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Spatial analysis of the percentages of smokers, alcohol drinkers, social welfare expenditure and insomniacs in Japan

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Insomnia is a significant public health problem; however, no research has conducted a spatial analysis on insomnia in Japan. Therefore, this study aimed to identify potential spatial clusters of insomnia and its related factors among prefectures and to explore the factors associated with insomnia at the prefecture level in Japan. Data from the Japan COVID-19 and Society Internet Survey (JACSIS 2023) was used to estimate the percentages of smokers, alcohol drinkers, and insomniacs for each prefecture using Bayesian statistics. Getis-Ord Gi* spatial statistics was applied to identify potential clusters for all factors. Additionally, Global Ordinary Least Squares (OLS) regression was conducted to examine factors associated with insomnia at the prefecture level in Japan. The percentage of smokers, alcohol drinkers, and individuals with insomnia in the overall population ranged from 19.2 to 23.4%, 44.6–55.7%, and 8.7–15.8%, respectively. The percentages of smokers and alcohol drinkers were higher among males than females, whereas the percentage of insomnia was greater among females. The hot spots for social welfare expenditure are notably concentrated in the western regions, while the cold spots are concentrated in the central areas of Japan. A similar pattern was observed among the male population for the percentages of smokers, alcohol drinkers, and insomniacs. The factors associated with insomnia differed between males and females. In the male model, percentage of smokers was positively associated with percentage of insomniacs ($b = 0.875$, p -value < 0.001), whereas in the female model, social welfare expenditure of each prefecture had a significant positive effect on percentage of insomniacs ($b = 0.091$, p -value = 0.003). In conclusion, smokers, alcohol drinkers, social welfare expenditure and individuals with insomnia exhibit spatial variations and clustering across Japan's prefectures. Percentage of smokers has a significant positive association with percentage of insomniacs among males, while social welfare expenditure has a positive association with percentage of insomniacs among females.

Keywords Spatial analysis, Bayesian statistics, Smokers, Alcohol drinkers, Social welfare expenditure, Insomnia, Japan

Insomnia is a common sleep disorder that can cause people to struggle to fall asleep or stay asleep¹. Previous studies have shown that insomnia is an important risk factor for various physical and mental disorders². Sleep disorders can impair attention, concentration, and higher-order cognitive functions such as working memory³, while also contributing to increased levels of stress, anxiety, and depression⁴. There is an urgent need to incorporate sleep as a factor in financial capacity assessment protocols⁵. Sleep problems have been found to be associated with the systemic immune-inflammation index (SII)⁶ and coronary heart disease⁷ in U.S. adults. In 2016, Osamu Itani et al. conducted a nationwide epidemiological study of insomnia in Japan. The prevalence of insomnia and insomnia with daytime dysfunction was 12.2% (95% CI, 10.3%–14.1%) in men and 14.6% (95% CI, 12.8%–16.4%) in women. The factors associated with insomnia vary by sex. In men, unemployment and poor mental health were identified as key contributors, while in women, age, years of schooling, and poor mental health were significant factors⁸.

Alcohol consumption and smoking are factors linked to numerous public health problems. A study used an infodemiology approach to determine the prevalence of smokers in Japan through an internet search engine,

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and the average estimated smoking prevalence in 2022 was 23.492% (95% CI 21.617% – 25.367%) for the overall population, 29.024% (95% CI 27.218% – 30.830%) for men and 8.793% (95% CI 7.531% – 10.054%) for women⁹. Concerning alcohol consumption in Japan, Tasuku Okui's study revealed that approximately 30.17% of women were alcoholics, which is considerably lower than the 61.7% observed in men¹⁰. According to the Japan Specific Health Checkups Study, 73.3% of women and 30.8% of men reported rarely drinking alcohol¹¹. Moreover, a study revealed that the rates of rarely drinking alcohol among CKD patients were 41.11% for women and 15.3% for men¹². In contrast, another study reported rates of 56% for women and 36.9% for men among CKD patients¹³.

Smoking and alcohol consumption are considered risk factors related to insomnia. A meta-analysis showed that regular smoking was a significant risk factor for insomnia¹⁴. According to a study on Japanese adolescents, the likelihood of having insomnia was 48% greater among smokers and 22% greater among alcohol drinkers¹⁵. A study using National Health and Nutrition Examination Survey (NHANES) 2015–2018 data found that current e-cigarette users had significantly higher odds of reporting trouble sleeping (OR = 2.16, 95% CI: 1.49–3.13) compared to never e-cigarette users. Current cigarette smokers also showed increased odds (OR = 1.36, 95% CI: 1.03–1.79). Dual users had even higher odds (OR = 2.14, 95% CI: 1.34–3.42)¹⁶. Another study revealed that heavy drinkers were 74% more likely to report insomnia than nondrinkers¹⁷. Furthermore, several studies have investigated the associations between smoking and alcohol consumption and insomnia^{18–21}.

