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Association of gambling activities and modalities with problem gambling in Japan: A nationwide cross-sectional online survey-based study

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ABSTRACT

Background and Aims: Problem gambling (PG) is a relevant public health concern. Thus, this study aimed to identify the association of specific gambling activities and modalities with PG in Japan.
Methods: A cross-sectional study using data from a large-scale online survey was conducted in Japan between February 6 and 27, 2023. Candidate gambling activities and modalities include sports betting (offline/online), casinos (offline/online), lotteries (offline/online), electronic gaming machines, and trading activities. PG was defined as a score $\geq$ 8 on the Problem Gambling Severity Index. All estimates were weighted using a nationally representative survey conducted in Japan in 2019. To estimate the association between gambling engagement and the prevalence of PG, multivariable logistic regression models were fitted after adjusting for 13 confounding factors representing demographic, socioeconomic, health-related, and geographic characteristics.
Results: A total of 12,955 respondents aged 15–82 years who had gambled in the past year were included. Among the respondents, 12.2 % (95 % confidence interval [CI] 11.4–13.1) were reported PG. The weighted multivariable logistic regression models revealed significant associations of PG with online sports betting (adjusted odds ratio [aOR] 2.41, 95 % CI 1.86–3.13), offline casinos (aOR 1.53, 95 % CI 1.16–2.02), online casinos (aOR 4.25, 95 % CI 3.09–5.86), and cryptocurrency trading (aOR 1.60, 95 % CI 1.22–2.10).
Conclusion: Experiences in online sports betting, online and offline casinos, and cryptocurrency trading demonstrated statistically significant associations with the prevalence of PG. These findings emphasize the need for legal awareness of casinos and restrictions on gambling access and betting amounts.

1. Introduction

Gambling is a highly profitable commercial activity that has grown substantially over the past decades, with the global gambling market reaching approximately $449 billion in 2022 (The Business Research Company, 2024). Although gambling expenditure has leveled off or declined in some countries, it continues to increase in large nations, such as the United States (US) and the United Kingdom (UK) (American Gaming Association, 2024; Gambling Commission, 2024). According to a recent meta-analysis, the global prevalence of past-12-month

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gambling engagement among adults was 46.2 % (approximately 2.3 billion people), with regional variations (Tran et al., 2024). In addition, recent technological innovations in the internet and mobile devices have introduced online gambling to many individuals, contributing to its strong growth (World Health Organization, 2017). Gambling can harm individuals and society (Langham et al., 2016) and thus is of high interest individually, socially, and globally.

Japan has one of the highest international gambling revenues and prevalence of individuals suspected of having gambling disorders. In 2022, gambling revenues were approximately 23.3 trillion Japanese Yen (JPY, $155.3 billion), which was higher than those in the US or the UK (American Gaming Association, 2024; Gambling Commission, 2024; Japan Productivity Center, 2024). In 2020, the past-year prevalence of probable gambling disorder (scoring $\geq$ 5 on the South Oac Gambling Screen [SOGS]) was 2.2 % in 2020, comparable to the US (2.4 %, 2011–2014) but higher than the UK (0.9 %, 2010) (National Hospital Organization Kurihama Medical and Addiction Center, 2021; Wardle et al., 2011; Welte et al., 2015). In Japan, legal gambling activities include sports betting in public races (horse, bicycle, boat, and automobiles), lotteries, sports promotion lotteries, and pachinko. Each type of gambling is regulated by a specific legislation. All forms of legal gambling, except pachinko, are available online and offline. The minimum age requirements vary: 20 years for sports betting on public racing, 19 years for sports promotion lotteries, 18 years for pachinko, and no age restrictions for lotteries. Despite the lack of legalized casinos, both land-based and online, various gambling activities are available in Japan. Pachinko parlors and lottery outlets are widespread across the country, from rural to urban areas, including public racetracks in major cities. In addition, tickets for public races and lotteries, and trades of stocks, commodities, foreign exchange, and cryptocurrency are readily available on the internet. Individuals living in Japan can access other forms of gambling that are not legal in Japan, including underground casinos within the country, land-based casinos in neighboring countries (such as Korea or Macau), and online casinos. In addition, Japan's first land-based casino is scheduled to open in Osaka by 2030 (Imai, 2018). The widespread availability of such opportunities, which pose a significant risk for gambling disorders, has received considerable attention from Japanese policymakers.

Problem gambling (PG), characterized by gambling behaviors that negatively impact individuals engaging in gambling, their family, or the community, may cause gambling-related harms, such as financial distress, mental illness, self-harm, weakened links to the community or society, reduced work or study productivity, and active crime (Blaszczynski & Nower, 2002; Langham et al., 2016). PG is a term used in screening tools for the general population and in primary care settings. However, some individuals with serious gambling problems may meet the diagnostic criteria for gambling disorder as defined in the Diagnostic and Statistical Manual of Mental Disorders, 5th edition (DSM-5) (American Psychiatric Association, 2022). For early intervention in gambling-related harm, numerous studies have examined the etiology (Nower et al., 2022), risk, and protective factors (Dowling et al., 2017) of PG, which clinicians are highly interested in. However, studies regarding PG as a public health issue are scarce. Consequently, the World Health Organization (WHO) highlighted the urgent need for evidence-based policies and prevention strategies for PG and gambling-related harms (World Health Organization, 2017).

