensive roster of all residents aged 18–69 years, domiciled within the selected clusters, was meticulously compiled. During the second phase, 65 participants were randomly selected from each of these lists, employing a systematic sampling method, while adhering to an anticipated participant outreach rate of 62%. Consequently, this approach resulted in an average of 40 individuals being assessed within each cluster.

2.3 Inclusion criteria

This study utilized the WHO STEPS questionnaire to establish specific inclusion criteria, ensuring a comprehensive and representative participant pool. Inclusion criteria encompassed individuals between the ages of 18 and 69 years, spanning both genders. Additionally, participants were required to be residents of the

TABLE 1 Characteristics of study participants at baseline.

Index	Total	Male	Female
Age groups, *N* (%)			
18–29	674 (14.0)	310 (6.5)	364 (7.6)
30–39	1,021 (21.3)	370 (7.7)	651 (13.6)
40–49	1,094 (22.8)	378 (7.9)	716 (14.9)
50–59	1,205 (25.1)	407 (8.5)	798 (16.6)
60–69	806 (16.8)	258 (5.4)	548 (11.4)
Marital status, *N* (%)			
Single or unmarried	793 (16.5)	308 (6.4)	485 (10.1)
Married	3,419 (71.2)	1,322 (27.5)	2097 (43.7)
Married but living separately	33 (0.7)	10 (0.2)	23 (0.5)
Divorced	293 (6.1)	54 (1.1)	239 (5.0)
Widower/widow	244 (5.1)	22 (0.5)	222 (4.6)
Civil marriage	18 (0.4)	7 (0.1)	11 (0.2)
Ethnic groups, *N* (%)			
Kazakh	3,522 (73.4)	1,291 (26.9)	2,231 (46.5)
Russian	979 (20.4)	328 (6.8)	651 (13.6)
Uzbeks	20 (0.4)	8 (0.2)	12 (0.3)
Ukrainians	50 (1.0)	14 (0.3)	36 (0.8)
Tatars	70 (1.5)	21 (0.4)	49 (1.0)
Other	158 (3.3)	61 (1.3)	97 (2.0)
Education level, *N* (%)			
No schooling	45 (0.9)	30 (0.6)	15 (0.3)
Completed primary school (4 grades)	8 (0.2)	1 (0)	7 (0.1)
Completed secondary school (9 grades)	271 (5.6)	115 (2.4)	156 (3.3)
Completed secondary school (11 grades)	1,121 (5.6)	377 (7.9)	744 (15.5)
Completed high school	2,433 (50.7)	902 (18.8)	1,532 (31.9)
Master's/Postgraduate/Doctoral studies	922 (19.2)	299 (6.2)	623 (13.0)
Labor force status, *N* (%)			
State employee	648 (13.5)	197 (4.1)	451 (9.4)
Private sector worker	1938 (40.4)	870 (18.1)	1,068 (22.3)
Budget employee	702 (14.6)	188 (3.9)	514 (10.7)
Entrepreneur	296 (6.2)	122 (2.5)	174 (3.6)
Farm worker	14 (0.3)	12 (0.3)	2 (0)
Student	65 (1.4)	38(0.8)	27 (0.6)
Housewife	326 (6.8)	16 (0.3)	310 (6.5)
Pensioner	552 (11.5)	149(3.1)	403 (8.4)
Unemployed (able to work)	220 (4.6)	114 (2.4)	106 (2.2)
Unemployed (unable to work)	39 (0.8)	17 (0.4)	22 (0.5)

surveyed regions in Kazakhstan, as defined by our research scope (6). No specific inclusion criteria were applied based on gender.

The age range of 18–69 years was chosen to encompass a significant portion of the adult population, allowing for a broad and comprehensive examination of health-related parameters across various age groups within the adult demographic. By including individuals from young adulthood to late middle age, this study could capture a diverse range of health behaviors and conditions.

Individuals within the age range of 18–69 years often experience diverse lifestyle factors. This age range spans crucial life stages where lifestyle choices, such as smoking, alcohol drinking, physical activity levels, and obesity, may significantly impact health outcomes.

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TABLE 2 Characteristics of study participants at baseline: behavioral and metabolic risk factors by sex.

Index	Total	Male	Female	*p*-value
Smoking status, *N* (%)				0.001
Yes	655 (13.6)	503 (10.5)	152 (3.2)	
No	4,145 (86.4)	1,220 (25.4)	2,925 (60.9)	
Alcohol drinking, *N* (%)				0.001
Yes	2,254 (47.0)	962 (20.0)	1,292 (26.9)	
No	2,546 (53.0)	761 (15.9)	1785 (37.2)	
Waist circumference, *N* (%)				0.001
< 80 cm	1,649 (34.4)	425 (8.9)	1,224 (25.5)	
80–94 cm	1775 (37.0)	635 (13.2)	1,140 (23.8)	
>94 cm	1,376 (28.7)	663 (13.8)	713 (14.9)	
BMI category, *N* (%)				0.413
Underweight (< 18.5)	95 (2.0)	35 (0.7)	60 (1.3)	
Normal (18.5–24.9)	1806 (37.6)	655 (13.6)	1,151 (24.0)	
Pre-obesity (25.0–29.9)	1831 (38.1)	634 (13.2)	1,197 (24.9)	
Obesity class I (30.0–34.9)	771 (16.1)	277 (5.8)	494 (10.3)	
Obesity class II (35.0–39.9)	227 (4.7)	92 (1.9)	135 (2.8)	
Obesity class III (≥40)	70 (1.5)	30 (0.6)	40 (0.8)	
Physical activity, *N* (%)				0.001
Yes	925 (19.3)	448 (9.3)	477 (9.9)	
No	3,875 (80.7)	1,275 (26.6)	2,600 (54.2)	
Hypertension, *N* (%)				0.001
Yes	1,220 (25.6)	391 (8.1)	837 (17.4)	
No	3,572 (74.4)	1,332 (27.8)	2,240 (46.7)	
High cholesterol, *N* (%)				0.001
Yes	566 (11.8)	157 (3.3)	409 (8.5)	
No	4,234 (88.2)	1,566 (32.6)	2,668 (55.6)	
Diabetes, *N* (%)				0.311
Yes	359 (7.5)	120 (2.5)	239 (5.0)	
No	4,441 (92.5)	1,603 (33.4)	2,838 (59.1)	
Heart disease, *N* (%)				0.389
Yes	623 (13.0)	214 (4.5)	409 (8.5)	
No	4,177 (87.0)	1,509 (31.4)	2,668 (55.6)	

Exploring these factors in a population with a broad age range provides a more nuanced understanding of how lifestyle choices may vary across different life stages.

The selected age range aligns with the specific focus of the current study, which explores the associations between gender, NCDs, and health-related behaviors. Understanding how these factors interact in adults aged 18–69 years in West Kazakhstan is essential for drawing meaningful conclusions about the prevalence and patterns of smoking, alcohol drinking, physical inactivity, and obesity in this population.

In summary, the rationale behind choosing the age group 18–69 years is rooted in the desire to conduct a thorough and meaningful investigation into the associations between gender, NCDs, and key health-related behaviors in a diverse adult population in West Kazakhstan. This age range allows for a comprehensive exploration of the factors that contribute to health outcomes in the context of the current study.

2.4 Exclusion criteria

To maintain the integrity and ethical standards of our study, rigorous exclusion criteria were applied during participant selection.

Individuals lacking the capacity to offer informed consent due to cognitive impairment or any other factor that might undermine their comprehension of the study procedures were excluded.

Non-residents of the surveyed regions were excluded to ensure the geographical relevance of our findings.

Participants who declined to participate in the study were also excluded, as their voluntary participation was fundamental to the research process (6).

2.5 Survey

The Russian-translated version of the STEPS questionnaire, which had undergone prior translation (specifically, the WHO STEPS tool, encompassing both basic and advanced modules), was employed for data collection. These WHO STEPS questionnaires were integrated into the HealthTrack mobile application, facilitating their utilization by the certified interviewers who conducted the survey.

2.6 Covariates

Blood pressure was measured through three tests, with the caveat that any variation exceeding 10 mm Hg. between readings prompted the utilization of the mean value derived from the two readings closest in proximity. The measurements were taken using an Omron digital automatic blood pressure monitor model HEM-8712, equipped with appropriately sized cuffs, from Omron Health Care Co., Japan28. Elevated blood pressure was defined as systolic blood pressure reaching or exceeding 140 mm Hg. and/or diastolic blood pressure equal to or exceeding 90 mm Hg. during the study or as per previously established diagnoses of arterial hypertension.

Diabetes was defined by fasting plasma glucose levels of ≥7.0 mmol/L (126 mg/dL), 2 h plasma glucose levels of ≥11.1 mmol/L (200 mg/dL), HbA1c concentrations of ≥6.5%, a self-reported history of diagnosed diabetes, or the use of anti-diabetic medications. High cholesterol was determined by fasting serum total cholesterol levels of ≥6.22 mmol/L or the utilization of cholesterol-lowering medications.

Body mass index (BMI) indicators were categorized into five distinct groups: BMI < 18.4—indicative of underweight; BMI ≥ 18.5 and < 24.9—reflecting normal weight; BMI ≥ 25 and < 29.9—indicative of overweight; BMI ≥ 30 and < 34.9—representing obesity of the first degree; and BMI > 35—characterizing obesity of the second degree (7). The BMI was calculated using a standardized protocol based on the WHO guidelines. Weight and height measurements were obtained using calibrated instruments, ensuring accuracy and reliability in the data collection process. Trained personnel conducted these measurements following established procedures to minimize potential sources of error. The BMI of the study participants was calculated using precise anthropometric measurements. Trained personnel conducted height and weight measurements during face-to-face interviews. Height was measured to the nearest 0.1 cm using a standard height meter, and weight was measured to the nearest 0.1 kg using calibrated electronic scales. The measurements followed standardized procedures, and participants were asked to remove heavy outer clothing and shoes before measurements. Consistent measurement instruments were utilized across all study locations. The same model of calibrated electronic scales and height meters was employed to maintain measurement uniformity and accuracy. The instruments were regularly calibrated to ensure the reliability of the measurements. No declared values were used for the calculation of BMI. All measurements were taken directly from the study participants during the data collection process. To ensure the accuracy and reliability of the collected data, quality control measures were implemented, including training sessions for data collectors, regular calibration of instruments, and periodic checks on measurement procedures.

In this study, cardiovascular disease is operationally defined to encompass myocardial infarction, stroke, and coronary artery disease. The term cardiovascular disease refers to a class of diseases that involve the heart or blood vessels. In the context of the study, the term "cardiovascular disease" is a broad category that includes various conditions affecting the heart and blood vessels. Myocardial infarction is commonly known as a heart attack, which occurs when the blood supply to a part of the heart muscle is blocked, leading to damage or death of the heart tissue (8). Stroke refers to the condition where there is a sudden interruption in the blood supply to the brain, leading to damage or death of brain cells. Strokes can be caused by a blockage or bleeding in the brain (9). Coronary artery disease is a condition where the blood vessels supplying the heart muscle (coronary arteries) become narrow or blocked, affecting blood flow to the heart (10).

With regard to educational attainment, survey respondents were categorized into the following groups: those with no formal schooling; individuals who had completed primary education (up to grade 4); those who had completed secondary education (up to grade 9); those with a secondary education diploma (up to grade 11); individuals with higher education qualifications; respondents engaged in master's, postgraduate, or doctoral studies; and those who declined to provide an answer.

Based on nationality, respondents were segmented into distinct groups encompassing Kazakhs, Russians, Uzbeks, Ukrainians, Uighurs, and Tatars, individuals belonging to other ethnic backgrounds, and those who chose not to disclose their ethnicity.

Marital status was classified into the following categories: single or unmarried, married, individuals in a married or married but living separately status, divorced, widowed, individuals in a civil partnership, and individuals who declined to respond.

With respect to smoking habits, respondents were categorized into two groups, distinguishing between smokers and non-smokers. Smoking involves inhaling tobacco smoke from cigarettes, cigars, or pipes.

In terms of alcohol drinking, the questionnaire encompassed a series of inquiries designed to ascertain the respondent's alcohol drinking habits, specifically determining whether they engage in alcohol drinking. Alcohol drinking is defined as the consumption of beverages containing ethanol, such as beer, wine, and spirits.

According to the WHO guidelines on physical activity and sedentary behavior, adults should engage in at least 150–300 min of moderate-intensity aerobic physical activity or at least 75–150 min of vigorous-intensity aerobic physical activity, or an equivalent combination of moderate- and vigorous-intensity activity throughout the week, to achieve substantial health benefits (11).

Dietary habits were evaluated through a series of inquiries, including questions such as "On an average day, how many servings of fruit do you typically consume?" and "On an average day, how many servings of vegetables do you typically consume?" The participants' responses were categorized into quartiles. Respondents indicated their customary consumption of standard-sized food

portions, with a maximum frequency of up to six times per day. The frequency and quantity of each specific food item, encompassing both fruits and vegetables, were then converted into an average daily intake for each respective category (12).

2.7 Statistical analysis

All statistical analyses were weighted to ensure the representation of the entire adult population in West Kazakhstan, aged 18–69 years, by employing individual sampling weights to account for non-response. Prior to proceeding with further analyses, an assessment of the normality of the variables was conducted. Comparative analysis of participant characteristics across various residential settings was executed through chi-square tests applied to categorical variables. The study calculated the overall prevalence of smoking, alcohol drinking, physical inactivity, and obesity. Additionally, the prevalence of individual behavioral risk factors was delineated by gender, age, and the regions of West Kazakhstan, namely, Aktobe region, Atyrau region, Mangystau region, and West Kazakhstan region. To visually depict the geographical distribution of these behavioral risk factors, the province-specific prevalence was graphically represented using GraphPad Prism 7.0.

To investigate the connection between behavioral risk factors and metabolic conditions, binary logistic regressions and multinomial logistic regressions were employed to derive odds ratios (ORs) and corresponding 95% confidence intervals (CIs). In the binary logistic regression models, metabolic conditions, categorized as either present or absent, were designated as dependent variables, while behavioral risk factors served as the independent variables. Statistical significance was established at a threshold of p-values below 0.05.