While individual-level or mixed-effects analyses provide valuable insights into associations between factors, ecological analysis can reveal geographic patterns and disparities across areas that may not be apparent from individual-level analysis alone. Understanding the spatial distribution of health-related behaviors, such as smoking, alcohol consumption, and insomnia, is crucial for developing targeted public health interventions. Previous studies have highlighted the spatial clustering of smoking^{22,23} and alcohol consumption²⁴; however, research on the spatial patterns of insomnia remains limited. Additionally, Japan faces significant health challenges related to these factors^{8,9,13}. Also, Japan experienced rapid improvements in social welfare during its period of high economic growth. To ensure continued economic growth and human development, governments should effectively collect taxes²⁵. While increasing taxes can be a source of financial stress on residents in various ways, there is limited direct research on the impact of social welfare expenditure (SWE) on insomnia. Given the existing literature, we hypothesize that there is a spatial association between smoking, alcohol consumption, social welfare expenditure and insomnia. Therefore, this study aims to identify the spatial patterns of these behaviors to support the implementation of more effective public health campaigns, optimize resource allocation, and enhance preventive measures, ultimately improving overall public health outcomes in Japan.

Methods

Study area

The study area is Japan, which is located in the northwest Pacific Ocean. The GPS coordinates of Japan are 35° 39' 10.1952" N and 139° 50' 22.1208" E. The total area of Japan is approximately 377,975 km². Administratively, Japan is divided into 47 prefectures. The names and codes of Japan's prefectures are presented in Supplemental File Table 2. Each prefecture can have many small areas far from the main area. These small areas can affect spatial analysis; therefore, they were excluded from the study. Okinawa Prefecture was also excluded. Only the main area of each prefecture was included in the current study.

Population data source

The data were obtained from a population-based online questionnaire survey, the Japan COVID-19 and Society Internet Survey (JACSIS 2023). Participant recruitment was conducted through Rakuten Insight, a commercial research agency with a panel comprising approximately 2.2 million individuals from the Japanese population. Participant selection was stratified by sex, age, and geographic region. The initial target sample size was set at 28,000 participants; however, a total of 33,000 individuals participated in JACSIS 2023, with 29,268 providing eligible responses. The comprehensive data collection included measures of socioeconomic indicators, occupational factors, health-related measures, physical and mental health, quality of life, smoking habits, alcohol use, lifestyle behaviors, and other health-related behaviors²⁶. Participants younger than 20 years old were excluded from the current analysis, resulting in a final sample size of 27,149 individuals. Supplemental File Table 3 shows the distribution of the participants per prefectures in Japan. All methods were carried out in accordance with relevant guidelines and regulations.

Investigated variables

Exposures

- Smoking

The participants were asked 17 questions regarding different smoking materials (Cigarettes, hand-rolled cigarettes, Ploom Tech, Ploom X, IQOS, glo (glow), lil HYBRID, electronic cigarettes (those containing nicotine), electronic cigarettes (those that do not contain nicotine), electronic cigarettes (products that may or may not contain nicotine), cigars, little cigar, pipe, smoke pipe (kisel), chewing tobacco, and snuff such as snus, Hookah (Shisha)).

Each question was rated as follows: (1) I have never smoked (used) before. (2) I tried smoking (using) at least once, but I did not use it habitually. (3) I used to smoke (use) habitually, but now I have stopped. (4) Sometimes there are days when I smoke (use). (5) I smoke (use) almost every day. However, it is transformed as follows: codes 1, 2, and 3 are converted to code 0 as “non_smoker”, and codes 4 and 5 are converted to code 1 as “current smoker”. Then the seventeen questions were combined into one question using the OR logical operator.

- Alcohol consumption

The participants were asked one question about drinking alcohol. The questions were rated as follows: (1) I have never drunk it before. (2) I tried drinking it at least once, but I did not use it habitually. (3) I used to drink it habitually, but now I have stopped. (4) There are days when I sometimes drink. (5) I drink it almost every day. However, it is transformed as follows: codes 1, 2, and 3 are converted to code 0 as “non_use (alcohol)” and codes 4 and 5 are converted to code 1 as “current use (alcohol).”