Therefore, addressing the harm associated with gambling is critical. One approach to tackling PG and related issues is to regulate gambling activities that contribute to it (van Schalkwyk et al., 2021). In this context, identifying the gambling activities or modalities associated with PG can inform and enhance public health policies. Although some studies have attempted to investigate the risk of developing PG for specific types of gambling (Gooding & Williams, 2023; Mazar et al., 2020; Ronzitti et al., 2016; Scalese et al., 2016), evidence that comprehensively covers recent diverse gambling activities and modalities, such as playing the stock market, commodities, or cryptocurrency markets (Delfabbro et al., 2021; Johnson et al., 2023; Oksanen et al., 2022), as well as online gambling remains limited.

To fill the research gap on PG from policymakers' perspectives, this study aimed to investigate the types of gambling activities associated with PG in Japan, where gambling is widely practiced. The variations in these associations across age and gender groups are also examined.

2. Method

2.1. Study design

In this cross-sectional study, data from a nationwide non-probability survey between February 6 to 27, 2023 (n = 34,000) were used. All respondents were included and thus sample size calculations were not performed. All questionnaires were designed such that the respondents must answer each question before proceeding to the next, ensuring complete data.

2.2. Details of the survey

The survey used in this study was a longitudinal study comprising a series of annual internet surveys conducted since 2015. As of April 1, 2024, 10 surveys have been conducted. All participants were recruited from a survey panel provided by a Japanese internet research agency. The latest survey with the respondents was conducted between February 6 and February 27, 2023. The target number of respondents was set at 34,000. Upon enrollment, participants were primarily recruited from those who also participated in previous surveys. A total of 28, 437 respondents were used in this study. To achieve the targeted response number (n = 34,000), 5,563 respondents aged 15–79 years were recruited from the aforementioned panelists. Other important information regarding the survey is provided in the Appendix Method.

2.3. Inclusion and exclusion criteria

Respondents who were engaged in gambling at the time of the survey were included in this study. To define engagement in gambling, a specific question was developed following the SOGS (Lesieur & Blume, 1987) validated in Japanese (Kido & Shimazaki, 2007). Three categories of gambling engagement were defined (never, past, and current). "Current" engagement is defined as those who had engaged in at least one gambling session during the past year. The exclusion criteria were as follows: (1) respondents with straight-line responses about comorbidities (i.e., if they chose the same response option to answer all questions in a set of questions) and (2) those who failed an attention check. The following instructions were provided in the attention check: "Please choose the second answer from the bottom." Respondents who selected responses other than the second from the bottom were excluded.

2.4. Gambling activities and modalities

The exposure of interest for analysis were gambling activities and their modalities. On the basis of the SOGS framework (Lesieur & Blume, 1987), this study assessed engagement in the following gambling activities: betting on a horse, bicycle, boat, and auto racing; casino gambling; lottery; sports promotion lottery; pachinko; and trading activities. Response options were categorized as follows: "not at all," "in a year (less than once a week)," "in a year (once a week or more)," "over a year ago (less than once a week)," and "over a year ago (once a week or more)." From these responses, three categories of gambling engagement were defined: (1) never engaged – respondents who answered "not at all" for a specific gambling activity; (2) current engagement – respondents who reported engaging in a specific gambling activity during the past year; and (3) past engagement – respondents who engaged in gambling more than a year ago. Given the cross-sectional nature of this study, respondents who reported gambling either "less than once a

week" or "once a week or more" during the past year were classified as having current engagement. Conversely, for each gambling activity, respondents classified as either 'never engaged' or 'past engagement' were defined as having no engagement in that specific gambling activity during the survey. In the question aimed to determine gambling use, some specific types of gambling not played globally were included (*e.g.*, betting on bicycles, boats, auto racing, or sports promotion lotteries). In Japan, only betting at public racing events is legally recognized as sports betting. Thus, betting on horse, bicycle, boat, and auto racing were combined into "sports betting." Moreover, given that the sports promotion lottery and conventional lottery are similar in terms of their sales format and prize structure, lottery and sports promotion lottery were combined into "lottery." The offline and online modalities were obtained separately. In Japan, pachinko and slot machines (pachi-slot), which are widely played in pachinko parlors, are often equipped with large, liquid crystal display screens and feature electronically controlled, flashy presentations that dramatize wins. They are designed to maximize the consumption of time and money, which is the same as electronic gaming machines (EGMs) (Australian Institute of Family Studies, 2017). Thus, they were defined here as "EGM and slot machines." Lottery tickets, including conventional lottery and sports promotion lottery, are available through two purchasing methods: in-person at physical outlets ("offline lottery") and through digital platforms ("online lottery"). Lottery engagement was categorized on the basis of these purchasing methods. All reclassifications were based on a previous meta-analysis of the risk factors of PG (Allami et al., 2021), the details of which are presented in Table 1.