It is pertinent to clarify that gender-specific analyses were undertaken, encompassing separate analyses for men and women. This approach was adopted to discern potential sex-specific patterns and variations in the relationship between behavioral risk factors and metabolic conditions. The distinction between gender-specific analyses ensures a nuanced understanding of these associations, acknowledging potential differences in health behaviors and outcomes between men and women.

All statistical analyses were conducted using SPSS, specifically version 25.0, developed by IBM SPSS, Inc. and headquartered in Chicago, Illinois, United States.

3 Results

3.1 Characteristics of study participants

Tables 1, 2 display the characteristics of the study participants (N = 4,800), categorized by their respective regions of residence. The overall prevalence rates of smoking, alcohol drinking, current obesity, and physical inactivity were 13.6% (95%CI: 3.2–24.0%), 47.0% (27.7–66.3%), 22.3% (9.0–35.6%), and 80.7% (55.4–106.0%), respectively. Additionally, the overall prevalence rates of hypertension, diabetes, high cholesterol, and cardiovascular diseases were 25.6% (11.3–39.9%), 7.5% (−0.2 to 15.2%), 11.8% (2.1–21.5%), and 13.0% (2.8–23.2%), respectively.

Based on the data presented in Table 3, it is evident that a substantial majority of respondents, constituting 80.4% (95%CI: 55.1–105.7%), reported the consumption of one daily serving of fruit. However, when categorized by gender, only 29.7% (95%CI: 14.3–45.1%) of men and 50.7% (95%CI: 30.6–70.8%) of women reported the same dietary habit. Similarly, responses regarding the consumption of one daily serving of vegetables were prevalent, with 73.0% (95%CI: 48.9–97.1%) of respondents indicating this practice. When stratified by gender, 26.8% (95%CI: 12.2–41.4%) of men and 46.2% (95%CI: 27.0–65.4%) of women reported consuming one daily serving of vegetables.

Regarding the consumption of processed foods characterized by elevated salt content, it was observed that 26.7% (95%CI: 12.1–41.3%) of respondents reported frequent consumption. However, when gender-specific differences were considered, 10.9% (95%CI: 1.6–20.2%) of men and 16.1% (95%CI: 4.8–27.4%) of women reported a similar dietary pattern.

3.2 Gender-related prevalence of smoking, alcohol drinking, physical inactivity, and obesity in West Kazakhstan

Figure 1 illustrates the age-stratified prevalence of current smoking, alcohol drinking, physical inactivity, and obesity in both men and women. Among these parameters, men exhibited a notably higher prevalence of smoking and alcohol drinking across all age categories, while women displayed a greater prevalence of physical inactivity and obesity than men. An observable decline in the prevalence of current smoking was evident with advancing age in men, extending across all four regions, except for the age groups of 40 years in Aktobe and 45 years in Atyrau, with similar exceptions identified for alcohol drinking among men aged 40–55, except in the Atyrau region among 45-year-old men. Conversely, a discernible trend indicated an elevated prevalence of physical inactivity among all participants as age increased. Additionally, the prevalence of obesity demonstrated an upward trajectory with age, particularly among urban men aged 45–55 years.

3.3 Gender-related prevalence of NCDs in West Kazakhstan

Figure 2 depicts the age-specific prevalence of hypertension and diabetes in both men and women across four regions in West Kazakhstan. The data reveal a considerably elevated prevalence of hypertension, diabetes, high cholesterol, and heart disease in both men and women across all age groups, with the only exception being diabetic women in the Aktobe and Atyrau regions within the age range of 60–69 years. Additionally, a higher prevalence of high cholesterol was observed in men, and a greater prevalence of heart disease was identified in women.

3.4 Regional prevalences of smoking, alcohol drinking, physical inactivity, and obesity in West Kazakhstan

The regions of West Kazakhstan and Mangistau displayed the highest prevalence of smoking, at 21.0% (95%CI: 8.0–34.0%) and 17.8% (95%CI: 5.8–29.7%), respectively. Notably, the three regions

TABLE 3 Characteristics of nutrition of study participants at baseline.

Index	Total	Male	Female	*p*-value
How many servings of fruit do you consume on one of these days?				0.015
Q1[a]	3,858 (80.4)	1,424 (29.7)	2,434 (50.7)	
Q2	440 (9.2)	139 (2.9)	301 (6.3)	
Q3	334 (7.0)	113 (2.4)	221 (4.6)	
Q4	168 (3.5)	47 (1.0)	121 (2.5)	
How many servings of vegetables do you consume on one of these days?				0.211
Q1	3,505 (73.0)	1,288 (26.8)	2,217 (46.2)	
Q2	726 (15.1)	250 (5.2)	476 (9.9)	
Q3	243 (5.1)	84 (1.8)	159 (3.3)	
Q4	287 (6.0)	87 (1.8)	200 (4.2)	
Q5	39 (0.8)	14 (0.3)	25 (0.8)	
How often do you add salt or savory sauces to food before eating it or directly during meals?				0.001
Always	879 (18.3)	290 (6.0)	589 (12.3)	
Often	678 (14.1)	281 (5.9)	397 (8.3)	
Sometimes	1,258 (26.2)	510 (10.6)	748 (15.6)	
Rarely	1,107 (23.1)	410 (8.5)	697 (14.5)	
Never	878 (18.3)	232 (4.8)	646(13.5)	
How often are salt, salty spices, or salty sauces added during cooking in your household?				0.001
Always	1979 (41.2)	633 (13.2)	1,346 (28.0)	
Often	690 (14.4)	272 (5.7)	418 (8.7)	
Sometimes	1,142 (23.8)	444 (9.3)	698 (14.5)	
Rarely	824 (17.2)	318 (6.6)	506 (10.5)	
Never	165 (3.4)	56 (1.2)	109 (2.3)	
How often do you eat processed foods high in salt?				0.001
Always	387 (8.1)	136 (2.8)	251 (5.2)	
Often	895 (18.6)	373 (7.8)	522 (10.9)	
Sometimes	1773 (36.9)	656 (13.7)	1,117 (23.3)	
Rarely	1,493 (31.1)	495 (10.3)	998 (20.8)	
Never	252 (5.3)	63 (1.3)	189 (3.9)	
How much salt or salty sauces do you think you consume?				0.001
Always	81 (1.7)	28 (0.6)	53 (1.1)	
Often	475 (9.9)	200 (4.2)	275 (5.7)	
Sometimes	3,116 (64.9)	1,156 (24.1)	1960 (40.8)	
Rarely	888 (18.5)	267 (5.6)	621 (12.9)	
Never	240 (5.0)	72 (1.5)	168 (3.5)	
How important is it for you to reduce salt in your diet?				0.001
Always	2,138 (44.5)	702 (14.6)	1,436 (29.9)	
Often	2,262 (47.1)	861 (17.9)	1,401 (29.2)	
Sometimes	400 (8.3)	160 (3.3)	240 (5.0)	
Do you think that eating too much salt or savory sauces can cause you serious health problems?				0.001
Always	3,285 (68.4)	1,087 (22.6)	2,198 (45.8)	
Often	1,109 (23.1)	465 (9.7)	644 (13.4)	
Sometimes	406 (8.5)	171 (3.6)	235 (4.9)	

[a]"Q" represents the quartiles (Q1–Q4) of reported servings of fruit consumed on one of these days. For each quartile, the table provides the total number and percentage of participants, as well as the gender-specific distribution. Quartiles are a statistical method of dividing a data set into four equal parts, offering insights into the distribution of fruit consumption within the study population.

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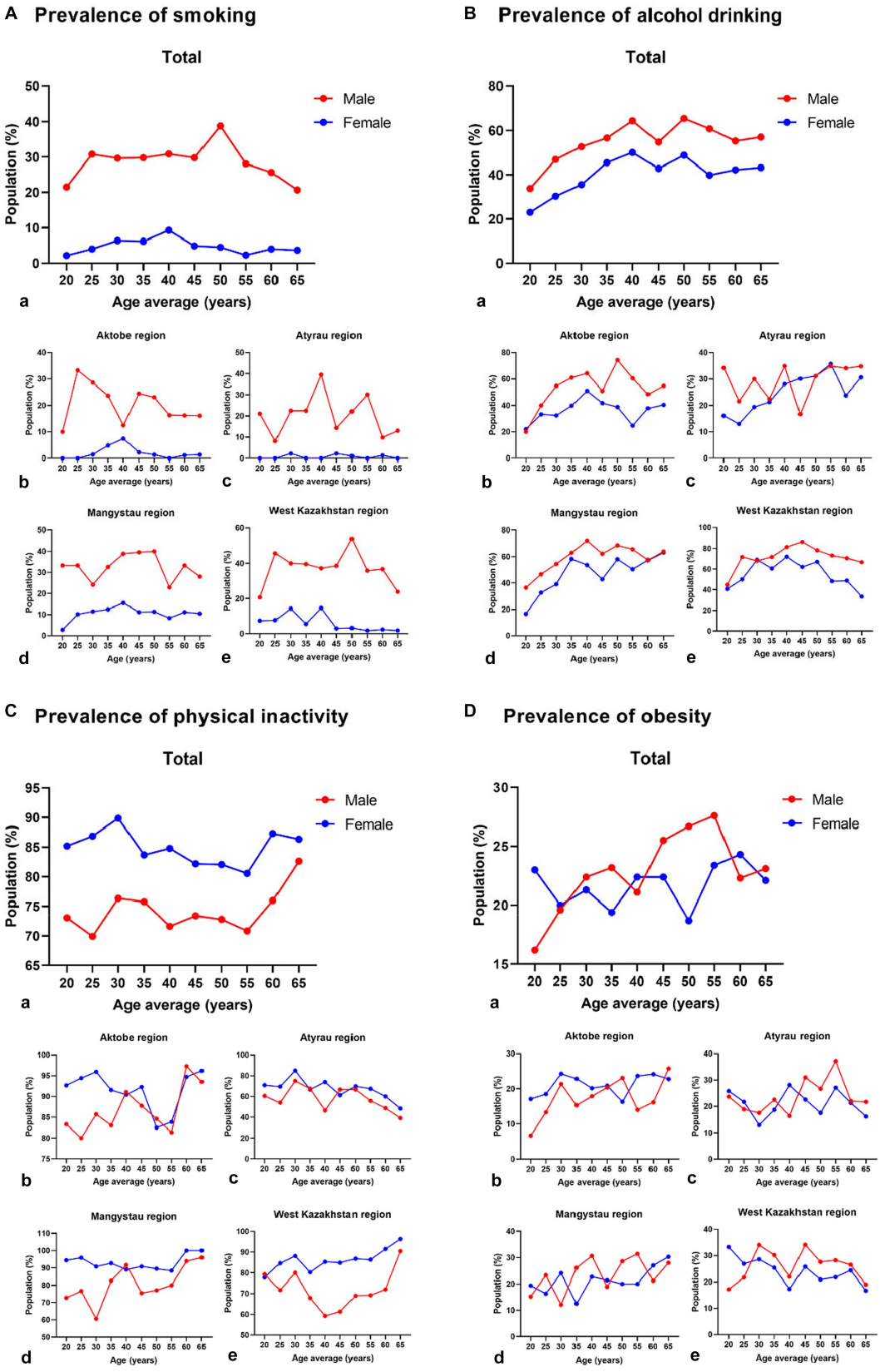

FIGURE 1
Prevalence of current smoking, alcohol drinking, physical inactivity, and obesity among men and women in the regions of West Kazakhstan. a–e Graphs with small letters labelling show total and four regions of west Kazakhstan.

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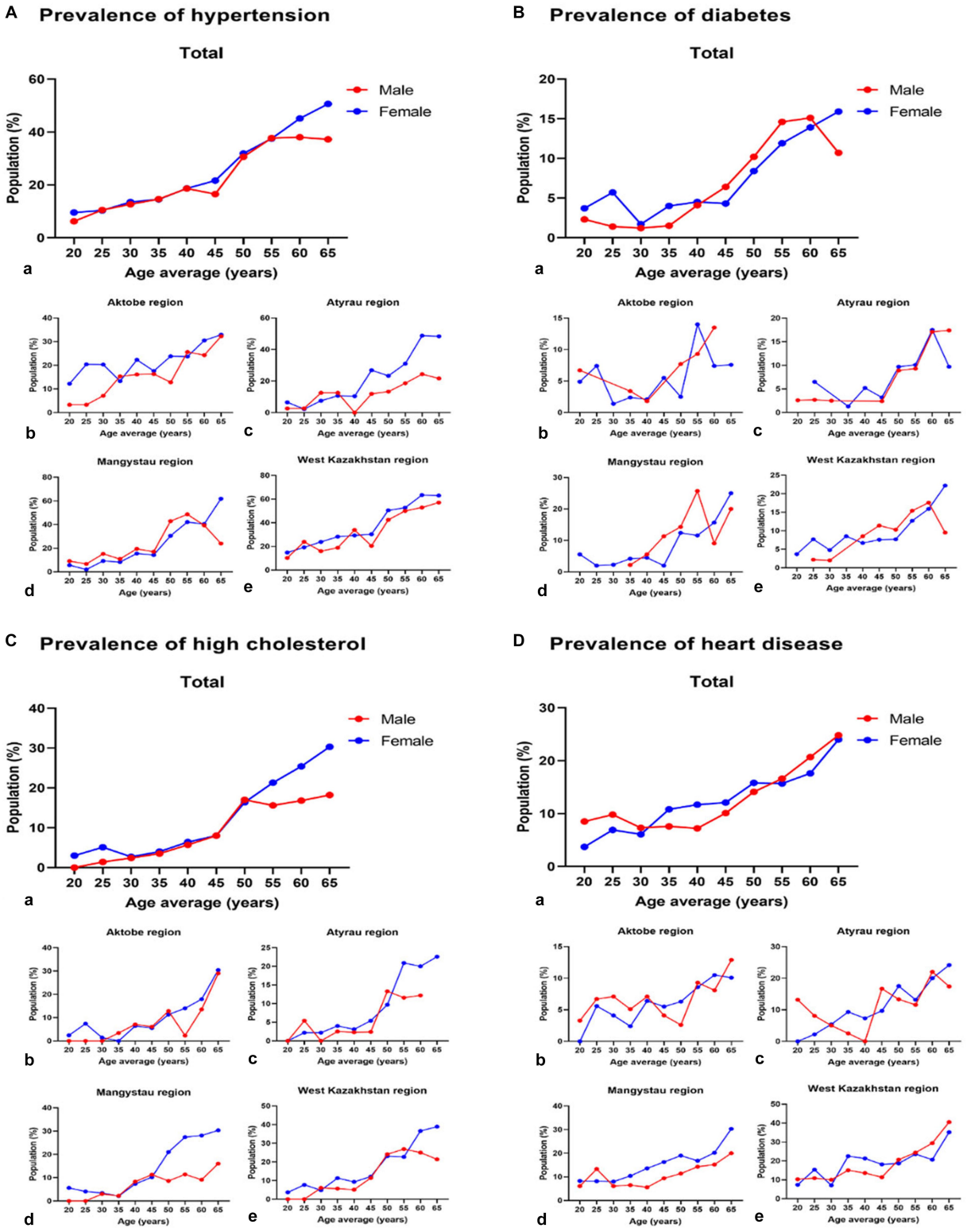