- Social Welfare Expenditure (SWE)

The prefectural-level social welfare expenditure (SWE) per capita (thousand yen) data for Japan was obtained from Anqi Li²⁷.

Outcome

- Use of sleeping pills/anti-anxiety drugs

The participants were asked one question about using sleeping pills/anti-anxiety drugs for indication of insomnia (lack of sleep). The questions were rated as follows: (1) I have never used it before. (2) I tried using it at least once, but I did not use it habitually. (3) I used to use it habitually, but now I have stopped. (4) There are days when I sometimes use. (5) I use it almost every day. However, it is transformed as follows: codes 1, 2, and 3 are converted to code 0 as “non_use (sleeping pills)” and codes 4 and 5 are converted to code 1 as “current use (sleeping pills).”

Estimating of the percentages of smokers, alcohol-drinkers, and individual with insomnia at the Prefecture level in Japan

Online surveys are prone to selection bias as they only reach a subgroup of the target population²⁸. To address this, JACSIS 2023 employed inverse probability weighting (IPW) based on propensity scores derived from a pooled sample combining: (1) JACSIS 2023 survey respondents and (2) a population-representative sample from Japan’s Comprehensive Survey of Living Conditions of People on Health and Welfare (CSLCPHW). However, a study evaluating sociodemographic weighting in online surveys found that while age and gender distributions differed between weighted and unweighted samples, some measurements (such as insomnia severity, stress levels, and anxiety symptoms) showed remarkable consistency across both approaches²⁹. Moreover, two studies comparing weighted and unweighted estimates from online surveys found that demographic weighting reduced bias in certain cases but significantly increased it in others^{30,31}. Recent study analysed aggregated data on racial and ethnic disparities in COVID-19 mortality have shown that using weighted population distributions tends to underestimate the excess mortality burden among African American and Latin individuals, compared to analyses based on unweighted populations³². Bayesian methods offer a probabilistic approach to analyzing ecological data, which can be a powerful alternative to traditional weighting techniques. Instead of assigning arbitrary weights to data points, Bayesian methods combine prior knowledge with observed data to update and refine our understanding of the model parameters.

In the current study, Bayesian inference was used to estimate the parameters (percentages) of smokers, alcohol drinkers, and sleep pill users for each prefecture, addressing the issue of small sample size in some prefectures. The posterior distribution of the parameters was determined using conjugate priors’ technique. The beta distribution was used as a prior distribution of the parameters, and binomial distribution was used for the likelihood function. The function “beta.select” in the LearnBayes package in R was used to find the shape parameters of the beta distribution. The function “summarize_beta_binomial” in the bayesrules package was used to determine the posterior probability. However, the inputs to the “beta.select” function are two parameters named quantile1 and quantile2. Each quantile is a list with components p (representing the probability) and x (the corresponding value) which define the prior percentiles, and the function returns the values of the matching beta parameters. The probability of quantile 1 was at 2.5%, and for quantile 2 at 97.5%.

The corresponding values were obtained from the literature:

- For smokers⁹.

The percentages in quantile 1 and quantile 2 were 21.617% and 25.367%, respectively, for the overall population; 27.218% and 30.83%, respectively, for males; and 7.531% and 10.054%, respectively, for females.

- For alcohol drinker^{10–13}.

The percentages in quantile 1 and quantile 2 were 44% and 60%, respectively, for the overall population; 60% and 70%, respectively, for males; and 30% and 45%, respectively, for females.

- For insomniacs^{8,33}.

The percentages in quantile 1 and quantile 2 were 12.2% and 21.5%, respectively, for the overall population; 10.3% and 14.1%, respectively, for males; and 12.8% and 16.4%, respectively, for females.

Spatial analysis

Hot spot analysis

Global Moran’s I statistics were used to determine whether the distribution of the investigated variables (smokers, alcohol drinkers, and insomniacs) was random at the prefecture level of Japan. A Moran’s I value close to -1

indicates a dispersed distribution, whereas a value close to +1 suggests a clustered distribution. A Moran's I value near 0 indicates that the variables are randomly distributed. A statistically significant Moran's I ($p < 0.05$) result indicates that the variable's distribution is not random, rejecting the null hypothesis³⁴.

Hot spot analysis was conducted to assess how spatial autocorrelation varies across the prefectures of Japan by calculating the Getis-Ord Gi* statistic for each location. The Getis-Ord Gi* spatial statistics tool was used to identify clusters of both hot spots (high values) and cold spots (low values). A hot spot is detected when a high value is surrounded by other high-value features, whereas a cold spot occurs when a low value is surrounded by other low-value features³⁴.