2.5. Covariates

Covariates of interest included demographic, socioeconomic, and health-related status based on a previously published meta-analysis of risk factors for PG (Allami et al., 2021). The demographics included age group (15–24, 25–34, 35–44, 45–54, 55–64, 65–74, and 75–82 years) and gender (male or female). Socioeconomic status included marital status (unmarried, married, widowed/separated), employment (employer, self-employed, regular employee, part-time employee, or unemployed), urbanization level in residential areas (metropolitan areas, large cities, accessible small towns, remote small towns, accessible rural settlements, remote rural settlements, or unidentifiable), educational attainment (high school education or lower, college education or higher), and income. Employment status was determined using a comprehensive questionnaire covering various employment situations. Urbanization levels were determined using densely inhabited district (DID) data from the 2020 Population Census of Japan. By matching the respondents' ZIP codes with the DID data, their residences were classified as either urban or rural (metropolitan areas, large cities, accessible small towns, remote small towns, accessible rural settlements, and remote rural settlements). As an income indicator representing health inequity in Japanese populations (Fukuda et al., 2007), the equivalent household income calculated by dividing the household income by the square root of household size was used (categorized by the quartiles of equivalent household income [1st quartile, JPY 0–2.25 million; second quartile, JPY 2.26–3.25 million; third quartile, JPY 3.26–4.75 million; fourth quartile, JPY 4.76 million and more; and unknown/declined to answer]) (Yoshioka et al., 2021). Health-related factors included smoking, alcohol use, binge drinking, and psychiatric comorbidities (anxiety, depression, and others). For smoking, heated tobacco product use (never, past, or current), which is widely used in Japan, and potential risk factors for gambling, such as electronic cigarettes in the United States (McGrath et al., 2018; Odani & Tabuchi, 2022) and combustible cigarette use (never, past, or current) were selected. Alcohol use and binge drinking were simultaneously assessed using the Alcohol Use Disorders Identification Test (AUDIT) (Saunders et al., 1993)—a 10-item questionnaire developed by the World Health Organization to identify hazardous alcohol use that has been validated in Japanese (Kawada et al., 2011; Saunders et al., 1993). The AUDIT guideline-based classification was followed (no or low-risk use = 0–7 points; medium-risk use = 8–15 points; high-risk use = 16–19 points; and likely alcohol dependent = 20–40 points) (World Health Organization, 2001). For the indicator of anxiety issues, psychological distress measured by the Kessler-6 scale (no psychological distress = 0–4 points; moderate psychological distress = 5–12 points; serious psychological distress = 13–24 points) (Furukawa et al., 2008) was used, which was employed in the WHO World Mental Health survey (Kessler et al., 2010). Depression (absent or present) and other psychiatric disorders (absent or present) were selected as psychiatric comorbidities, both of which were assessed using self-reported questionnaires. Each comorbidity was classified as "present" on the basis of responses indicating "*currently having*" the condition in the questionnaire. All questionnaires, response options, and details of the urbanization levels used in this study are shown in the Appendix Method.

Table 1
Details in re-classification of gambling.

Classification	Types and forms of gambling that were obtained
Sports betting (offline)	**Betting on the following:**
	Offline horse racing
	Offline bicycle racing
	Offline boat racing
	Offline auto racing
Sports betting(online)	**Betting on the following:**
	Offline horse racing
	Offline bicycle racing
	Offline boat racing
	Offline auto racing
Casino (offline)	Offline casino
Casino (online)	Online casino
Lottery (offline)	Offline lottery
	Offline sports promotion lottery
Lottery (online)	Online lottery
	Online sports promotion lottery
EGM and slot machine	Pachinko and slot machine
Stock, commodities, or foreign exchange trading	Stock, commodities, or foreign exchange trading
Cryptocurrency trading	Cryptocurrency trading

Notes. EGM, electronic gaming machine.

2.6. Outcome variables

Our primary outcome was the presence of PG as measured by the Problem Gambling Severity Index (PGSI) (Ferris, Wynne, Ladouceur, Stinchfield, & Turner, 2001)—a nine-item questionnaire developed to identify PG in the general population that has been validated in Japanese (So et al., 2019). The PGSI comprises nine items, each scored on a four-point Likert scale ranging from "never" (0) to "almost always" (3), with intermediate responses of "sometimes" (1) and "most of the time" (2). The sum of these scores yields a total score ranging from 0 to 27. In the original study that developed the PGSI, a score of 0 suggested non-PG, and 1–2, 3–7, and 8–27 suggested low-risk, moderate-risk, and PG, respectively (Ferris, Wynne, Ladouceur, Stinchfield, & Turner, 2001). Combined with previous validation studies (So et al., 2019), the same classification as described above was used, and the presence of PG (score of eight or more) was defined as the primary outcome.

2.7. Statistical analyses

First, baseline characteristics were described, including the experience of each gambling activity and modality, and the prevalence of the PGSI categories. Second, multivariable logistic regression models were fitted to investigate the associations of gambling activities and modalities with PG, after adjusting for confounding factors. To approach the estimates of the general Japanese population from survey respondents,

an inverse probability weighting (IPW) method using propensity scores adjusted for the differences between online survey respondents and the general public in Japan was used (Schonlau et al., 2009). Such a propensity score-based adjustment has been used in other studies (Tabuchi et al., 2018, 2016). The sampling weights were calculated using data from the 2019 Comprehensive Survey of Living Conditions on Health and Welfare, a nationally representative survey in Japan. The weights were scaled to 31,037 (the number of valid respondents after excluding straight-line responses and failed attention checks). For respondents aged 20–82 years, weights were predicted using a logistic model adjusted for area of residence, marital status, education, home ownership, self-rated health, and smoking status. For ages 15–19 years, the model was adjusted for residential area, education, home ownership, and self-rated health (excluding marital status due to minimal variation and smoking status as it was not obtained). Weights were stratified by gender (male, female) and age (15–19, 20–29, 30–39, 40–49, 50–59, 60–69, and $\geq$ 70 years), creating 14 strata. Three models were constructed for the multivariable analysis. Model 1 (crude model) included only the gambling variables. Model 2 was adjusted for demographic and socioeconomic characteristics in addition to the gambling variables. Model 3 (fully adjusted model) incorporated all the covariates described above. Third, as an exploratory analysis, nine gambling variables were combined into a single summary score (ranging from zero to nine), the association between this total score and the prevalence of PG was examined using the same multivariable models as in the main analysis. Given that this was an exploratory assessment, a category of "six or more" was created by combining categories with less than 10 % of the respondents (i.e., scores of six or higher). The scores were considered categorical variables (dummy variables), and the adjusted odds ratios for each score were estimated using a score of one as the reference category. The linearity between the number of gambling activities and PG was also examined. A separate multivariable logistic regression analysis was conducted using the continuous number of gambling activities (one to six or more) as the exposure variable and the presence of PG as the outcome variable and estimated the *p*-value for the trend. A subgroup analysis stratifying dichotomous age groups (18–44 and 45–82 years) and gender groups (male and female) was also conducted on the basis of the assumption of age and gender heterogeneity for the risk of PG (Rahman et al., 2012; Wong et al., 2013). The cut-off value for the age group was defined as the median of all respondents (44 years). To enhance the interpretability, interaction tests were conducted for each subgroup. For interaction testing, separate multivariable logistic regression models that included interaction terms between gambling activities/modalities and each subgroup (age and gender) were fitted, and *p*-values were estimated for interaction. As a secondary analysis, the focus was limited to respondents who gambled at least once a week (i.e., those who reported regular gambling), given that this population is clinically relevant as they are at risk for PG and may require interventions at specialized facilities. Similar multivariable and subgroup analyses were also conducted, including the same confounding factors. For subgroup and exploratory analyses, Model 3 (fully adjusted model) from the main analysis was applied.