FIGURE 2
Prevalence of hypertension, diabetes, high cholesterol, and heart disease among men and women in the regions of West Kazakhstan. a–e Graphs with small letters labelling show total and four regions of west Kazakhstan.

with the highest prevalence of alcohol drinking were the West Kazakhstan region (64.0, 95%CI: 41.4–86.6%), the Mangystau region (52.9, 95%CI: 32.4–73.4%), and the Aktobe region (43.3, 95%CI: 24.8–61.9%). Furthermore, the Aktobe and Mangistau regions were distinguished by having the highest prevalence of physical inactivity, with rates of 89.7% (95%CI: 63.0–116.3%) and 88.9% (95%CI: 62.4–115.5%), respectively. The West Kazakhstan region, particularly in the northern part, exhibited a relatively high prevalence of obesity at

24.7% (95%CI: 10.6–38.7%). Regarding the prevalence of hypertension, diabetes, high cholesterol, and heart disease, the West Kazakhstan region recorded the highest rates than the other regions, with respective percentages of 39.0% (95%CI: 21.4–56.6%), 9.7% (95%CI: 0.9–18.5%), 17.3% (95%CI: 5.5–29.0%), and 20.0% (95%CI: 7.4–32.6%). Additional detailed information is shown in Supplementary Table S1.

Figure 3 depicts the prevalence of behavioral risk factors in a particular region. Furthermore, Supplementary materials present an illustration of the prevalence of these behavioral risk factors for both genders across the four regions in West Kazakhstan (Supplementary Figure S1), respectively.

3.5 Regional prevalences of NCDs in West Kazakhstan

Figure 4 shows the comprehension of NCD prevalence within the four regions of West Kazakhstan. Additionally, the Supplementary materials offer a visual representation of the prevalence of NCDs in both men and women across the four regions in West Kazakhstan (Supplementary Figure S2), separately.

3.6 Association of prevalences of NCDs and smoking, alcohol drinking, physical activity, and obesity in West Kazakhstan

The results from the multinomial logistic regression analysis indicated a significant association between increased physical activity and a reduced risk of hypertension (odds ratio [OR]: 0.704; 95% confidence interval [CI]: 0.593–0.837), diabetes (OR: 0.647; 95%CI: 0.494–0.846), and heart disease (OR, 0.514; 95%CI: 0.419–0.630). In contrast, obesity exhibited a significant association with a heightened risk of hypertension (OR: 1.574; 95%CI: 1.362–1.819), high cholesterol (OR: 1.705; 95%CI: 1.403–2.072), and heart disease (OR: 1.414; 95%CI: 1.178–1.697). However, neither alcohol drinking nor smoking displayed significant associations with any of the examined metabolic conditions (Table 4).

The inclusion of Table 4 serves to explore the nuanced relationship between behavioral risk factors and metabolic risk factors, taking into account the potential moderating effect of gender. While it is acknowledged that the association between behavioral and metabolic risk factors has been observed across various cultural settings, our study aims to specifically investigate whether sex differences modulate this relationship.

The decision to adjust for gender in the final analysis is rooted in the objective of understanding how gender may influence the associations between behavioral and metabolic risk factors. By treating gender as a potential moderator, we aim to discern whether the impact of behavioral risk factors on metabolic outcomes differs between men and women. This approach allows for a more granular exploration of sex differentials in the interplay between lifestyle choices and metabolic health.

The adjustment for gender in Table 4 enables us to delineate whether the observed variations in behavioral risk factors translate into similar or distinct metabolic risk factor prevalence among men and women, providing a valuable perspective on whether sex-specific patterns exist in the relationship between behavior and metabolic health outcomes. This adjustment enhances the depth of our analysis, contributing to a more comprehensive understanding of gender-related disparities in the studied population. The choice to present

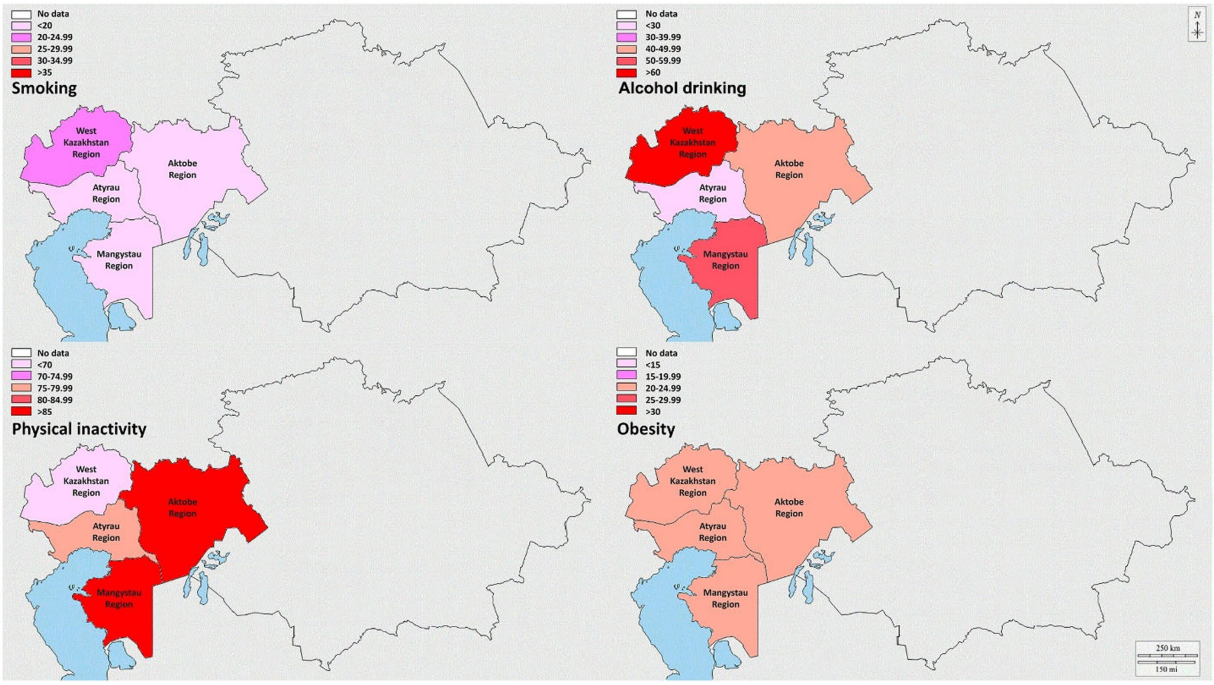

FIGURE 3
Prevalence of smoking, alcohol drinking, physical inactivity, and obesity in the regions of West Kazakhstan.

gender-adjusted results aligns with the study's focus on sex differentials and allows for the identification of potential variations in the associations that may be obscured in unadjusted analyses.

4 Discussion

Our analysis of West Kazakhstan regions unveiled significant findings, including the overall prevalence rates of behavioral risk factors and metabolic conditions: smoking (13.6%), alcohol drinking (47.0%), current obesity (22.3%), and physical inactivity (80.7%). Furthermore, NCDs showed an overall prevalence rate, including hypertension (25.6%), diabetes (7.5%), high cholesterol (11.8%), and heart diseases (13.0%). Key insights are as follows: (1) This study exposed varying prevalence rates of essential behavioral risk factors and NCDs among West Kazakhstan's population. Notably, high levels of physical inactivity and obesity were identified, affecting a substantial portion of the populace. (2) Gender disparities manifested in smoking, alcohol drinking, physical inactivity, and obesity. Men displayed higher smoking and alcohol drinking rates, while women exhibited a greater prevalence of physical inactivity and obesity. (3) Region-specific analysis unveiled distinct patterns of risk factors and NCDs, with the West Kazakhstan region reporting the highest prevalence of smoking, alcohol drinking, and specific metabolic conditions. These findings underscore the significance of tailored public health interventions at the regional level.

The findings of this study shed light on the prevalent behavioral risk factors and metabolic conditions among the population of West Kazakhstan, offering insights into the region's public health landscape. These results prompt discussions on multiple levels, including the implications for public health interventions, the effect of gender disparities, and the importance of region-specific approaches (13, 14).

The study's primary outcome, the prevalence of behavioral risk factors and metabolic conditions, reveals several notable trends. Smoking, alcohol drinking, obesity, and physical inactivity were identified as common concerns in West Kazakhstan. These factors pose significant challenges to the population's health and well-being, necessitating comprehensive public health strategies to address them effectively (3, 15–17).

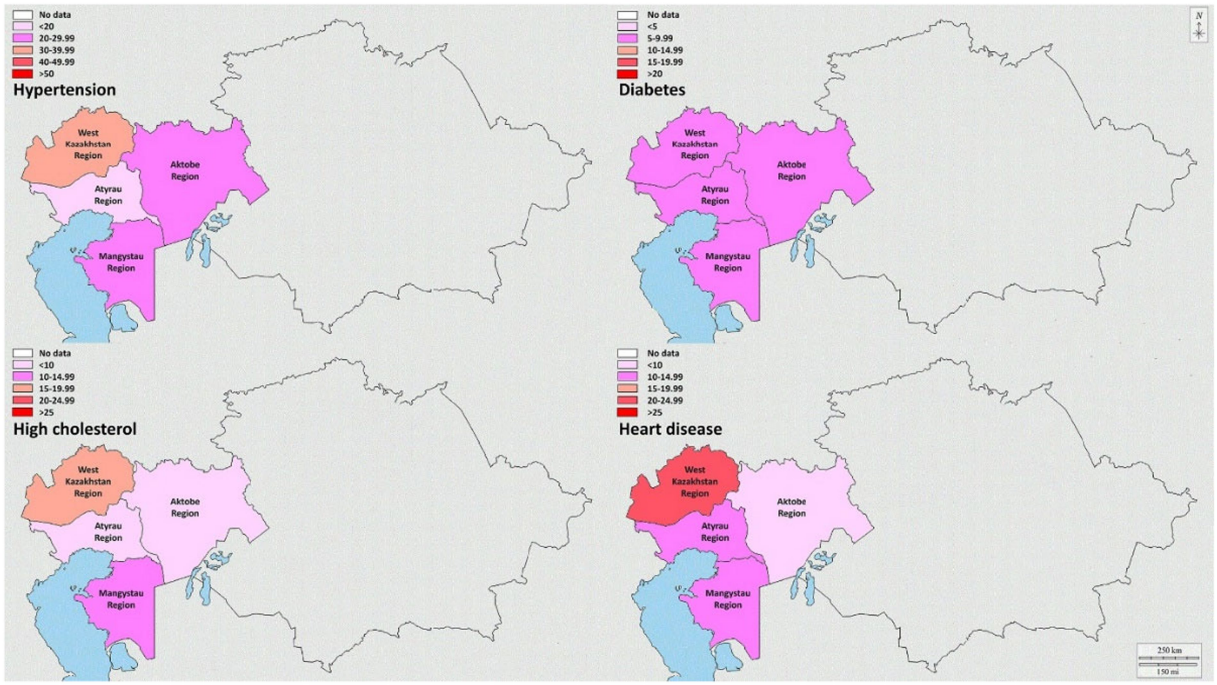

FIGURE 4
Prevalence of hypertension, diabetes, high cholesterol, and heart disease in the regions of West Kazakhstan.

TABLE 4 Association between behavioral risk factors and metabolic conditions.

Index	Hypertension	Diabetes	High cholesterol	Heart disease
Smoking	1.264 (1.021–1.566) *	1.059 (0.751–1.494)	0.973 (0.718–1.318)	1.327 (1.027–1.714) *
Alcohol drinking	0.889 (0.756–1.045)	0.961 (0.741–1.246)	0.907 (0.731–1.125)	1.010 (0.821–1.241)
Physical inactivity	0.704 (0.593–0.837) ***	0.647 (0.494–0.846) ***	0.711 (0.594–0.896) **	0.514 (0.419–0.630) ***
Obesity	1.574 (1.362–1.819) ***	1.235 (0.980–1.557)	1.705 (1.403–2.072) ***	1.414 (1.178–1.697) ***

Multinomial logistic regression was used to estimate the odds ratio (95% confidence interval) of metabolic conditions in relation to smoking, alcohol drinking, physical inactivity, and obesity. Models were adjusted for age, gender, education and living region, ethnicity, marital status, labor force status, and fruit and vegetable consumption. *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

The study also illuminates distinct gender disparities in the prevalence of risk factors and conditions. Men exhibited higher rates of smoking and alcohol drinking, underscoring the need for targeted interventions to reduce these behaviors among men. On the other hand, women displayed a greater prevalence of physical inactivity and obesity. Understanding these gender-specific differences is crucial for developing interventions tailored to the specific needs of both men and women (18–20).

The region-specific analysis revealed variations in the patterns of risk factors and NCDs across West Kazakhstan. The West Kazakhstan region, notably the northern part, displayed higher rates of smoking, alcohol drinking, and specific metabolic conditions. This finding emphasizes the importance of tailoring public health interventions to address the unique challenges faced by each region. Localized efforts may include region-specific health campaigns, community engagement, and targeted healthcare services (21, 22).