Modelling Spatial relationships

Global Ordinary Least Squares (OLS) regression was performed to identify factors associated with insomnia at the prefecture level of Japan. It assumes a constant relationship across all prefectures and produces a single global estimate for the association. Several assumptions were tested: the Jarque-Bera test for residual normality to ensure unbiased residuals, Koenker's studentized Breusch-Pagan test to assess heteroscedasticity of residual errors, Moran's I test to determine whether residual errors were spatially autocorrelated, and the Variance Inflation Factor (VIF) to check for multicollinearity. If Koenker's studentized Breusch-Pagan test or Moran's I test for residuals was statistically significant (p -value < 0.05), a spatial regression model, Geographically Weighted Regression (GWR), which allows for varying associations across different prefectures will be used³⁴. However, in the current study, the assumptions were not violated; therefore, GWR was not implemented. (Supplemental File Table 1). Spatial analysis was conducted using Esri ArcGIS 10.8 software³⁵.

Results

A weighted total of 27,149 participants were included in the study. Approximately half (50.8%) of the participants were male. The mean age of the participants was 49.36 years ($SD = 17.57$). The majority of participants (62.26%) were married, and nearly half (50.63%) had graduated from high school (Table 1).

At the prefecture level in Japan, the percentage of smokers, alcohol drinkers, and individuals with insomnia in the overall population ranged from 19.2 to 23.4%, 44.6–55.7%, and 8.7–15.8%, respectively. For males, the percentages of smokers and alcohol drinkers were greater than those for females (smokers: 27.3–29.1%, alcohol drinkers: 56.5–66.2%; smokers: 8.1–9.9%, alcohol drinkers: 34–44.4%, respectively). However, females exhibited more symptoms of insomnia than males did (9.8–16.6% for females, 9.5–12.3% for males) (Fig. 1).

Spatial autocorrelation analysis revealed that the Moran's I statistic was significant for all variables, except for smokers in the female model, which showed a random effect (Table 2).

The hot spot analysis of the overall population detected six hot spots of smokers in the study area, including Oita with a 95% CI; and Yamaguchi, Fukuoka, Saga, Kumamoto, and Miyazaki with a 90% CI. Seventeen cold spots of smokers were also identified: Toyama, Yamanashi, Nagano, Gifu, Shizuoka, and Aichi, with a 99% CI; Ibaraki, Tochigi, Gunma, Saitama, Chiba, Kanagawa, Ishikawa, Fukui, and Shiga, with a 95% CI; and Tokyo and Mie, with a 90% CI (Fig. 2A).

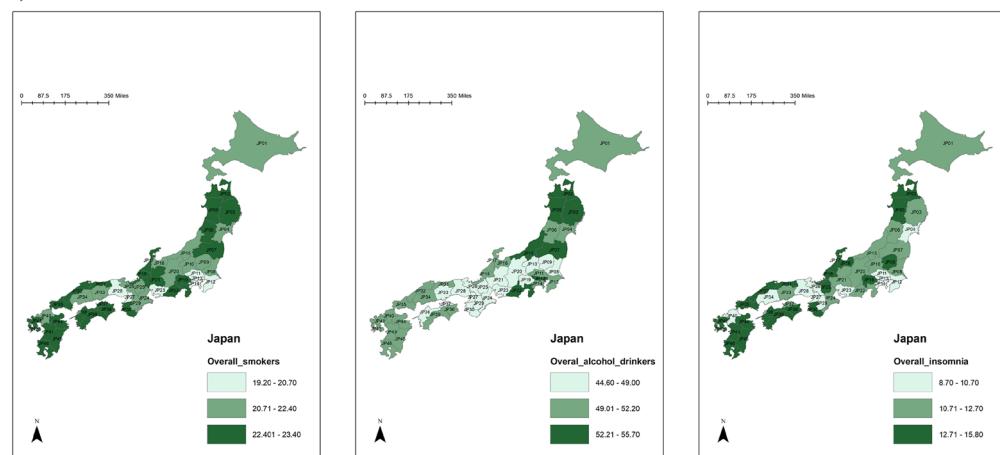
The spatial patterns of hot spots and cold spots of insomnia for the overall population was similar to that of smokers. Two additional hot spots were found for insomnia in Nagasaki and Kagoshima, while Tokyo and Kanagawa were not classified as cold spots, and Niigata was classified as a cold spot (Fig. 2A).