To confirm the robustness of the main findings, two post hoc sensitivity analyses were employed. The first sensitivity analysis focused on respondents showing at least moderate-risk gambling behavior, in which early intervention is particularly crucial. For at least moderate-risk gambling, the classification (PGSI $<$ 5/ $\geq$ 5) that has demonstrated discriminative validity in previous evidence was adopted (Currie et al., 2013). A multivariable logistic regression analysis incorporating the same covariates as in the main analysis was performed to estimate the association of each gambling engagement with at least moderate-risk gambling. In the second sensitivity analysis, considering the ongoing debate on whether trading should be classified as a form of gambling activity (Grall-Bronnec et al., 2017), trading activities were excluded from gambling activities. While maintaining the same logistic regression approach as in the main analysis, trading activity status (yes/no) was included as an additional covariate in Model 3 alongside those used in the main analysis.

Descriptive statistics included numbers, proportions (%), weighted proportions, and confidence intervals. The regression analyses included weighted odds ratios (ORs) and confidence intervals (CIs).

All CIs and *p*-values were based on a robust variance estimator to account for IPW. As the primary analysis was based on multiple tests, the statistical significance for the primary analysis was set at $p < 0.0056$, and the second sensitivity analysis was set at $p < 0.0071$ after the Bonferroni correction (Nakagawa, 2004). Given that the subgroup analyses were exploratory, statistical significance was set at $p < 0.05$. All analyses were performed using STATA version 16.1 (Stata Corp, College Station, Texas, USA).

2.8. Ethical considerations

All participants responded to the web-based questionnaires after agreeing to provide web-based informed consent and participate in this survey. A credit point known as "Epoints," which can be used for online shopping and cash conversion, was provided to the participants as an incentive. Personal information collected in the survey was protected using secure data-handling procedures. Rakuten Insight processes data to prevent individual identification before transmitting it to investigators via password-protected storage and maintains information security in compliance with Japanese personal information protection laws. All procedures were performed in accordance with the ethical standards of the 1975 Declaration of Helsinki, revised in 2013. This study was approved by the Institutional Review Boards of Osaka International Cancer Institute (approval number: 20084) and Keio University School of Medicine (approval number: 20231018). The STROBE guidelines were followed for conducting the cross-sectional studies, and the CHERRIES checklist was used for online surveys.

3. Results

In total, 12,955 respondents were eligible for the study (Fig. 1). Of the respondents, the weighted proportions were 36.5 % for female respondents, 21.4 % for respondents aged 35–44 years, 43.7 % for college graduates or higher, and 63.5 % for those who were married. For gambling activities and modalities, the weighted proportions of offline sports betting, casinos, and lotteries were 46.8 %, 13.2 %, and 76.4 %, respectively, whereas those for online sports betting, casinos, and lotteries were 34.7 %, 7.9 %, and 50.9 %, respectively. The weighted proportions of EGM and slot machine, stocks, commodities, foreign exchange trading, and cryptocurrency trading were 59.8 %, 31.0 %, and 16.5 %, respectively. Of the respondents, 12.2 % reported PG (Table 2).

The results of the main analyses are presented in Table 3. In all multivariable models, the experiences of sports betting (online), casino (offline), casino (online), and cryptocurrency trading were associated with the prevalence of PG (Model 3: sports betting [online], adjusted OR [aOR] 2.41, 95 % CI 1.86–3.13, $p < 0.001$; casino [offline], aOR 1.53, 95 % CI 1.16–2.02, $p = 0.002$; casino [online], aOR 4.25, 95 % CI 3.09–5.86, $p < 0.001$; cryptocurrency trading, aOR 1.60, 95 % CI 1.22–2.10, $p = 0.001$).

In the exploratory analysis, a linear association of PG prevalence with the number of gambling activities engaged in (*e.g.*, two, aOR 1.39, 95 % CI 0.91–2.13, $p = 0.13$; six or more, aOR 12.59, 95 % CI 8.41–18.85, $p < 0.001$; p for trend < 0.001; Fig. 2).