The results of the multinomial logistic regression analysis provide valuable insights into the relationship between risk factors and metabolic conditions. Notably, physical inactivity exhibited a significant association with an increased risk of hypertension, diabetes, and heart disease. Conversely, obesity was significantly associated with a heightened risk of hypertension, high cholesterol, and heart disease. While the absence of significant associations between smoking and alcohol drinking with these conditions may appear counterintuitive, further research is required to understand the intricate relationships between these factors and metabolic health fully (23–25).

This study offers a comprehensive view of the behavioral risk factors and metabolic conditions prevalent in West Kazakhstan. Understanding these patterns, gender disparities, and regional variations is pivotal for the development of targeted public health interventions aimed at improving the health and well-being of the region's population. Further research is needed to explore the complex interactions between these risk factors and conditions, enabling the design of more effective and tailored interventions.

5 Limitations

While our study contributes valuable insights into the prevalence of behavioral risk factors and NCDs in West Kazakhstan, it is essential to acknowledge several limitations that may impact the interpretation of our findings.

Cross-Sectional Design: The cross-sectional nature of our study design limits our ability to establish causal relationships between behavioral risk factors, metabolic conditions, and demographic variables. Longitudinal studies would be more suitable for exploring temporal trends and causal associations over time.

Self-Reported Data: The reliance on self-reported data, particularly for lifestyle behaviors such as smoking, alcohol drinking, and physical activity, introduces the potential for recall bias. Participants may underreport or overreport certain behaviors due to social desirability or memory lapses.

Generalization to Other Regions: Our study focuses on the West Kazakhstan regions, and caution should be exercised when generalizing the findings to other geographical areas. Variations in cultural, socioeconomic, and healthcare factors may influence the prevalence rates of behavioral risk factors and NCDs in different regions.

Exclusion of Specific Age Groups: While the chosen age range (18–69 years) provides a comprehensive view of the adult population, the exclusion of individuals outside this range limits our understanding of the prevalence of behavioral risk factors and NCDs in younger and older age groups.

Limited Exploration of Additional Risk Factors: Our study primarily focuses on key behavioral risk factors and metabolic conditions. While these factors are crucial, the exclusion of other potential risk factors, such as genetic predispositions and environmental exposures, limits the comprehensive assessment of determinants influencing health outcomes.

BMI Calculation Methodology: Although efforts have been made to enhance the clarity of our BMI calculation methodology, it is important to note that the accuracy of BMI values relies on precise weight and height measurements. Variations in measurement techniques or instruments may introduce minor inaccuracies.

Limited Socioeconomic and Cultural Context: The study lacks an in-depth exploration of the socioeconomic and cultural factors that may influence behavioral risk factors and NCDs. A more comprehensive understanding of the broader context would provide additional insights into the observed patterns.

Sampling Methodology: While our sampling strategy aimed at achieving a representative sample, the use of cluster sampling introduces the potential for sampling bias. Variability within selected clusters may impact the generalizability of our findings to the entire West Kazakhstan population.

In light of these limitations, readers are encouraged to interpret our findings with caution, recognizing the inherent constraints of our study design and methodology. Addressing these limitations in future research endeavors will contribute to a more nuanced understanding of the complex interplay between behavioral risk factors, NCDs, and the unique contextual factors influencing health outcomes in the West Kazakhstan region.

6 Conclusion

In conclusion, this study conducted in West Kazakhstan revealed significant variations in the prevalence of behavioral risk factors and NCDs across different regions, genders, and age groups. Notable findings include higher rates of smoking and alcohol drinking in men, while women exhibited a greater prevalence of physical inactivity and obesity. The prevalence of these risk factors and metabolic conditions varied by region, with the West Kazakhstan region demonstrating distinct patterns, including higher rates of smoking, alcohol drinking, physical inactivity, obesity, and metabolic conditions. Moreover, the study highlighted the importance of addressing these risk factors and tailoring interventions to address specific demographic and regional characteristics to improve public health in West Kazakhstan, considering variability in genders.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Local Ethics Committee of S.D. Asfendiyarov Kazakh National Medical University, Almaty, Republic of Kazakhstan. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

AB: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Software, Supervision, Writing – original draft. AA: Data curation, Investigation, Writing – review & editing. NM: Methodology, Resources, Validation, Writing – review & editing. AK: Methodology, Resources, Validation, Visualization, Writing – review & editing. GY: Methodology, Software, Writing – review & editing. SZ: Investigation, Methodology, Writing – review & editing. ZA: Investigation, Methodology, Writing – review & editing. KZ: Investigation, Methodology, Validation, Writing – review & editing. AU: Formal analysis, Methodology, Validation, Writing – review & editing. AN: Investigation, Methodology, Validation, Writing – original draft, Writing – review & editing. AT: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Software, Supervision, Writing – original draft.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2024.1333887/full#supplementary-material

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Emotional experiences and gender roles of men with fibromyalgia syndrome: a cross-cultural qualitative study

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Introduction: Gender roles may impact men with fibromyalgia, causing a high number of negative emotional states and affective disorders. There are few studies that detect men's high emotional suffering. This study examined the emotional experience of men with fibromyalgia.

Methods: A qualitative cross-cultural study utilized inductive thematic analysis was performed at the Fibromyalgia and Chronic Fatigue Unit Santa Maria University Hospital in Spain, the Fibromyalgia and Chronic Fatigue Clinic at Mayo Clinic in the US, and volunteers from the Winneshiek County in the US A total of 17 participants, 10 men from Spain and 7 men from the US were included.

Results: Three themes related to feelings/emotions emerged: (1) psychological level; (2) social level; and (3) physical level. Men with fibromyalgia from Spain and the US experienced many negative emotions. Men often experience negative emotions that are worsened by common misunderstandings and social biases/stigma about their condition.

Conclusion/implications: A proper assessment of emotions when evaluating the global health of men with fibromyalgia as well as the provision of emotional support would improve their mental health and therefore their overall physical health. Emotional management should be incorporated into all treatment protocols for fibromyalgia, especially for men given the gender stigma. Health policies designed by legislators, policymakers, and support agencies must be accompanied by education in gender role concepts to

improve the emotions of men with FMS. The mass media will be essential for the disclosure of the emotional suffering of male patients so that society might better understand them.

KEYWORDS

emotional experience, gender role, fibromyalgia syndrome, cross-cultural studies, qualitative study

1 Introduction

Fibromyalgia syndrome (FMS) is characterized by chronic widespread pain along with fatigue, sleep difficulties, cognitive disturbances, and mood disorders. Prevalence ranges from 2 to 8% of the world population (1). Women have a high predominance of FMS cases, approximately 80–96% (2, 3). The American College of Rheumatology states that diagnosis is based on clinical evaluation and patient reports, as there are no reliable biomarkers to identify this disease (4). All this leads to frustration on the part of patients but also health professionals, family, friends, and co-workers (5). Differences between men and women in FMS prevalence may be linked to misdiagnosis or underdiagnosis in men due to the social stigma that this is a "female disease" (6). FMS is associated with a high prevalence of emotional and affective disorders (7). Patients with FMS tend to frequently experience feelings of anger that they repress, which often leads to the inability to implement strategies to regulate their emotional state (8). It is often considered atypical if a man complains about pain, compared to a woman. Hopefully, these attitudes are changing (9). Gender differences have been difficult to study because of relatively fewer men being diagnosed with FMS (10–13). There is a high prevalence of pain, fatigue, and other common FMS symptoms among women, while the frequency of neuropsychiatric symptoms is higher among men (14).

The concept of emotion has multiple definitions. The lack of an agreed upon definition is a constant source of misunderstandings and a series of debates, mostly unproductive, between different disciplines (15). A feeling can trigger an emotion or be the response to one. In everyday language, emotions and feelings are often used interchangeably (16). It is known that emotions impact the management of FMS (17), its symptomatology (18), functioning, and adjustment (19). Emotion management can suppress or reverse negative emotions and consequently improve the experience of pain (20). Furthermore, high levels of emotional intelligence are also related to better social interaction (20, 21). However, there are very few studies on the impact of emotions in men with FMS, but the few that exist detect men's emotional discomfort. There have been several qualitative studies exploring experiences of illness due to FMS (22–26). Moreover, there are also other mixed methods and quantitative studies of men which analyze the impact of FMS and, in turn, emotions (12, 13, 27, 28). Additionally, men reported emotions of anger, depression, anxiety, post-traumatic stress syndrome, and irritability in the setting of FMS (28).

The purpose of this study is to add to our understanding of emotional experiences in men with FMS. Additionally, we seek to understand men's emotional experiences resulting from FMS in the context of culture, and as such, we include men from Spain and United States in our study. These cultures have considerably different healthcare systems and approaches to treating FMS and these macro-causal factors may uniquely impact the emotional experience of men with FMS.

2 Methods

2.1 Design

The design of this study was qualitative and cross-cultural, including men from Spain and the United States (US). Men with FMS provided qualitative data on their emotional experiences through focus groups and in-depth interviews (29). To facilitate the understanding of the question on emotions, we asked: What feelings/emotions do you experience because of fibromyalgia?

2.2 Participants and settings

The sample was purposive (30) and was composed of outpatients attending FMS units of medical facilities in Spain and the US. A total of 17 participants were obtained, 10 from Spain and 7 from the US. Collaboration of these two specialized FMS centers started through the contact of two universities, one in Spain and the other in the US, for the specific purpose of cross-cultural research projects in FMS. Shared interests centered around examining FMS from a biopsychosocial perspective where cultural and gender factors, health policies developed in each country and the organization of health systems were of considered of great importance to understand this condition.

To protect participants' identities, we used fictitious names in reporting our results. The current study was approved by the Ethics and Research Committee of the Primary Care University Institute Jordi Gol i Gurina from Barcelona, code: 4R18/223„ and the Mayo Clinic Human Subjects Review Board, code: 10429.010. Informed consent was obtained from all participants.

2.3 Data collection

2.3.1 Spain

Participants were selected from a list provided by the Fibromyalgia and Chronic Fatigue Clinic from Lleida, Spain and were contacted by phone. The focus groups conducted in

this clinic were divided into 2, 1 month apart in 2018 (May and June). They were conducted by two health professionals trained in focus groups and a third observer familiar with the study. Each group interview took about 120 minutes, was audio-recorded, and later transcribed by two of the researchers who attended these sessions.

2.3.2 US

Participants were recruited from a list provided by the Fibromyalgia and Chronic Fatigue Clinic at Mayo Clinic (Rochester, USA) and were contacted by phone, and from voluntary contact in response to public regional advertisements of the study in Luther College (Decorah, USA) in August 2018. Due to logistical difficulties in coordinating appropriate times for group sessions in the US, focus groups were not conducted and instead one-to-one interviews were deemed the best option. Two men completed a joint interview, while five men completed individual interviews in 2018 (August). Two health professionals conducted the interviews at Mayo Clinic. The individual interviews lasted between 45 and 60 min, while the joint interview lasted 120 min. The interviews were audio-recorded for accuracy and later transcribed.

2.4 Data analysis

Qualitative data were analyzed according to the established methods of inductive thematic analysis through a reduction process to manage and classify the data (31). All recorded data were transcribed by three members of the research team and then independently reviewed by three other researchers to verify the accuracy of the data. Then, four team researchers generated codes and grouped them into categories. The categories were organized into themes with the consensus of the whole group. Biopsychosocial and gender perspectives were analyzed (32). The data were analyzed separately in each country, but the two lead researchers had ongoing conversations to ensure standard coding criteria were in place at each site.

3 Results

The patient's characteristics are shown in Table 1. Regarding the emotional experience in men with FMS, three emotional themes emerged: (1) psychological level; (2) social level; and (3) physical level (Table 2).

3.1 Theme 1: psychological level

Most of the emotions that emerged were negative in both Spanish and US men. These negative emotions included anger/rage, frustration/impotence, uncertainty, stress, anxiety, depression/sadness/suicidal thoughts, futility, and guilt. Positive emotions were acceptance, hope, relief with diagnosis, and enjoy in leisure time.

3.1.1 Anger/rage

Due to the lack of understanding of the disease by the people around them and even by the health system, men with FMS experience a great deal of anger and rage.

> "You continually feel impotence, anger, and social pressure, because those around you don't understand the disease" (P3-Spain).

> "Overall, I do hate it... I'll tell you that up front. I can get mad at it for having it... so you get the emotional anger, frustration..." (P3- US).

3.1.2 Frustration/impotence

Men with FMS experience frustration and feelings of impotence because some health providers seem to not understand the condition of FMS. Men have difficulty doing chores, daily life activities, and hobbies; even the simplest tasks are difficult. Men struggle in supporting their families due to the disease's impact on employment. Moreover, men are frustrated because it took them a long time to be diagnosed and they feel they are not getting better. They are also frustrated due to the lack of a cure or effective treatment.

> "You climb 2 steps and backward. Pressure, incomprehension plus impotence..." (P3- Spain).

> "If you have pain or fatigue or fogginess and you knew it was for a week, then you can manage it, but if you knew it was forever... that weighs on you" (P7- US).

3.1.3 Uncertainty/fear (in the diagnosis and in the disease process)

The symptoms that appear are unpredictable and often take a considerable amount of time to diagnose. Participants have undergone numerous medical examinations and diagnostic evaluations. Many believe that they may have a serious disease such as cancer. This leads to significant feelings of fear, uncertainty, anxiety, and depression. Furthermore, they are concerned about how the disease will evolve and whether they will be able to manage the disease.

> "From the onset of symptoms to having the diagnosis I had to wait 13 years..." (P10- Spain).

> "I guess I do have a fear if it gets worse at some point that I would become disabled or not be able to work." (P2- US).

3.1.4 Stress

Participants consistently identified job stress. Some experience very high levels of stress similar to post-traumatic stress.

TABLE 1 Participant characteristics.