The spatial patterns of hot spots and cold spots of alcohol drinkers for the overall population were different from those of smokers and insomnia. Iwate, Akita, Aomori, Miyagi, Yamagata, and Fukushima were identified

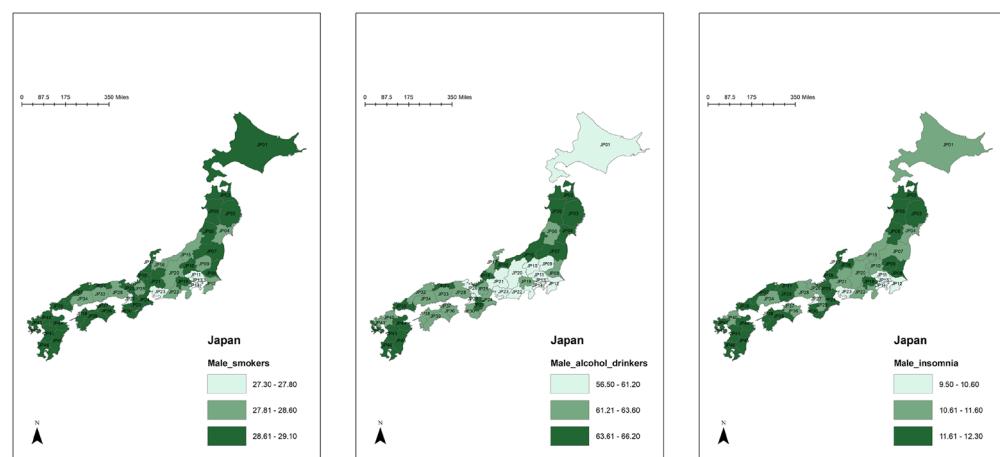
Variables	Weighted frequency ($N=27,149$)	percentage (%)
Gender		
Male	13,789	50.8
Female	13,360	49.2
Age		
Mean \pm SD	49.36 ± 17.57	
Marital status		
Have a spouse	16,903	62.26
Unmarried	7,401	27.26
Bereavement	1,365	5.03
Divorced	1,480	5.45
Education		
Junior high school	1224	4.51
High school	13,744	50.63
Vocational school/Junior college/technical college	5081	18.72
University	6068	22.35
Graduate university	588	2.16
Other	444	1.63

Table 1. Socio-demographic characteristics of the study participants in Japan, JACSIS 2023.

A)



B)



C)

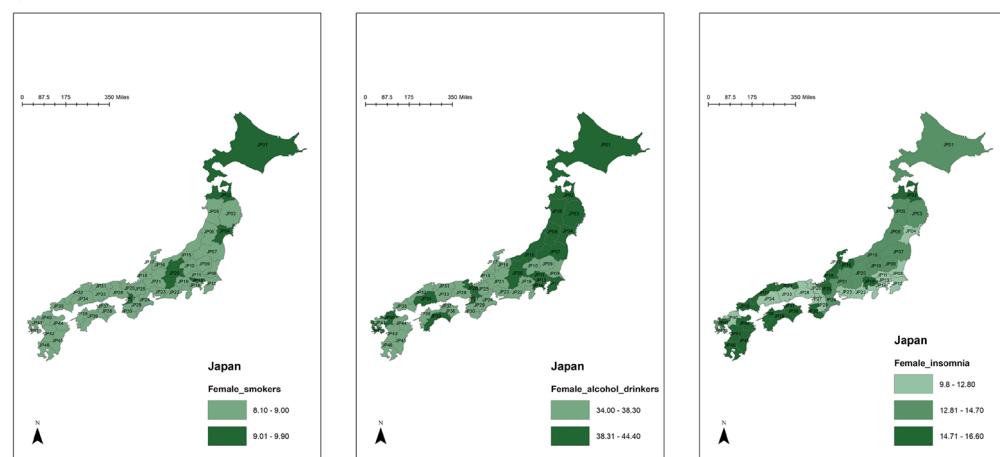


Fig. 1. Spatial distribution of the percentages of smokers, alcohol drinkers, and individual with insomnia for the (A) overall population, (B) males, and (C) females, JACSIS 2023³⁵.

as hot spots for alcohol drinkers, while Fukui, Gifu, Shizuoka, Aichi, Mie, Shiga, Kyoto, Osaka, Hyōgo, Nara, Wakayama, Tottori, Okayama, Tokushima, and Kagawa were classified as cold spots for alcohol drinkers (Fig. 2A).