The baseline characteristics of the gender and age subgroups are shown in Tables A.1 and A.2, respectively. In the subgroup analyses, substantial interactions were observed in sports betting (online: male, aOR 2.12, 95 % CI 1.59–2.83; female, aOR 4.60, 95 % CI 2.64–8.00; p for interaction = 0.008), casino (offline: male, aOR 1.43, 95 % CI 1.04–1.96; female, aOR 2.29, 95 % CI 1.42–3.69; p for interaction = 0.003), EGM and slot machine (male, aOR 1.26, 95 % CI 0.92–1.73; female, aOR 1.64, 95 % CI 0.86–3.11; p for interaction = 0.046), and cryptocurrency

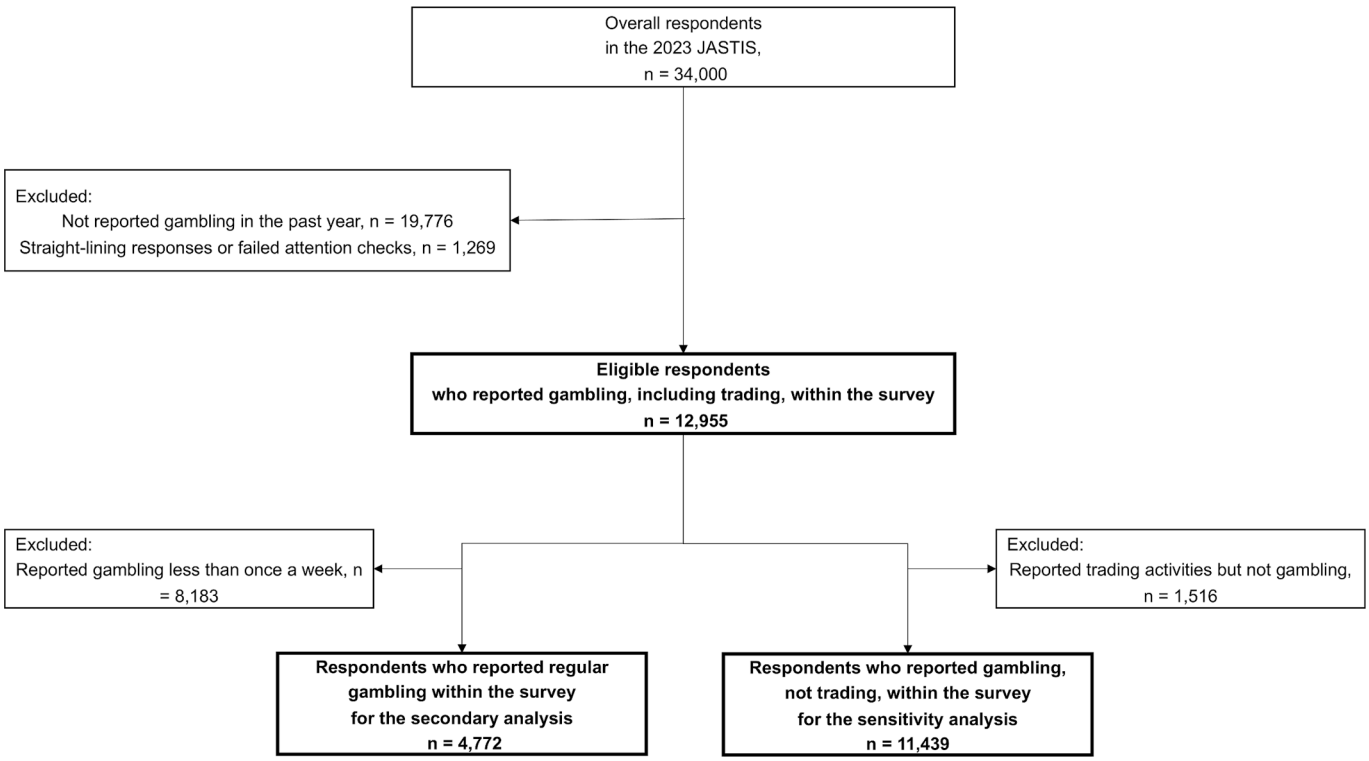

Fig. 1. Flow diagram of this study.

trading (male, aOR 1.32, 95 % CI 1.01–1.72; female, aOR 4.18, 95 % CI 2.06–8.47; p for interaction = 0.001) for gender. Contrarily, for age groups, an interaction was observed only in offline casinos (18–44 years, aOR 1.80, 95 % CI 1.26–2.57; 45–82 years, aOR 1.22, 95 % CI 0.75–1.98; p for interaction = 0.009; Fig. 3).

The secondary analysis included 4,772 respondents who reported regular gambling within the survey (Fig. 1). Of these, 25.2 % (weighted proportion) reported PG (Table A.3). Similar to the respondents in the main analysis, experiences with offline sports betting, offline lotteries, EGM, and slot machines were prevalent (weighted proportions: 63.7 %, 80.7 %, and 74.9 %, respectively). In all multivariable logistic regression models, the experiences of sports betting (online), casino (online), and cryptocurrency trading were associated with the prevalence of PG (Model 3: sports betting [online], aOR 2.34, 95 % CI 1.62–3.39, $p <$ 0.001; casino [online], aOR 5.82, 95 % CI 3.87–8.76, $p < 0.001$; cryptocurrency trading, aOR 1.68, 95 % CI 1.19–2.38, p = 0.003) (Table A.4**)**. In the subgroup analyses, substantial interactions were observed in casino (offline) and cryptocurrency trading only for gender (male, aOR 1.20, 95 % CI 0.80–1.82; female, aOR 3.13, 95 % CI 1.33–7.33, p for interaction = 0.022; and male, aOR 1.35, 95 % CI 0.96–1.85; female, aOR 5.37, 95 % CI 2.32–12.43, p for interaction = 0.041, respectively) (Fig. A.1).