Participant	Country	Age	Civil status	Occupational level	Level of education	Number of people at home	Time from onset of symptoms to diagnosis (years)	Time living with the disease (years)
1. Steven	United States	57	Married or in couple	Active worker	4-year college	Between two and four	15–20 years	15–20 year
2. Don	United States	51	Married or in couple	Active worker	Graduate or doctoral degree	Between two and four	2 years	7 years
3. Andrew	United States	57	Married or in couple	Active worker	Graduate or doctoral degree	Between two and four	8 years	30 years
4. Matthew	United States	50	Single	Permanent disability	High School	One	1	4
5. Oliver	United States	63	Married or in couple	Permanent disability	High School	Between two and four	1996 (22 years)	22 years
6. Ryan	United States	60	Married or in couple	Temporary disability	High School	Between two and four	2 years	June 2018
7. Henry	United States	53	Married or in couple	Active worker	4-year college	Between two and four	1.5 years	2 years
1. Daniel	Spain	59	Divorced or separated	Unemployed	High School	One	3	20
2. Jack	Spain	30	Divorced or separated	Active with temporary incapacity for work	High School	Between two and four	3	4
3. Samuel	Spain	46	Married or in couple	Retired or pensioner	4-year college	Between two and four	2	10
4. Alexander	Spain	45	Married or in couple	Active with temporary incapacity for work	Elementary school	Between two and four	4	5
5. Adam	Spain	60	Married or in couple	Unemployed	High School	Between two and four	22	40
6. James	Spain	55	Divorced or separated	Retired or pensioner	High School	One	6	10
7. Jordan	Spain	35	Single	Unemployed	High School	Between two and four	17	20
8. Jonathan	Spain	55	Divorced or separated	Permanent disability	4-year college	Between two and four	2	9
9. Julian	Spain	50	Married or in couple	Permanent disability	High School	Between two and four	2	12
10. Victor	Spain	53	Widower	Retired or pensioner	High School	Between two and four	13	15

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TABLE 2 Themes, categories on feelings/emotions in men with fibromyalgia.

Theme and categories	Spain	United States	Quotations example
1. Psychological level			
1.1. Anger/rage	4	6	*"Sometimes, when you cannot support the pain anymore, you feel angry and pay it with the other people. People think you are crazy. My personality has changed..." (P4-Alexander Spain)*
1.2. Frustration/impotence	19	14	*"I'm divorced, I have to pay child support, I saw myself with a lot of impotence when I finished working, I went out crying every day" (P2-Jack Spain)*
			"Um ... I mean it's embarrassing to have this sort of thing that shuts your body down so that it feels like you can't do anything. Yeah. I guess I would say embarrassing" (P2-Don US).
1.3. Uncertainty/fear (in the diagnoses and the disease process)	25	29	*"I am 30 years old, and I had a lot of CT scans, resonances, colonoscopy, laparoscopies.... "In the beginning, it was all just misdiagnoses, that if you have cancer, that if you have different misdiagnoses, you get depressed, anxious and psychotic" (P2-Jack Spain)*
			"This diagnosis... at least for me is recent. It is disappointing because you kind of want a... hey you have this blood test. It means that you have this and here is the pill for it. I guess that ties into the same general theme... uncertainty. And an unknowing in will I be able to manage this or not?" (P7-Henry US)"
1.4. Stress	10	14	*"A doctor told me that I suffered from post-traumatic stress like war soldiers and their tragedies. I did not experience a war, but my life has been like a war..." (P2-Jack Spain)*
			"Yeah, and now I'm not working so now there are financial worries... I've started selling stuff to pay bills" (P4-Mattew US).
1.5. Anxiety	13	13	*"I'm anxious because I've been in pain and undergoing tests for three years. At first you think it will pass but it doesn't" (P2-Jack Spain)*
1.6. Depression/sadness/suicidal thoughts	15	19	*"If I remember the intensity of the pain... I just couldn't do anything... [(muffled) you know. I didn't go out with friends or anything like that... I sort of withdrew. That was part of being depressed about it. My depression started in that period. Generalized anxiety disorder started" (P3-Andrew US)*
			"Hitting rock bottom, we've all hit it several times, but you always think it can't be worse, but it is, and each time you're going to stop further. Like you go up two stairs and back four" (P3-Samuel Spain)
			"I get depression because of all my hobbies I had were physical. I'm not able to do any of them. So that's a lot of... and my relaxation was reading. I can't concentrate to read. All my fun stuff has gone... And my social life has gone too" (P4-Matthew US)
1.7. Futility	16	2	*"I am feeling a zero on the left. I was complaining about what I couldn't do as a father and couldn't do as a worker. We feel useless" (P8-Jonathan Spain)*
			"They were recommendations based on the fibromyalgia clinic that I went to. It sounded great during that week, and they are very good about trying to encourage you to do those things. They did all that they could do, but I haven't honestly implemented much of anything I learned there yet... although I respect everything that they suggested. In real life you can't turn on a dime" (P7-Henry US)
1.8. Guilt	3	n/a	"I go to the hospital 8-9 times in a month to get medication and a nurse told me not to go so many times. I feel like a burden" (Jack, Spain)
			"My father is 81 and my father-in-law 70 and they are better than me. You thank for them, but you see that you don't value anything" (P4-Alexander Spain)
1.9. Acceptance	n/a	20	"Um... I try to look at everything positively. And with fibromyalgia that is just my nature... to be positive.... That is just my nature and just the type of person I am" (P3-Andrew US)
1.10. Hope	4	5	*I have never in my life experienced hopelessness. With my congestive heart failure everyone was crying, and I was like no I don't like to sit and worry about it. [(muffled) My attitude was positive.... I'm a problem solver. I'm a project manager and all of my career I have been a problem solver, and this is a problem solving issue. So, I just don't have that feeling of hopelessness... you know. I just put it into problem solving. That is just my nature and just the type of person I am.(P3- Andrew US)*
1.11. Relief with diagnosis	3	3	*He pulled out the book and said it's fibromyalgia. That was back in '98. About 1998... that time period. It was part relief now that I know what it was, I can actually deal with it... that was my mindset at the time." (P3-Andrew US)*
1. 12. Enjoy in leisure time (have fun) and with the ordinary daily events of life	4	7	*"I enjoy nature and my dog. I go for a walk with him, and he helps me a lot with nature, with animals, with flowers and insects. I have done a course in organic farming. (P5-Adam Spain)*
			"I ride my motorcycle. That this summer has gone way down. Now only half hour top" (P4-Matthieu US).

(Continued)

TABLE 2 (Continued)

Theme and categories	Spain	United States	Quotations example
2. Social level			
2.1. Couple/family/social misunderstanding	15	12	*"Few people understand this illness. If you tell a person you're in pain, they think you're faking it. They look at you from the bottom up and see you're fine. They think it's not true what you say" (P8-Jonathan Spain)*
			"I think that a lot of people feel like it is just a cop out thing. You know what I mean? I mean if I could say I have MS or this disease or that disease that's what is causing this then they would get it better" (P1-US Steven)
2.2. Work misunderstanding	5	6	*"I was replaced and did not get disability" (P5-Adam Spain)*
			"Discrimination yes. My last boss... She needed someone who could be there every single day at work. It came down to that they recognized that she was discriminating me for my fibromyalgia. I mean if I am working on a skyscraper... I can't do that in a wheelchair... and that's obvious... you know. But if I'm in a wheelchair and I am physically in pain I shouldn't be punished for that. At least that's what I believe" (P3-US Andrew)
2.3. Stressful job	4	3	*"I think about retiring every single day (laughs). That is five years away and I don't know if I can do this for five more years. I really don't. So, I don't know what to do really. I am in this place right now where I just have to figure something out" (P1- Steven US)*
2.4. Misunderstanding by doctors	8	10	*"They don't know a lot about fibromyalgia. They don't know a lot about chronic pain in general. I don't know. I guess someone is going to have to make some recommendation or something to figure this out. (P1-Steven US)*
3. Physical Level			
3.1. Suffering	7	4	*"For me, it is a struggle of continued pain" (P2-Jack Spain)*
3.2. Snowball effect suffering	3	2	*"Then comes overweight, poor sleep and other symptoms. At the beginning you do not have depression or anxiety but with chronic pain, they appear... and as time passes, the pain increases too..." (P3-Samuel Spain)*

They describe job stress when working and if not working financial concerns.

> "I did the work of 4 people before I was diagnosed with this disease, alone and working 10 h every day" (P6- Spain).

> "I identify the cause of FM with other previous diseases and especially work stress" (P1- Spain).

3.1.5 Anxiety

Pain and sleep difficulties lead to anxiety in men with FMS. Although some of them have learned to manage it.

> "My sleep has gotten worse, I have insomnia, I wake up suddenly with anxiety, nightmares..." (P10- Spain).

> "Well, I have certainly had more anxiety. Anxiety level is decent right now too" (P5- US).

3.1.6 Depression/sadness/suicidal thoughts

Men reach the limit of their emotional strength due to physical pain, economic problems, healthcare mistreatment, lack of symptomatic improvement, lack of hope in a cure, suicidal thoughts in some cases, and obsessive thoughts. Loss of social life and hobbies contributes to these feelings as well. Many believe that they are too young for the physical limitations caused by FMS. In addition, the fact of thinking that the illness is for the rest of their lives also may cause them to become depressed.

> "They sent me to the psychiatrist, because with so many pains, I hit bottom at the level of committing suicide, of not being able to take more or endure more" (P10- Spain).

> *Asked if he experienced hope in his recovery* "Not anymore." "I am only 57 years old. It's depressing." "The whole idea of living like this for the rest of my life is just more than I can take sometimes. . ." (P1- US).

3.1.7 Futility

Men feel lots of futile because they are not able to do the same things they used to do; most of them don't work and their body doesn't respond as it should. Spanish men presented more feelings of futility. Feelings of futility because men are young, and they can't do the same things as young people or the older adult/adults.

> "When I went to the gym, I saw older people doing stretches that I couldn't do" (P7- Spain).

> "During the early years of being diagnosed, I didn't have the depression and irritability and all those things that are going on right now. It's like my body has reached its limits" (P5- US).

3.1.8 Guilt

Spanish men feel guilty that their family members have to put up with them (i.e., burden). In addition, they cannot fulfill the role of parent or breadwinner and they feel bad about it. US men didn't identify guilt as a feeling or emotion.

> "We complain about not doing what has been assigned to us and we feel bad about it" (P3- Spain).

3.1.9 Acceptance

Acceptance of FMS occurred in US men versus Spanish men. Spanish men didn't identify guilt as a feeling or emotion.

> "... but then you realize well... that's not helping me. Right now, they don't have a cure for it. I have got to deal with it" (P3-US).

3.1.10 Hope

A common experience for men is to cling to hope. For some, it seems the only solution.

> "The doctors burned me the starry ganglion and it took away my pain for 3 days, it's not worth it, but there is a hope... something can be done" (P3-Samuel Spain).

> "Hope and... well there is always hope.... Again, I was just given the word fibromyalgia a couple weeks ago by Dr. XXX in Rheumatology. I was told it was an autoimmune disease... rheumatoid arthritis. Now I am told it is fibromyalgia. I'm not sure about that. Obviously, I'm not a doctor. I want to learn more. I have looked at it a little on my phone. I'm not a big I.T. guy. I don't learn well from reading" (P6- US).

3.1.11 Relief with diagnosis

The positive aspects of the disease emerged more in US men. As it is a condition that remains permanent and cannot be completely cured, they believe that they have no other solution but to accept and adapt to it. Others remark that they are more positive and put the problems on aside.

When they were diagnosed, participants felt relief, and now some of them are able to cope with the disease.

> "Before we knew what we had, we suffered torments. I think we went through an ordeal of numerous diagnoses before we knew what we really had" (P3- Spain).

3.1.12 Enjoy in leisure time (have fun) and with the ordinary daily events of life

Men with FMS attempt to maintain their hobbies. They do well going for a walk with their dog, having contact with nature, and controlling their breathing. However, some are no longer capable of engaging in their hobbies, which leads to significant mood changes. This emotion has not been included together with the positive emotions as it concerns only leisure time.

> "We know how to enjoy many more things because it gives us the energy to continue " (P3- Spain).

> "I do voice work for a radio station here in Cedar Rapids...I do it about once a week. I always look forward to and have been enjoying" (P2- US).

3.2 Theme 2: social level

Similar codes about feelings of misunderstanding appeared in the US and Spain. Regarding work-life, Spanish men were not currently working but referred to the difficulties perceived during their working lives.

3.2.1 Couple/family/social misunderstanding

Men with FMS do not believe that those around them understand the condition. As a result of their normal external appearance, participants often feel embarrassed and ashamed, or that they might be faking an illness. Another reason is the social pressure they have to do the housework if they are the ones who stay at home and the wife works.

> "I do the housework and my wife Works" (P3- Spain).

> "Back home a lot of people don't know about the disease, so when I tell them what I have they are like oh what's that? So, they don't realize that it is mostly women" (P4- US).

3.2.2 Work misunderstanding

Men have lost many jobs due to frequent illness-related absences. Colleagues mocked them because they did not believe that their suffering was real. Some felt discriminated at work.

> "I have had many job losses, people laughed, they said I was cheating" (P8- Spain).

> "I have had to miss work a couple of times where it was more substantial...my coworkers noticed, and my boss noticed. I feel like there were decisions made about my role at that time that wouldn't have been made had I been there" (P2- US).

3.2.3 Stressful job

Some have stopped working and others are waiting for the opportunity to leave work since they do not know how long they will be capable.

3.2.4 Role reversal

> "I was autonomous, I had workers under my charge. I had to quit work and since then I have been the mother and my wife the father of the house" (P3- Spain).

3.2.5 Inability to diagnose appropriately

Some clinicians inaccurately believe that they understand the disease. Other clinicians actually do have a better understanding of patients with FMS. For FMS to be identified, patients go through numerous evaluations. They have the belief that clinicians doubt if the disease exists, that not much is known about it, and that further research is needed.

> "I've been explaining to doctors for many years, but they're not interested. (P10- Spain).

> "Started with neurology. Went to cardiology. Went to rheumatology. The doctor in rheumatology... Dr. XXX was the first to give me... to put any kind of label of anything on it. Dr. XXX was the first thing and that started out as autoimmune... rheumatoid arthritis. If doctors don't agree with it and only a certain set of doctors whether it is just rheumatologists or whatever that's it" (P6- US).

3.3 Theme 3: physical level

Similar codes about feelings of physical suffering appeared in US and Spanish men. Pain is the main symptom that makes it difficult for them to perform activities. There is a snowball effect, and the symptoms are chained one after another. The pain appears, leading to decreased physical activity, weight changes, sleeping difficulties, and mood changes ("snowball effect"). For some, as time goes by, the pain increases.