Figure 2B illustrates the spatial distribution of hot spots and cold spots for smokers, alcohol drinkers, and insomnia among males. The hot spots are notably concentrated in the western regions, while the cold spots are

	Moran's index	Z-score	P-value	Pattern
Smokers				
Overall	0.149	3.597	<0.001	Cluster
Men	0.199	4.690	<0.001	Cluster
Female	-0.026	-0.076	0.939	Random
Alcohol drinkers				
Overall	0.123	3.025	0.002	Cluster
Men	0.235	5.358	<0.001	Cluster
Female	0.136	3.164	0.001	Cluster
Insomniacs				
Overall	0.114	2.816	0.004	Cluster
Men	0.207	4.854	<0.0001	Cluster
Female	0.085	2.152	0.031	Cluster
Social Welfare Expenditure (SWE)	0.359	7.829	<0.0001	Cluster

Table 2. Global moran's I for the percentages of smokers, alcohol drinkers, social welfare expenditure and individuals with insomnia, JACSIS 2023.

concentrated in the central areas of Japan for all three factors. However, two additional hot spots, Iwate and Akita, were identified with a 99% confidence interval in northern Japan for alcohol drinkers.

Figure 2C shows the spatial distribution of hot spots and cold spots for smokers, alcohol drinkers, and insomnia among females. Hot spots and cold spots did not appear in smokers. However, the spatial patterns of hot spots and cold spots of alcohol drinkers was different compared to insomnia, the hot spots and cold spots were concentrated in different prefectures.

Figure 3 presents the hot spots and cold spots for social welfare Expenditure (SWE) in Japan. The hot spots are primarily concentrated in the western regions, while the cold spots are mainly located in the central areas of the country.

Table 3 presents the global regression analysis of the percentage of insomnia on the percentage of smokers, percentage of alcohol drinkers, and social welfare expenditure (SWE) at the prefecture level in Japan. The coefficient of determination (R^2) was 0.674 for the overall population model, 0.598 for the male model, and 0.226 for the female model. The ANOVA results indicated that all models were statistically significant ($p < 0.05$).

For the overall population, the percentage of smokers and SWE were significant positive predictors of the percentage of insomnia ($b = 1.215, p < 0.001$; $b = 0.044, p = 0.017$, respectively). In the male model, only the percentage of smokers was a significant positive predictor of the percentage of insomnia ($b = 0.875, p < 0.001$). However, in the female model, SWE was the only significant positive predictor of the percentage of insomnia ($b = 0.091, p = 0.003$).

Discussion

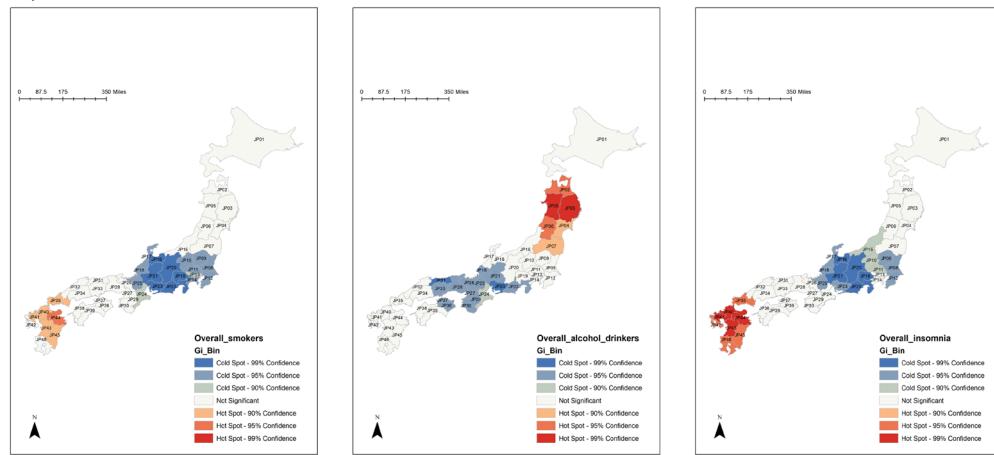
Insomnia can negatively affect daytime concentration, workplace productivity, accident and injury risk, and overall quality of life. Additionally, smoking and alcohol consumption in adults are associated with a range of physical and psychological issues³⁶. However, given the limited research on spatial analysis in Japan regraded these factors and SWE, this study analyzed the percentages of smokers, alcohol drinkers, social welfare expenditure, and individuals with insomnia across 46 prefectures. It identified spatial patterns and high-risk areas, as well as determined the predictors of insomnia using geospatial techniques.