The results of the first sensitivity analysis are listed in Table 4. Consistent with the main analysis, online sports betting, online casino, and cryptocurrency trading showed statistically significant associations with at least moderate-risk gambling behavior in all models (Model 3: online sports betting, aOR 2.32, 95 % CI 1.87–2.89, $p < 0.001$; online casino, aOR 4.14, 95 % CI 3.00–5.72, $p < 0.001$; cryptocurrency trading, aOR 1.45, 95 % CI 1.14–1.85, p = 0.003). Unlike the main analysis, offline casino did not show statistical significance (aOR 1.17, 95 % CI 0.91–1.52, p = 0.222), whereas EGM and slot machine demonstrated statistical significance (aOR 1.78, 95 % CI 1.37–2.31, $p < 0.001$).

Table 5 presents the results of the second sensitivity analysis. In line with the main analysis, online sports betting and offline and online casinos showed statistically significant associations with PG behavior in all models (Model 3: online sports betting, aOR 2.46, 95 % CI 1.87–3.23, $p < 0.001$; offline casino, aOR 1.56, 95 % CI 1.17–2.09, $p = 0.002$; online casino, aOR 4.08, 95 % CI 2.92–5.70, $p < 0.001$). As in the first sensitivity analysis, EGM and slot machine use showed statistical significance (Model 3: aOR 1.52, 95 % CI 1.13–2.04, $p = 0.005$).

4. Discussions

This nationwide Japanese internet-based study found that online gambling (sports betting, online casinos, and cryptocurrency trading) and offline casinos were associated with PG prevalence among respondents engaging in gambling. The subgroup analyses revealed substantial effect modifications regarding casinos and cryptocurrencies for gender and offline casinos for age groups, suggesting that female or young individuals experiencing such gambling may be specific populations of interest to policymakers. When the respondents were limited to those who reported regular gambling, similar associations and interactions were observed.

Some possible mechanistic explanations can be hypothesized from the results, such as that online, rather than offline, gambling, except for casinos, was associated with PG. Compared to offline gambling, online gambling is easily accessible and affordable (Montiel et al., 2021). Moreover, it frequently involves communities or peer networks in which individuals share gambling tips, experiences, gambling in general, and other gambling-related issues (Sirola et al., 2018). Such easy access to online gambling and the misperceptions acquired from online communities may accelerate individuals' use of online gambling, potentially leading to PG. Another possible explanation is that online gambling use is a proxy for harmful gambling, regardless of gambling activities and modalities. Some studies have reported that internet gambling accelerates offline gambling (Gainsbury, 2015; Gainsbury et al., 2019). Hence, co-engagement with offline and online gambling may cause gambling-related harm and lead to serious pathological gambling (Gainsbury et al., 2019). Furthermore, unlike the main analysis, the sensitivity analysis revealed that offline casino use was not statistically associated with at least moderate-risk gambling, which can also be explained by this hypothesis. Specifically, although offline casino use may serve as a

Table 2
Demographic characteristics of the included respondents.