3.3.1 Suffering

Chronic generalized pain is the main aspect of physical suffering identified. It makes it difficult to perform physical exercise.

> "Pain that penetrates to the soul" (P8- Spain).

> "I have to get down to the ground a lot sometimes. I avoid it now a lot if I don't need to" (P1- US).

3.3.2 Snowball effect suffering

First, the pain comes, and then other symptoms appear, such as difficulty sleeping, being overweight, anxiety, and depression. It is like a snowball that is increasing.

> "Part of this is because it's all a big snowballing effect, right? I like to do walking if I can for exercise because I need to lose weight, but the more I do the more I hurt. Then you don't walk, and you don't do things because you hurt. So, then the weight comes and then you know I don't sleep well and then that causes more things. It's a big snowball effect where then I turn into this hot mess (laughs)"(P1- US).

4 Discussion

Our findings highlighted that men with FMS experienced so many negative emotions due to the changes in their physiology but also because they had to make numerous changes to adapt their lives to the onset of FMS. It's difficult to make these adjustments. Their bodies are imprisoned by pain and other crippling symptoms, and they have been suffering from many failed treatments (25). These emotions were associated with different events due to the nature of the disease itself, psychological factors, and the cultural and social contexts in the men's lives. Despite these different contexts in terms of emotions between the US and Spain, more similarities than differences were found. However, US men expressed more feelings of positive emotions (mostly acceptance) and enjoyment of leisure time. Spanish men showed more feelings of futility and guilt.

Overall, men feel anger, frustration, helplessness, depression, sadness, and impotence because of the difficulty in performing the tasks of daily life, at work, and in their own families. Men also felt frustration for not being the father or spouse they used to be, due to an inability to support their family (33). The more traditional expectation for men is that they develop a conservative role within the family, as the main breadwinner. The inability to do this has a direct impact on men as they are unable to fulfill this gender mandate produces negative emotions such as worthlessness, depression, sadness, and suicidal thoughts (34). They felt futility and depression due to inability to work, engage in recreational activities, or participate in basic daily activities (32). Most of the Spanish participants were not active workers while most US participants were currently working. Patients in Spain are allowed to exempt themselves from work by receiving a small pension, while men in the US describe fewer options to leave their jobs. The Spanish health and social system provide healthcare coverage and pension provision (27). Participants in our study also identified negative emotions like anger, frustration, and impotence experiences with the misunderstandings by some healthcare professionals with did not contribute to their improvement (11, 22, 23). The misunderstanding of the disease and lack of empathy on the part of family, friends, and health professionals caused emotions of anger, rage, frustration, and helplessness (11, 25). Also, men reported the lack of recognition of FMS in men has such a strong influence on men who are affected because it is not believed that men can suffer from it, as it is mostly associated with the female sex (35).

The difficulty in diagnosis creates negative emotions such as uncertainty, fear, stress, and anxiety (26), and it was clearly observed that men endure a lot of pain and fear of being seen as complainers (24). Men with FMS stated the difficulty for men to express their feelings in order not to be labeled as inferior men, as culturally, men's complaints may challenge their socially constructed masculinity (23).

Men in Spain felt that life was futile and they felt guilty about their condition. This is because they were not able to fulfill the traditional gender role of being a breadwinner for their household. More commonly men were unemployed, retired (pensioner), or on permanent disability. The concept of "gender" refers to culturally accepted norms, attitudes, and beliefs about

what it is to be male or female. In contrast to the old-school term "gender role," (36) gender should be understood as an ongoing process and not as a fixed entity or outcome, and that it is linguistically constructed and contextually situated. Deviating from norms can be subject to negative stigmatization and, even worse, social exclusion (37). The construction of masculinity from cultural achievement, such as sport or manual labor means that gender is vulnerable if performance cannot be sustained due to illness or physical disability (38).

Psychosocial support is needed to improve the quality of life of men with FMS (25). Pain impacts a wide variety of experiences both physically and emotionally (24). When the pain was intense, they unloaded the tension with their closest relatives (25). Both depression and FMS challenged the traditional male identity and thus had a demasculinizing effect (39, 40). There are some key limitations to the study. First, the sample size was small. Second, fewer men are diagnosed with FMS, and as such, many men may not have wanted to make themselves visible in their communities.

5 Conclusion

The emotional experience associated with men with FMS was largely negative (anger, frustration, helplessness, uncertainty, fear, worthlessness, futility, stress, anxiety, depression, sadness, and suicidal thoughts). Spanish men had more futility and guilt than US men. In smaller amounts, there were also positive emotions such as acceptance, hope, and relief. Acceptance and enjoyment in leisure time were more present in US men. At the social level, there is incomprehension among partners, family, health professionals, employers, and coworkers. Men also described wanting to quit or escape from work. At the physical level, a generalized and unbearable sensation of pain provokes a cascade of negative emotions at the psychological and physical levels. Clinicians should also be trained in emotional management from a gender perspective in which men are significantly stigmatized due to FMS. Findings from this study might inform health policy design by legislators, policymakers, and support agencies as they work to improve the visibility of the emotional difficulties experienced by men with FMS and improve men's social support and therapeutic relationships with professionals.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The current study was approved by the Ethics and Research Committee of the Primary Care University Institute Jordi Gol I Gurina from Barcelona, code: CEIC- P18/073, and Mayo Clinic, IRB 10429.010. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

PM-C: Writing – review and editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. LT: Writing – review and editing, Writing – original draft, Visualization, Validation, Supervision, Resources, Methodology, Investigation, Formal analysis, Conceptualization. AK: Supervision, Writing – review and editing, Writing – original draft, Validation, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. IR: Writing – original draft, Investigation, Formal analysis. SL: Writing – original draft, Project administration, Investigation, Formal analysis. LR: Writing – review and editing, Supervision, Project administration, Investigation, Funding acquisition, Conceptualization. CC: Writing – original draft, Investigation, Formal analysis. SC: Writing – review and editing, Project administration, Investigation. CL: Writing – original draft, Project administration, Investigation. AG: Writing – review and editing, Formal analysis. CA: Writing – review and editing, Writing – original draft, Project administration. AV: Writing – review and editing, Writing – original draft, Project administration, Investigation. AM: Resources, Writing – review and editing, Project administration, Investigation.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Menopausal wellbeing: navigating quality of life and osteoporosis risk

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Background: Multifaceted dimensions influence the quality of life among post-menopausal women. Osteoporosis, a condition characterized by fragile bones, poses a significant risk, potentially leading to fractures and decreased wellbeing. This study aims to assess the quality of life of postmenopausal women, its determinants, and also the risk of osteoporosis among them.

Methods: A cross-sectional study was done among 379 post-menopausal women residing in rural and urban areas of Ernakulam district, Kerala, India. They were selected by probability proportional to size sampling from 10 clusters. Quality of life was measured using MENQOL-I questionnaire and osteoporosis risk assessment was done using OSTA score.

Results: The study participants had a mean age of 60 years, (standard deviation of 6.83 years). On average, menopause occurred at 50.58 years (standard deviation of 4.28 years). The most common symptoms impacting quality of life among postmenopausal women were psychosocial symptoms, followed by physical and vasomotor symptoms. Furthermore, a high proportion (63.6%) of participants were at risk for osteoporosis. History of fracture, concern of falling, marital status and having an insurance, are factors associated with various domains of quality of life.

Conclusion: This study underscores the complex interplay of demographic factors, menopausal experiences, and their impact on the participants' quality of life. The prevalence of psychosocial symptoms and the significant risk of osteoporosis call for tailored healthcare interventions. Postmenopausal women with history of fracture, high concern of fall and single women require special attention. Encouraging women to take up selfcare practices will help during the menopausal transition to have a good quality of life.

KEYWORDS

postmenopausal women, quality of life, osteoporosis, vasomotor, physical, psychosocial

1 Introduction

Women experience distinct reproductive life stages, including infancy, childhood, adolescence/menarche, adulthood, pre-menopause, menopause, and post-menopause. The World Health Organization (WHO) defines menopause as "a natural phenomenon that is deemed to have occurred after 12 consecutive months without menstruation for which there is no other obvious physiological or pathological cause and in the absence of clinical intervention" (1).

During menopause, hormonal changes occur due to decreased ovarian endocrine activity, impacting the production of estrogen and progesterone, potentially affecting quality of life. Menopausal symptoms may encompass vasomotor issues like hot flashes and night sweats, psycho-social challenges including increased anxiety and reduced sleep, physical discomfort like joint and knee pain, backache, and vaginal dryness, as well as reduced interest in sexual activity. These and the related changes occurring in cardiovascular risk profile and osteoporosis are well-elucidated in the SWAN study (2). Numerous global studies have explored the quality of life in menopausal women, employing various assessment tools, with the Menopause-Specific Quality of Life Questionnaire-Intervention (MENQOL-I) (3) being a commonly used instrument. Studies have shown that women at early peri, late peri or post menopause exhibited significant reduction in functioning than premenopausal women (4). National level studies have shown prevalence of post-menopausal women experiencing menopausal symptoms and poor quality of life to range between 70.2 and 73.8% (5, 6).

The concept of QoL encompasses various dimensions, including physical, psychological, and social wellbeing, as well as functional status. Osteoporosis can profoundly impact each of these dimensions, compromising an individual's ability to engage in daily activities, maintain independence, and enjoy a fulfilling life. Postmenopausal osteoporosis (PMO) is a generalized skeletal disorder in which decreased bone density contributes to increased risk of fracture (7). A hospital-based study from North India, estimated the prevalence of osteoporosis to be 37.5% among postmenopausal women (8).

Standard equipment used to measure osteoporosis is the use of Dual Energy Xray Absorptiometry (DEXA) scan which is expensive, inaccessible and makes use of high energy X-Ray radiation. One low cost, easy, no radiation tool for screening osteoporosis in older people is Osteoporosis Self-Assessment Tool for Asians (OSTA) (9).

One of the causes of fracture is minor trauma that occurs following falls. Older people with past history of falls have been found to have increased risk of falls. A tool that is used to assess the fear of fall in older people is the Fall Efficacy Scale International (FES-I) questionnaire FES-I.[1]

This study aims to assess the quality of life and its determinants of post-menopausal women in Ernakulam district using the menopause specific Quality of Life Intervention (MENQOL-I) scale. This study also tries to look at risk of osteoporosis among menopausal women, and fear of fall as they are factors that contribute to fragility fractures and increased morbidity among older people. These measures are now in focus since Kerala is experiencing demographic transition in which there is an increase in the number of people in older age groups, especially women.

2 Methods

2.1 Participants

A community-based cross-sectional study was conducted in Ernakulam district, Kerala state, situated in the central region with a population of 3.2 million. The district comprises of seven talukas, including one corporation, 11 municipalities, and 14 block panchayaths. The basic unit was the ward in rural areas, with a population of 1,000–1,500 per ward and division in urban areas, each division with 7,500–10,000 people. These basic units were considered as clusters. Ten clusters were selected using probability proportional to size sampling from these administrative divisions. The chosen clusters were Parakkadavu, Rayamangalam, Choornikkara, Thuravoor, Eloor, Mulanthuruthy, Ramamangalam, Vytilla, Karuvelippady, and Palarivattom, covering both rural and urban areas.

The study focused on women who had completed 12 months without menstruation, excluding those over 70 years old because as age increases the physiological changes due to aging process will also affect the quality of life and those who reached menopause through surgical interventions like hysterectomy or bilateral oophorectomy. The sample size was determined based on a study by Pathak and Shivaswamy, with a prevalence of 63.9% for psychosocial symptoms and a relative precision of 10%, resulting in a sample size of 374 after applying a design effect of 1.5 (10).

The number of households to be visited in each cluster (ward) was calculated, and it was determined to be 38 post-menopausal women per cluster (Sample size/number of clusters). In cases where residents were not available during the initial visit, households were revisited at least twice, and data were collected.

For participant selection, starting from the first house to the right side of the first by-lane, adjacent houses were visited until 38 eligible females who had not experienced menstruation in the last 12 months and provided informed consent, were enrolled. This process was repeated for all 10 clusters.

2.2 Ethical considerations

The protocol designed for the present study was submitted to the Amrita School of Medicine Ethical Committee from where ethical clearance certificate (ECASM-AIMS-2021-008) was issued before the start of the study. The consent was printed in Malayalam, the local language and details of the study were explained to the participants. Written informed consent was obtained prior to data collection.

2.3 Variables and measurement

2.3.1 Study variables

Using a standard questionnaire and equipment following demographic and anthropometric measures were taken: age (years), age of attaining menopause (years), height (m), weight (Kg), Body Mass Index (BMI) (Kg/m^2), education, occupation, religion, area of residence, ownership of house, marital status, type of family, health care expense, socioeconomic status based on color of ration (public distribution system) card,

1 https://sites.manchester.ac.uk/fes-i/ (accessed September 12, 2022).

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TABLE 1 Distribution of sociodemographic and other determinants among post-menopausal women in Ernakulam district.

Characteristics	Category	Frequency ($n = 379$)	%
Sociodemographic determinants			
Age	≤60 years	202	53.3
	>60 years	177	46.7
Age of attaining menopause	≤50 years	214	56.5
	>50 years	165	43.5
Religion	Hindu	224	59.1
	Christian	99	26.1
	Muslim	56	14.8
Education	Primary	64	16.9
	Middle	124	32.7
	High school	129	34.0
	Higher secondary	45	11.9
	Graduation and above	17	4.5
Occupation	Unskilled	20	5.3
	Skilled	9	2.4
	Professional	2	0.5
	Home maker	338	89.2
	Retired	10	2.6
Type of family	Nuclear family	210	55.4
	Joint Family	12	3.2
	3 generation family	157	41.4
Marital status	Married	339	89.4
	Unmarried	3	0.8
	Widow	37	9.8
Area of residence	Rural	188	49.6
	Urban	191	50.4
Type of house	Owned	317	83.6
	Rent	62	16.4
Health care expenses	Out-of-pocket (OOP) expenses	360	95
	Insurance	19	5
Socio-economic status based on Ration card	BPL	137	36.2
	APL	242	63.8
BMI (South-east Asian)	Underweight	15	4.0
	Normal weight	96	25.3
	Overweight	210	55.4
	Obese	58	15.3
Other determinants			
History of fracture bone	Yes	49	12.9
	No	330	87.1
Calcium supplementation	Yes	85	22.4
	No	294	77.6
Calcium rich food	Yes	134	35.4
	No	245	64.6
Risk of osteoporosis based on OSTA score	Mild risk of osteoporosis	138	36.4
	Moderate risk of osteoporosis	201	53.0
	High risk osteoporosis	40	10.6
Fear of fall (based on fall efficacy Scale International)	Low concern about fear of fall	225	59.4
	Moderate concern about fear of fall	109	28.8
	High concern about fear of fall	45	11.9

BPL, below poverty line; APL, above poverty line; BMI, body mass index; OSTA, Osteoporosis Self-assessment Tool for Asians.

history of fracture bone, calcium supplementation, calcium rich food intake.