The population dynamics of smokers have dramatically changed over time³⁷. In Japan, the declining trend of smokers is expected to continue until around 2030. In addition, the prevalence of smoking among women is lower than among men, and it is expected that women's overall prevalence of smoking will eventually be close to or slightly lower than that of men by 2050³⁸. In addition, the current study showed that although the prevalence of smoking in women was less than that in men for all prefectures of Japan, it did not reveal spatial clusters similar to those found in men. For men, nine prefectures were identified as hot spots in the western part, and eighteen prefectures were identified as cold spots at the center of Japan.

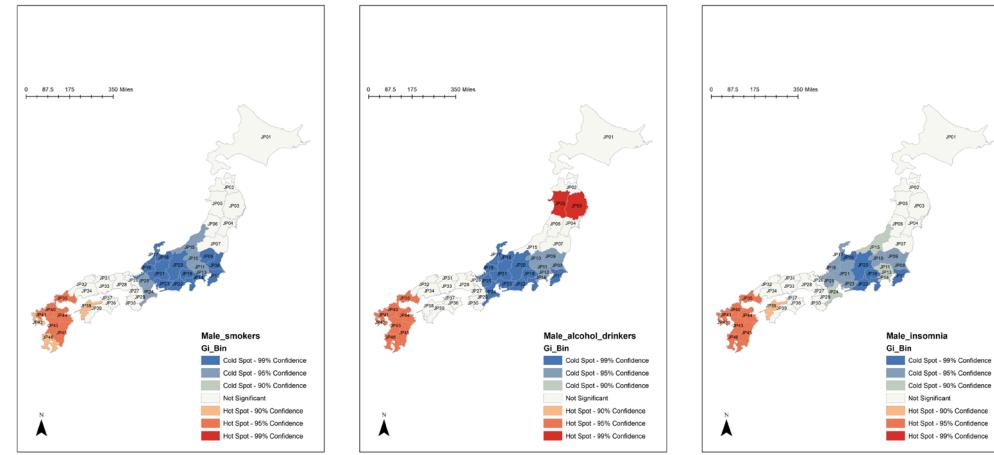
There was an increasing trend in alcohol-related deaths for both sexes from 1995 to 2016³⁹. Alcohol consumption exhibits statistically significant spatial variation across regions in Ethiopia among pregnant women and the general population^{24,40}. In this study, clusters of hot spots were concentrated in the eastern part of Japan, similar to a study that analyzed genomic data to identify the prefectures which higher tolerance to alcohol. That study found that the Tōhoku region has a higher tolerance to alcohol⁴¹. However, in the present study, female hot spot clusters were concentrated in the east, while male hot spot clusters were found in both the east and west of Japan. Overall, the hot spots were primarily concentrated in the eastern part of Japan.

Spatial analysis plays a crucial role in visualizing the distribution of smokers, alcohol drinkers, and individuals with insomnia. A study found that cigarette smoking was spatially associated with alcohol consumption in India⁴². In China, smoking and drinking are widespread not only among lower-income or less-educated groups but also among high-status individuals⁴³. Additionally, social welfare expenditure (SWE) per capita was higher in hot spot prefectures in Japan for smokers compared to cold spots. In contrast, SWE for alcohol drinkers was nearly the same between hot and cold spots, suggesting that cultural or social factors may play a significant

A)



B)



C)

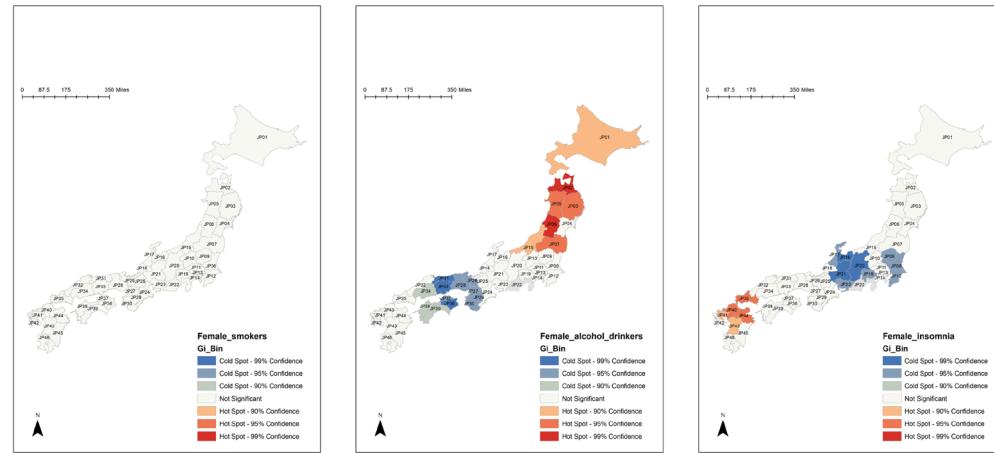


Fig. 2. Hot spot analysis of the percentages of smokers, alcohol drinkers, and individual with insomnia for the (A) overall population, (B) males, and (C) females, JACSIS 2023³⁵.

role in shaping alcohol consumption patterns. For insomnia, SWE was greater in hot spots than in cold spots²⁷. This finding contradicts by Yoshida's (2022) research, which highlights that increasing sleep duration through reduced labor hours not only benefits individual health but also enhances overall social welfare⁴⁴.