(N = 12,955)	n (%)	Weighted % (95 % CI)
Gender, Female	4,736 (36.6)	36.5 (35.3–37.8)
Age		
15–24	992 (7.7)	7.5 (6.8–8.2)
25–34	2,647 (20.4)	18.5 (17.6–19.5)
35–44	2,603 (20.1)	21.4 (20.4–22.5)
45–54	2,373 (18.3)	18.2 (17.3–19.2)
55–64	1,891 (14.6)	14.6 (13.8–15.5)
65–74	1,725 (13.3)	13.5 (12.5–14.5)
75–82	724 (5.6)	6.2 (5.4–7.1)
Educational attainment, College graduate or more	9,325 (72.0)	43.7 (42.5–44.9)
Marital status		
Married	7,844 (60.6)	63.5 (62.2–64.8)
Never married	4,077 (31.5)	27.6 (26.5–28.8)
Widowed/ separated	1,034 (8.0)	8.9 (8.1–9.8)
Employment		
Employer	508 (3.9)	3.5 (3.1–3.9)
Self-employed	927 (7.2)	7.0 (6.4–7.7)
Regular employee	5,953 (46.0)	44.3 (43.0–45.6)
Part-time employee	2,351 (18.2)	19.3 (18.3–20.4)
Unemployment	3,216 (24.8)	25.9 (24.7–27.2)
Equivalent household income		
1st quartile (0 to 2.25 million JPY and less)	2,376 (18.3)	21.1 (20.0–22.3)
2nd quartile (2.26 to 3.25 million JPY)	2,607 (20.1)	21.3 (20.2–22.4)
3rd quartile (3.26 to 4.75 million JPY)	2,786 (21.5)	19.8 (18.8–20.8)
4th quartile (4.76 million JPY and more)	3,015 (23.3)	19.0 (18.1–20.0)
Unknown/ declined to answer	2,171 (16.8)	18.8 (17.7–19.9)
Urbanization level in residential area		
Metropolitan areas	6,216 (48.0)	36.5 (35.3–37.7)
Large cities	1,950 (15.1)	16.9 (15.9–17.9)
Accessible small towns	699 (5.4)	6.1 (5.5–6.8)
Remote small towns	676 (5.2)	6.5 (5.8–7.2)
Accessible rural settlements	1,642 (12.7)	15.4 (14.4–16.4)
Remote rural settlements	1,418 (11.0)	16.1 (15.1–17.2)
Unidentifiable	354 (2.7)	2.6 (2.2–3.0)
Combustible cigarette use		
Never	5,858 (45.2)	41.9 (40.6–43.2)
Past	4,819 (37.2)	39.5 (38.2–40.8)
Current	2,278 (17.6)	18.6 (17.6–19.6)
Heated tobacco product use		
Never	9,307 (71.8)	70.5 (69.3–71.7)
Past	1,700 (13.1)	13.5 (12.6–14.4)
Current	1,948 (15.0)	16.0 (15.1–17.0)
Alcohol use measured by the AUDIT		
Low-risk use (0–7 points)	10,285 (79.4)	79.8 (78.8–80.8)
Medium-risk use (8–15 points)	1,691 (13.1)	12.8 (11.9–13.6)
High-risk use (16–19 points)	449 (3.5)	3.6 (3.1–4.1)
Likely alcohol dependent (20–40 points)	530 (4.1)	3.9 (3.4–4.4)
Psychological distress measured by the Kessler-6 scale		
No (0–4 points)	6,950 (53.7)	52.3 (51.0–53.6)
Moderate (5–12 points)	4,141 (32.0)	33.4 (32.2–34.6)
Serious (13–24 points)	1,864 (14.4)	14.3 (13.4–15.3)
Depression, Present	791 (6.1)	6.0 (5.4–6.7)
Other psychiatric disorder, Present	545 (4.2)	4.2 (3.7–4.8)
Engagement of gambling		
Sports betting		
Offline	6,129 (47.3)	46.8 (45.5–48.1)
Online	4,526 (34.9)	34.7 (33.5–35.9)
Casino		
Offline	1,970 (15.2)	13.2 (12.4–14.1)
Online	1,044 (8.1)	7.9 (7.2–8.6)
Lottery		
Offline	9,675 (74.7)	76.4 (75.3–77.5)
Online	6,294 (48.6)	50.9 (49.6–52.2)
EGM and slot machine	7,249 (56.0)	59.8 (58.5–61.0)
Stock, commodities, or foreign exchange trading	4,447 (34.3)	31.0 (29.8–32.2)
Cryptocurrency trading	2,323 (17.9)	16.5 (15.6–17.5)
Number of gambling activities engaged in		
1	2,610 (20.2)	19.3 (18.3–20.4)
2	2,699 (20.8)	21.0 (19.9–22.1)
3	2,466 (19.0)	19.3 (18.3–20.4)
4	1,980 (15.3)	15.9 (14.9–16.9)
5	1,415 (10.9)	11.5 (10.7–12.4)
6 or more	1,785 (13.8)	13.1 (12.2–13.9)
Gambling behavior by PGSI score		
Non-problem gambling (0 point)	8,998 (69.5)	68.8 (67.5–70.0)
Low-risk gambling (1–2 points)	1,415 (10.9)	10.6 (9.9–11.4)
Moderate-risk gambling (3–7 points)	1,052 (8.1)	8.4 (7.7–9.2)
Problem gambling (8–27 points)	1,490 (11.5)	12.2 (11.4–13.1)
Gambling behavior for sensitivity analysis		
Non-moderate-risk gambling (0–4 points)	11,067 (85.4)	84.2 (83.2–85.1)
At least moderate-risk gambling (5–27 points)	1,888 (14.6)	15.8 (14.9–16.8)

Notes. AUDIT, Alcohol Use Disorder Identification Test; CI, confidence interval; EGM, electronic gaming machine; PGSI, Problem Gambling Severity Index.

proxy for high-risk gambling behavior, it may not function as a proxy for at least moderate-risk gambling.

It is noteworthy that EGMs and slot machines did not show statistical significance, which is contrary to the results of meta-analyses that showed large effect sizes (Allami et al., 2021). This may be because pachinko and pachi-slots have the largest number of users and revenues in the Japanese gambling market (Japan Productivity Center, 2024), and Japanese laws have been continuously regulating the reduction of payouts and flashy presentations in pachinko and pachi-slots (Digital

Table 3
Multivariable logistic regression analysis to estimate the odds ratios of each gambling activity for at least problem gambling among those engaging in gambling.

Problem gambling	Model 1			Model 2			Model 3		
	OR	95 % CI	*p*-value	aOR	95 % CI	*p*-value	aOR	95 % CI	*p*-value
Engagement of the gambling type (ref. not engaged)									
Sports betting (offline)	1.30	(1.00–1.70)	0.049	1.39	(1.06–1.82)	0.016	1.26	(0.96–1.67)	0.099
Sports betting (online)	**3.16**	**(2.49–4.01)**	**<0.001**	**2.67**	**(2.09–3.40)**	**<0.001**	**2.41**	**(1.86–3.13)**	**<0.001**
Casino (offline)	**1.59**	**(1.25–2.03)**	**<0.001**	**1.80**	**(1.40–2.31)**	**<0.001**	**1.53**	**(1.16–2.02)**	**0.002**
Casino (online)	**7.15**	**(5.44–9.40)**	**<0.001**	**5.86**	**(4.42–7.77)**	**<0.001**	**4.25**	**(3.09–5.86)**	**<0.001**
Lottery (offline)	0.81	(0.63–1.05)	0.107	0.98	(0.76–1.27)	0.888	0.97	(0.75–1.27)	0.846
Lottery (online)	1.24	(0.99–1.55)	0.067	1.28	(1.02–1.60)	0.037	1.15	(0.91–1.46)	0.247
EGM and slot machine	**1.49**	**(1.14–1.94)**	**0.003**	**1.64**	**(1.25–2.17)**	**<0.001**	1.41	(1.06–1.87)	0.018
Stock, commodities, or foreign exchange trading	1.26	(1.01–1.56)	0.042	1.25	(0.99–1.57)	0.055	1.28	(1.00–1.62)	0.046
Cryptocurrency trading	**2.32**	**(1.85–2.91)**	**<0.001**	**1.73**	**(1.34–2.23)**	**<0.001**	**1.60**	**(1.22–2.10)**	**0.001**

Notes. aOR, adjusted odds ratio; CI, confidence interval; EGM, electronic gaming machine.
Model 1: Crude model.
Model 2: Adjusted for gender, age, educational attainment, marital status, employment, household equivalent income, and urbanization level in residential area.
Model 3: Adjusted for gender, age, educational attainment, marital status, employment, household equivalent income, combustible cigarette use, heated tobacco product use, alcohol use, depression, other psychiatric disorder, psychological distress, and urbanization level in residential area.