2.3.2 Study tools

2.3.2.1 Menopause specific quality of life-intervention (MENQOL-I) questionnaire

Permission to use MENQOL-I questionnaire was obtained online from the e-Provide-Mapi Trust organization (11). The instrument assesses quality of life across four domains: Vasomotor, Psychosocial, Physical, and Sexual domains. The questionnaire was administered through interviews. Participants answered "No" if no symptoms were present. If they responded affirmatively, they were asked to assign scores from 0 to 6, indicating the degree of botheration caused by the symptom (0 = not at all bothered to 6 = extremely bothered. The scores were then converted to conversion scores as follows: "No" is taken as 1, "Yes": 0 = 2, 1 = 3, 2 = 4, 3 = 5, 4 = 6, 5 = 7, and 6 = 8, for purpose of analysis.

Mean scores for each domain were calculated as the sum of scores in each domain divided by the number of symptoms in that domain. The Likert responses were categorized based on mean scores as either Low symptom score or High symptom score, following the methodology outlined by Bhandari (12). After determining the mean score in each domain, those above the mean

score were classified as having a high symptom score, while those below the mean were designated as having a low symptom score.

Since some of the participants were from rural areas and had difficulty in reading the MENQOL-I questionnaire, the same was administered by interview method. In rural areas and houses with large families, the administration of the questionnaire was done in the presence of other family members. So, it was difficult for the data collector to obtain information about responses in the sexual domain.

2.3.2.2 Osteoporosis self-assessment tool for Asians

This tool can be used for calculation of risk of osteoporosis based on formula: [weight (Kg)-age (years)] × 0.2 (9). Based on the score, risk of osteoporosis is calculated as Mild (>-1), Intermediate (score −1 to −4) and High risk (score < −4) of osteoporosis.

2.3.2.3 Fall Efficacy Scale International questionnaire (FES-I)

This questionnaire was used for assessing the fear of fall among older adult postmenopausal women. It has 16 questions answered with scores 1–4 by the woman. Based on the results, fear of fall is assessed as mild concern (16–19), moderate concern (20–27) and high concern (28–64) of fall.

2.4 Statistics

The data were tabulated on MS Excel sheet. Statistical Analysis was done with IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp. Quantitative variables with normal distribution were expressed as mean and standard deviations. Quantitative variables which were not normally distributed were expressed as median and interquartile range. Categorical variables were expressed as frequency and percentages.

Chi-square test was used to test association of various factors with designated high symptom score and low symptom score of quality of life. After logistic regression, all determinants with a p-value < 0.05 was assumed to be independent predictors of quality of life in its various domains (Table 6).

3 Results

The average age of the 379 post-menopausal women in this study was 60 years, with a standard deviation of 6.83 years. The mean age at menopause was determined to be 50.58 years, with a standard deviation of 4.28 years. Post-menopausal women in the study had an average BMI of 24.56 kg/m^2.

The majority of study participants identified with the Hindu religion (59.1%), while 34% had attained a high school level of education. Homemakers constituted 89.2% of the participants, and 55.4% resided in nuclear families. Majority, 89.4%, were married. Urban residents accounted for 50.4% of the participants, and 83.6% lived in self-owned houses. Notably, 95% reported Out-Of-Pocket expenses in healthcare, and 63.8% belonged to Above Poverty Line (APL) families based on their ration/public distribution system cards.

TABLE 2 Distribution of post-menopausal women based on response to MENQOL-I questionnaire.

S.no	MENQOL-I	Answered yes Frequency (n = 379)	Percentage
I.	Vasomotor domain		
1	Hot flushes or flashes	103	27.2
2	Night sweats	62	16.4
3	Sweating	99	26.1
II.	Psycho-social domain		
4	Dissatisfaction with my personal life	54	14.2
5	Feeling anxious or nervous	138	36.4
6	Poor memory	33	8.7
7	Accomplishing less than I used to	101	26.6
8	Feeling depressed, down or blue	24	6.3
9	Being impatient with other people	86	22.7
10	Feeling of wanting to be alone	6	1.6
III.	Physical domain		
11	Flatulence (wind) or gas pains	44	11.6
12	Aching in muscles and joints	245	64.6
13	Feeling tired and worn out	139	36.7
14	Difficulty sleeping	84	22.2
15	Aches in back of neck or head	142	37.5
16	Decrease in physical strength	79	20.8
17	Decrease in stamina	51	13.5
18	Lack of energy	92	24.3
19	Dry skin	75	19.8
20	Weight gain	92	24.3
21	Increased facial hair	41	10.8
22	Changes in appearance, texture or tone of your skin	27	7.1
23	Feeling bloated	40	10.6
24	Low backache	103	27.2
25	Frequent urination	38	10
26	Involuntary urination while laughing or coughing	14	3.7
30	Breast pain or tenderness	23	6.1
31	Vaginal bleeding or spotting	36	9.5
32	Leg pains or cramps	191	50.4

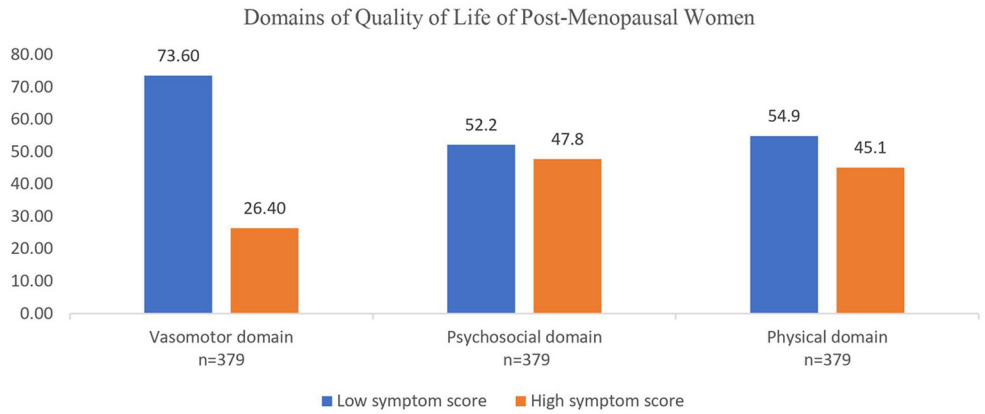

FIGURE 1
Domains of quality of life of post-menopausal women based in symptom score.

Among the post-menopausal women, 55.4% were classified as overweight, and 15.3% were categorized as obese. Additionally, 12.9% had a history of bone fractures, 22.4% were on calcium supplementation, and 35.4% reported a history of consuming calcium-rich foods such as milk and green leafy vegetables (Table 1).

According to responses from the MENQOL-I questionnaire, 27% of women (103) reported experiencing hot flashes in the vasomotor domain. In the psychosocial domain, 26.6% (101) mentioned accomplishing less than they used to. For the physical domain, 64.6% (245) of post-menopausal women reported aching muscles and joints (Table 2).

The psychosocial domain exhibited the highest impact on postmenopausal women, affecting 47.8% (181) of them, suggesting that this domain had the most significant influence. In close succession, the physical domain impacted 45.1% (171) of postmenopausal women, whereas the vasomotor domain had the lowest proportion, with 26.4% (100) of postmenopausal women affected (Figure 1).

Participants in the study perceived psychosocial symptoms such as anxiety or nervousness (36.4%) and impatience with others (22.7%) as highly impactful on their quality of life. Additionally, they identified physical symptoms like muscle and joint aches (64.6%), discomfort in the back of the neck and head (37.5%), and feelings of tiredness and fatigue (36.7%) as affecting their quality of life. Notably, a smaller proportion of women perceived vasomotor symptoms such as hot flashes (27.2%), sweating (26.1%), and night sweats (16.4%) as impacting their quality of life.

The various socio-demographic factors, risk of osteoporosis based on OSTA score, fear of fall based on Fall Efficacy Scale International questionnaire were checked for association with impact score in quality of life (high and low) in the vasomotor, physical and psychosocial domains. This analysis is represented in the Tables 3–5. All factors with a p-value in chi-square test <0.2 were further used in the logistic regression modeling, backward conditional model was used.

Logistic regression analysis was conducted to identify determinants affecting quality of life domains. In the vasomotor domain, occupation (employed) showed a significant association [adjusted odds ratio (aOR): 2.07, 95% confidence interval (C.I.): 1.05, 4.09]. In the psychosocial domain, factors such as age of attaining menopause (>50 years, aOR: 1.54, 95% C.I.: 1.00, 2.37), payment of health expenses (insurance, aOR: 3.24, 95% C.I.: 1.16, 9.00), history of bone fracture (yes, aOR: 2.34, 95% C.I.: 1.21, 4.52), and concern of falling (high concern, aOR: 2.74, 95% C.I.: 1.78, 4.23) were statistically significant. In the physical domain, factors such as house ownership (rent, aOR: 1.84, 95% C.I.: 1.42, 6.69), marital status (single, aOR: 3.09, 95% C.I: 1.42, 6.69), and concern of falling (high concern, aOR: 5.49, 95% C.I.: 3.48, 8.66) were found to be statistically significant (Table 6).

The evaluation of osteoporosis risk among post-menopausal women revealed that more than half (53%) of the post-menopausal women had moderate risk while 10.6% (40) were at high risk and 36.4% (138) at mild risk, respectively.

4 Discussion

In this cross-sectional community-based study involving 379 post-menopausal women from Ernakulam district, Kerala, the quality of life was assessed using the MENQOL-I questionnaire in the Vasomotor, Psychosocial, and Physical domains.

Studies from other parts of the country showed that the symptoms based on domains in MENQOL that affected the quality of life were different from the current study. However, pattern that was prominent were the symptoms in physical domain which affects the quality of life in post-menopausal women. Gaikwad et al. in a study looking at menopausal symptoms among teachers in Raipur, Chhattisgarh, found that 87.5% of the study participants had symptoms in the psychosocial domain, followed by 68.05% participants having symptoms in the physical domain and 51.85% suggesting vasomotor symptoms as affecting the quality of life (13).

Logistic regression analysis indicated that the determinant associated with symptoms in the vasomotor domain was occupation (employed participants). Women with high symptom scores in the psychosocial domain, were those who attained menopause above 50 years, participants with insurance, having a history of fracture and a high concern of falling. In the physical domain, high symptom scores were associated with women living

TABLE 3 Results of univariate analysis to test association of determinant factors on Vasomotor domain of MENQOL-I questionnaire.

Variables	Categories	Symptoms of postmenopausal women in vasomotor domain		Pearsons Chi-square test	*p*-value
		Less impact	High impact		
Age	≤60 years *n* = 202	141 (69.8)	61 (30.2)	3.24	**0.072**
	>60 years *n* = 177	138 (78.0)	39 (22.0)		
Age of menopause	≤50 years *n* = 214	156 (72.9)	58 (27.1)	0.13	0.718
	>50 years *n* = 165	123 (74.5)	42 (25.5)		
Area of residence	Rural *n* = 188	140 (74.5)	48 (25.5)	0.14	0.708
	Urban *n* = 191	139 (72.8)	52 (27.2)		
House of residence	Owned *n* = 317	232 (73.2)	85 (26.8)	0.67	0.754
	Rent *n* = 62	47 (75.8)	15 (24.2)		
Religion	Hindu *n* = 224	172 (76.8)	52 (23.2)	4.76	0.092
	Christian *n* = 99	72 (72.7)	27 (27.3)		
	Muslim *n* = 56	35 (62.5)	21 (37.5)		
Education*	Pre-high school *n* = 188	136 (72.3)	52 (27.7)	1.75	0.417
	High school *n* = 129	100 (77.5)	29 (22.5)		
	After high school *n* = 62	43 (69.4)	19 (30.6)		
Occupation**	Employed *n* = 41	24 (58.5)	17 (41.5)	5.38	**0.020**
	Home maker *n* = 338	255 (75.4)	83 (24.6)		
Socioeconomic status***	BPL *n* = 137	99 (72.3)	38 (27.7)	0.20	0.653
	APL *n* = 177	180 (74.4)	62 (25.6)		
Marital status#	Married n = 339	251 (74.0)	88 (26.0)	0.30	0.583
	Single *n* = 40	28 (70.0)	12 (30.0)		
Type of family##	Nuclear *n* = 210	150 (71.4)	60 (28.6)	1.16	0.282
	Extended *n* = 169	129 (76.3)	40 (23.7)		
Payment of health care expenses	Out of pocket expenses *n* = 360	269 (74.7)	91 (25.3)	4.53	**0.057**
	Insurance or other support *n* = 19	10 (52.6)	9 (47.4)		
BMI (South east Asian)###	Low BMI *n* = 111	82 (73.9)	29 (26.1)	0.01	1.000
	High BMI *n* = 268	197 (71)	71 (26.5)		
Risk of osteoporosis based@	Low risk of osteoporosis *n* = 138	95 (68.8)	43 (31.2)	2.457	**0.12**
	High risk of osteoporosis *n* = 241	184 (76.3)	57 (23.7)		
Fear of fall@@	Low concern of falls *n* = 225	169 (75.1)	56 (24.9)	0.638	0.48
	High concern of falls *n* = 154	110 (71.4)	44 (28.6)		

The bold values are the factors which have been considered for logistic regression analysis. *Education: Pre high school (Primary, Middle school), High School, Post high school (Secondary, Higher secondary, Graduation). **Occupation: Employed (Unskilled, skilled, professional, retired); Homemaker. ***Socioeconomic: BPL (Yellow, pink); APL (Blue, white). #Marital status: Married, Single (Unmarried, widow). ##Type of family: Nuclear, Extended (Joint family, three generation family). ###BMI South-east Asian: Low BMI (Underweight, normal weight); high BMI (Overweight, obese). @Risk of osteoporosis: Low risk, High risk (Moderate risk, High risk). @@Concern about falling: Low concern, High concern (moderate concern, high concern).

in rented house, single women and those with high concern of falling.