A relation between insomnia and smoking, as well as alcohol consumption, has been observed in many studies^{14,45–47}. In the current study, the spatial distribution of insomnia, smoking, and alcohol consumption differed between males and females. Among males, the OLS model showed that smoking had a significant

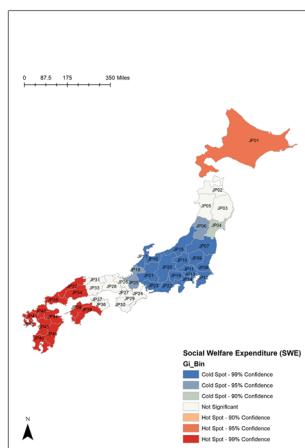


Fig. 3. Hot spot analysis of the social welfare expenditure (SWE)³⁵.

	Overall	Males	Females
F-ANOVA (p-value)	32.03(<0.001)	23.398(<0.001)	5.292(0.003)
Adjusted R²	0.674	0.598	0.226
Coefficients			
Smokers	1.215(<0.0001)	0.875(<0.001)	0.067(0.945)
Alcohol drinker	-0.047(0.441)	0.063(0.116)	-0.1942(0.123)
SWE	0.044 (0.017)	0.004(0.620)	0.091(0.003)

Table 3. Results of the global regression analysis of insomnia on percentages of smoker, percentages of alcohol drinker, and SWE regarding the overall population, males, and females. F-ANOVA: Test the overall model's significance. Coefficients: Unstandardized coefficients. SWE: Social Welfare Expenditure.

positive association with insomnia. Observing spatial correlations between smoking and insomnia prevalence can help policymakers to target regions exhibiting high co-prevalence of these behaviors through an integrated public health intervention that simultaneously address substance use and sleep health. In contrast, for females, the OLS model revealed that SWE had a significant positive association with insomnia. This positive association may be explained by factors such as a high aging population or higher unemployment rates in certain prefectures, both of which contribute to stress and, consequently, insomnia. Therefore, individual level study is needed to confirm the association between insomnia and SWE.

As a limitation, this study excluded Okinawa Prefecture from the analysis due to its geographical distance from other prefectures, which could affect spatial analysis. Additionally, the cross-sectional nature of the survey data prevents the establishment of causal relationships. Moreover, using only sleeping pills or anti-anxiety medications as indicators of insomnia is another limitation, as these medications are also prescribed for mental illnesses. However, the 12-month prevalence rate of any common mental disorder in Japan was 5.2%, and only 19.4% of those affected sought mental health treatment⁴⁸. Therefore, this limitation is likely to have only a minimal impact on the analysis.

The strength of this study lies in being the first to identify the spatial patterns of smokers, alcohol drinkers, social welfare expenditure, and insomnia in Japan. Additionally, it utilizes nationally collected data and includes different age groups. Furthermore, Bayesian inference was applied to address the issue of a small number of responses in some prefectures, ensuring adequate statistical power and enabling the generalization of findings at the national level.

Data availability

The data used in the present are not deposited in a public repository due to the containing of personally identifiable or potentially sensitive information. In accordance with the ethical guidelines' regulations in Japan, dissemination of the data is restricted by the Research Ethics Committee of the Osaka International Cancer Institute. Any inquiries regarding the data use should go to Dr Takahiro Tabuchi, tabuchitak@gmail.com. More details of data availability can be found on the website of JACESIS (<https://jacsis-study.jp/howtouse/>).

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Author contributions

NL conceptualized the study topic, designed the study, statistical analysis and writing the manuscript. TT obtained the data, supervised and critically revised the work for intellectual content. All authors contributed to the review, and editing and agreed on the final manuscript.

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Declarations

Ethics approval and consent to participate

The Japan COVID-19 and Society Internet Survey (JACSS 2023) was approved by the Ethics Committees of the Osaka International Cancer Institute (approval numbers 20084). Informed consent was obtained from all the participants.

Competing interests

The authors declare no competing interests.

Additional information

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