In a study by Karmakar et al. on the quality of life of post-menopausal women in West Bengal, it was found that vasomotor symptoms were associated with type of family; psychological symptoms were associated with age; physical symptoms with caste, education and marital status (14). In a study from Nepal, significant factors that were associated with quality of life were marital status, number of children, education, occupation and health seeking behavior (15). Studies have found women with occupation and higher educational status to have lower scores (16, 17).

In the current study, participants who were employed had higher odds of suffering from vasomotor symptoms. The stress of managing household work and occupation simultaneously may have a bearing on the condition. Many employed women pass through midlife crisis typically at this age. Having a supportive environment both at home and workplace can ease the stress.

TABLE 4 Results of univariate analysis to test association of determinant factors on psychosocial domain of MENQOL-I questionnaire.

Variables	Categories	Symptoms of postmenopausal women in psychosocial domain		Pearsons Chi-square test	*p*-value
		Low impact	High impact		
Age	≤60 years *n* = 202	117 (57.9)	85 (42.1)	5.59	**0.023**
	>60 years *n* = 177	81 (45.8)	96 (54.2)		
Age of menopause	≤50 years *n* = 214	120 (56.1)	94 (43.9)	2.89	**0.098**
	>50 years *n* = 165	78 (47.3)	87 (52.7)		
Area of residence	Rural *n* = 188	93 (49.5)	95 (50.5)	1.15	0.305
	Urban = 191	105 (55.0)	86 (45.0)		
House of residence	Owned *n* = 317	164 (51.7)	153 (48.3)	0.20	0.679
	Rent *n* = 62	34 (54.8)	28 (45.2)		
Religion	Hindu *n* = 222	123 (54.9)	101 (45.1)	1.65	0.437
	Christian *n* = 99	47 (47.5)	52 (52.5)		
	Muslim *n* = 56	28 (50.0)	28 (50.0)		
Education*	Pre-high school *n* = 188	95 (50.5)	93 (49.5)	4.56	**0.102**
	High school *n* = 129	63 (48.8)	66 (51.2)		
	After high school *n* = 62	40 (64.5)	22 (35.5)		
Occupation**	Employed *n* = 41	24 (58.5)	17 (41.5)	0.73	0.413
	Homemaker n = 228	174 (51.5)	164 (48.5)		
Socioeconomic status***	BPL *n* = 137	66 (48.2)	71 (51.8)	1.42	0.241
	APL *n* = 142	132 (54.5)	110 (45.5)		
Marital status#	Married *n* = 339	179 (52.8)	160 (47.2)	0.40	0.616
	Single *n* = 40	19 (47.5)	21 (52.5)		
Type of family##	Nuclear *n* = 210	116 (55.2)	94 (44.8)	1.69	0.215
	Extended *n* = 169	82 (48.5)	87 (51.5)		
Payment of health care expenses	Out of Pocket *n* = 360	192 (53.3)	168 (46.7)	3.42	**0.097**
	Insurance or other support *n* = 19	6 (31.6)	13 (68.4)		
BMI (Southeast Asian)###	Low BMI *n* = 111	55 (49.5)	56 (50.5)	0.46	0.572
	High BMI *n* = 268	143 (53.4)	125 (46.6)		
History of fracture bone	Yes *n* = 49	16 (32.7)	33 (67.3)	8.66	**0.004**
	No *n* = 330	182 (55.2)	148 (44.8)		
Calcium supplementation	Yes *n* = 85	45 (52.9)	40 (47.1)	0.02	0.902
	No *n* = 294	153 (52)	141 (48.0)		
Calcium rich food	Yes *n* = 134	68 (50.7)	66 (49.3)	0.19	0.669
	No *n* = 245	130 (53.1)	115 (46.9)		
Risk of osteoporosis based@	Low risk of osteoporosis *n* = 138	72 (52.2)	6 (47.8)	<0.001	1.000
	High risk of osteoporosis *n* = 241	126 (52.3)	115 (47.7)		
Concern of fall@@	Low concern of falls *n* = 225	140 (62.2)	85 (37.8)	22.103	**<0.001**
	High concern of falls *n* = 154	58 (37.7)	96 (62.3)		

The bold values are the factors which have been considered for logistic regression analysis. *Education: Pre high school (Primary, Middle school), High School, Post high school (Secondary, Higher secondary, Graduation). **Occupation: Employed (Unskilled, skilled, professional, retired); Homemaker. ***Socioeconomic: BPL (Yellow, pink); APL (Blue, white). #Marital status: Married, Single (Unmarried, widow). ##Type of family: Nuclear, Extended (Joint family, three generation family). ###BMI South-east Asian: Low BMI (Underweight, normal weight); high BMI (Overweight, obese). @Risk of osteoporosis: Low risk, High risk (Moderate risk, High risk). @@Concern about falling: Low concern, High concern (moderate concern, high concern).

TABLE 5 Results of univariate analysis to test association of determinant factors on physical domain of MENQOL-I questionnaire.

Variables	Categories	Symptoms of postmenopausal women in physical domain		Pearsons Chi-square test	*p*-value
		High impact	Low impact		
Age	≤60 years *n* = 202	123 (60.9)	79 (39.1)	6.31	**0.13**
	>60 years *n* = 177	85 (48)	92 (52.0)		
Age of menopause	≤50 years *n* = 214	121 (56.5)	93 (43.5)	0.55	0.468
	>50 years *n* = 165	87 (52.7)	78 (47.3)		
Area of residence	Rural *n* = 188	97 (51.6)	91 (48.4)	1.63	0.216
	Urban *n* = 191	111 (58.1)	80 (41.9)		
House of residence	Owned *n* = 317	181 (57.1)	136 (42.9)	3.85	**0.052**
	Rent *n* = 62	27 (43.5)	35 (56.5)		
Religion	Hindu *n* = 224	119 (53.1)	105 (46.9)	3.68	0.159
	Christian *n* = 99	62 (62.6)	37 (37.4)		
	Muslim *n* = 56	27 (48.2)	29 (51.8)		
Education*	Pre-high school *n* = 188	99 (52.7)	89 (47.3)	2.01	0.367
	High school *n* = 129	70 (54.3)	59 (45.7)		
	After high school *n* = 62	39 (62.9)	23 (37.1)		
Occupation**	Employed *n* = 41	21 (51.2)	20 (48.8)	0.25	0.623
	Homemaker *n* = 338	187 (55.3)	151 (44.7)		
Socioeconomic status***	BPL *n* = 111	54 (48.6)	57 (51.4)	2.46	**0.140**
	APL *n* = 268	154 (57.5)	114 (42.5)		
Marital status#	Married *n* = 339	196 (57.8)	143 (42.2)	11.18	**0.001**
	Single *n* = 40	12 (30.0)	28 (70.0)		
Type of family##	Nuclear *n* = 210	124 (59.0)	86 (4.0)	3.30	**0.078**
	Extended *n* = 169	84 (49.7)	85 (50.3)		
Payment of health care expenses	Out of Pocket *n* = 360	197 (54.7)	163 (45.3)	0.07	0.818
	Insurance or other support n = 19	11 (57.9)	8 (42.1)		
BMI (Southeast Asian)###	Low bmi *n* = 111	54 (48.6)	57 (51.4)	2.46	**0.140**
	High bmi *n* = 268	154 (57.5)	114 (42.5)		
History of fracture bone	Yes *n* = 49	21 (42.9)	28 (57.1)	3.28	**0.090**
	No *n* = 330	187 (56.7)	143 (43.3)		
Calcium supplementation	Yes *n* = 85	41 (48.2)	44 (51.8)	1.96	**0.175**
	No *n* = 294	167 (56.8)	127 (43.2)		
Calcium rich food	Yes *n* = 134	70 (52.2)	64 (47.8)	0.59	0.452
	No *n* = 245	138 (56.3)	107 (43.7)		
Risk of osteoporosis based@	Low risk of osteoporosis *n* = 138	75 (54.3)	63 (45.7)	0.025	0.915
	High risk of osteoporosis *n* = 241	133 (55.2)	108 (44.8)		
Concern of fall@@	Low concern of falls *n* = 225	161 (71.6)	64 (28.4)	62.175	**<0.001**
	High concern of falls *n* = 154	47 (30.5)	107 (69.5)		

The bold values are the factors which have been considered for logistic regression analysis. *Education: Pre high school (Primary, Middle school), High School, Post high school (Secondary, Higher secondary, Graduation). **Occupation: Employed (Unskilled, skilled, professional, retired); Homemaker. ***Socioeconomic: BPL (Yellow, pink); APL (Blue, white). #Marital status: Married, Single (Unmarried, widow). ##Type of family: Nuclear, Extended (Joint family, three generation family). ###BMI South-east Asian: Low BMI (Underweight, normal weight); high BMI (Overweight, obese). @Risk of osteoporosis: Low risk, High risk (Moderate risk, High risk). @@Concern about falling: Low concern, High concern (moderate concern, high concern).

TABLE 6 Logistic regression analysis for identifying the determinants of post-menopausal symptoms under various domains of MENQOL-I questionnaire.

Variable	Categories	OR (95% C.I)	*p*-value
Vasomotor domain			
Occupation	Homemaker (ref)	1	0.040
	Employed	2.07 (1.05, 4.09)	
Psychosocial domain			
Age of menopause	≤50 years (ref)	1	
	>50 years	1.54 (1.00, 2.37)	0.048
Payment of health care expenses	OOPE (ref)	1	
	Insurance	3.24 (1.164, 9.00)	0.024
History of fracture bone	No (ref)	1	
	Yes	2.34 (1.21, 4.52)	0.011
Concern of fall	Low concern (ref)	1	
	High Concern	2.74 (1.78, 4.23)	<0.001
Physical domain			
Type of house	Owned (ref)	1	
	Rent	1.84 (1.06, 3.21)	0.03
Marital status	Married (ref)	1	
	Single	3.09 (1.42, 6.69)	0.004
Concern of fall	Low concern (ref)	1	
	High concern	5.49 (3.48, 8.66)	<0.001

OR, odds ratio; 95% CI, 95 percent confidence interval; OOPE, out of pocket expenses.

Insured participants in this study had higher score in the psychosocial domain, reflecting the fact that better economic circumstances may influence health seeking behavior. Women with history of fracture and concerned about falling also had higher psychosocial domain scores. In another study conducted among menopausal women in urban part of Hyderabad, India characteristics like education and socioeconomic status were significant determinants of quality of life (6). In this study, among postmenopausal women, risk of osteoporosis was high in 40 (10.6%), moderate in 201 (53%) and mild risk seen in 138 (36.4%) of post-menopausal women.

In a study assessing the OSTA tool's efficacy in evaluating the risk of non-vertebral fractures in post-menopausal Chinese women, findings revealed that 46.1% exhibited high-risk osteoporosis, 34.3% showed moderate risk, and 19.6% had low risk (18). Another study by Ha and Baek found an association between BMI and lower bone mineral density, indicating a potential link with osteoporosis (19). Moreover, research by Kung and Huang emphasized genetic and environmental factors as contributors to osteoporosis, with environmental determinants including smoking, alcohol consumption, low calcium intake, low body weight, and physical inactivity (20).

In this community-based study of postmenopausal quality of life among women, it was found that quality of life was affected by multiple determinants. In depth analysis of the real scenario regarding these determinants calls for a mixed methodology approach. Only three domains namely, vasomotor, psychosocial and physical were addressed. The cultural scenario prevalent in the study area made it hard to explore the quality of life in sexual domain. Conversations about menopause are frequently avoided in families, communities, and workplaces. Providing a supportive environment at home and workplace and having a fall safe environment can improve the quality of life of postmenopausal women. Prevention of fractures should also be given importance, since women with a history of fracture had lesser quality of life. In view of the fact that being single aggravates the physical symptoms of menopause; having good friends and family support may contribute to improved quality of life during menopausal transition.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Amrita School of Medicine Ethical Committee. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

RN: Methodology, Software, Conceptualization, Data curation, Formal analysis, Investigation, Project administration, Resources, Writing – original draft. TJ: Methodology, Software, Supervision, Validation, Visualization, Writing – review & editing. LG: Conceptualization, Methodology, Writing – review & editing. AA: Writing – review & editing, Project administration. MM: Data curation, Formal analysis, Writing – review & editing, Software. GR: Data curation, Formal analysis, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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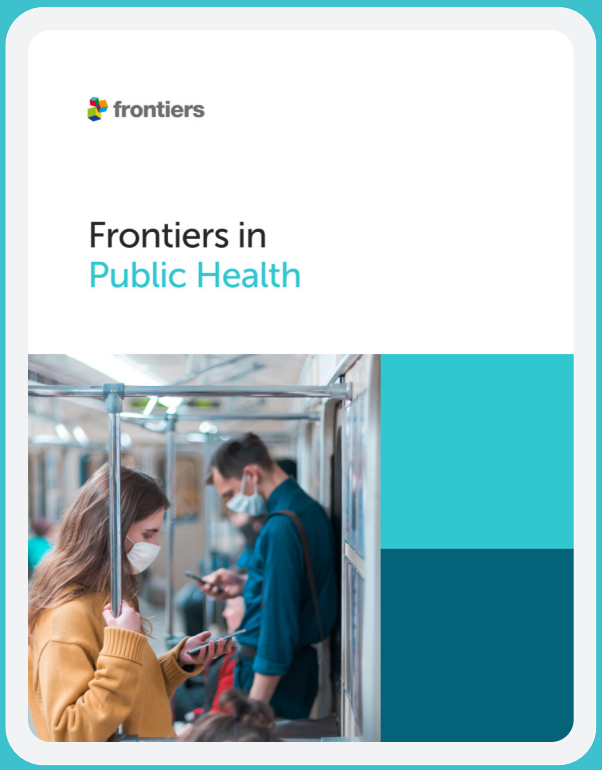

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