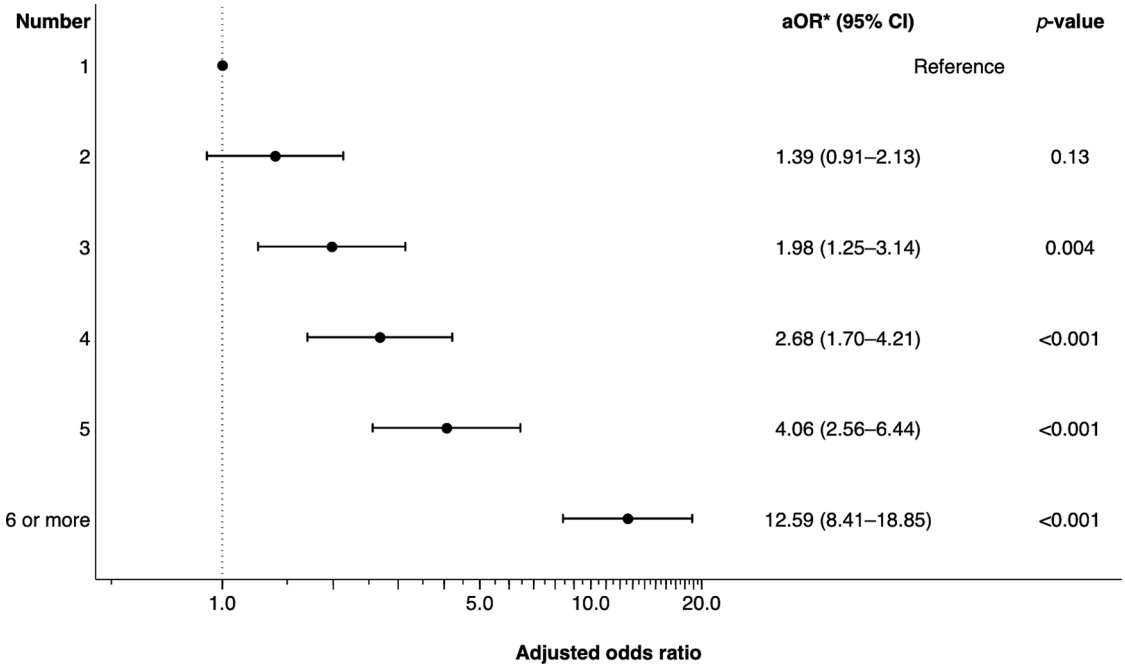

Fig. 2. Results of exploratory analyses Notes. aOR, adjusted odds ratio, CI, confidence interval. * Adjusted for sex, age, educational attainment, marital status, employment, household equivalent income, combustible cigarette use, heated tobacco product use, alcohol use, depression, other psychiatric disorder, psychological distress, and urbanization level in residential area.

Agency, 2024). Additionally, advertisements and promotions for pachinko, such as television commercials, are regulated by law (Digital Agency, 2024). This is in contrast to betting in public racing advertising, which was previously unregulated. Considering these regulations for pachinko and pachi-slots, EGMs did not demonstrate statistically significant associations in this study. Conversely, the fact that online sports betting showed statistical significance, in contrast to pachinko, may be partially explained by differences in advertising regulations. However, in the sensitivity analysis using a PGSI cutoff score of 5 or higher, the EGM and slot machines showed statistical significance. This result is particularly noteworthy as it demonstrates an association with at least moderate-risk gambling, despite the aforementioned regulations. These findings emphasize the importance of maintaining and continuing regulatory measures.

Numerous studies have examined the association between gambling types or formats in which individuals participate and the experience of PG. A meta-analysis of observational studies indicated that most gambling activities are substantially associated with PG in the general population (Allami et al., 2021). The meta-analysis revealed the different pooled estimates across gambling activities: internet gambling (OR 7.59, 95 % CI 5.24–10.99), EGM and slot machines (OR 7.20, 95 % CI 5.82–8.90), and poker (OR 6.78, 95 % CI 5.57–8.26) had large ORs, whereas weekly lottery (OR 1.36, 95 % CI 1.14–1.62), stocks, options, commodities (OR 1.47, 95 % CI 1.09–1.98), and all lottery games (OR 1.96, 95 % CI 1.67–2.29) had small ones (Allami et al., 2021). Due to cultural differences in gambling accessibility and individual attitudes toward gambling between countries, risk factors may vary by country. For example, a study from Italy found that sports (or other types of) betting and slot machines were associated with gambling severity in the general population (Scalese et al., 2016). The latest online survey in Japan presented findings similar to those of this study, in which respondents who engaged in casinos, pachinko, and betting on boats, bicycles, and auto racing were likely to have PG, as defined by a score of five points or more on the SOGS (Hayano et al., 2021). Although this

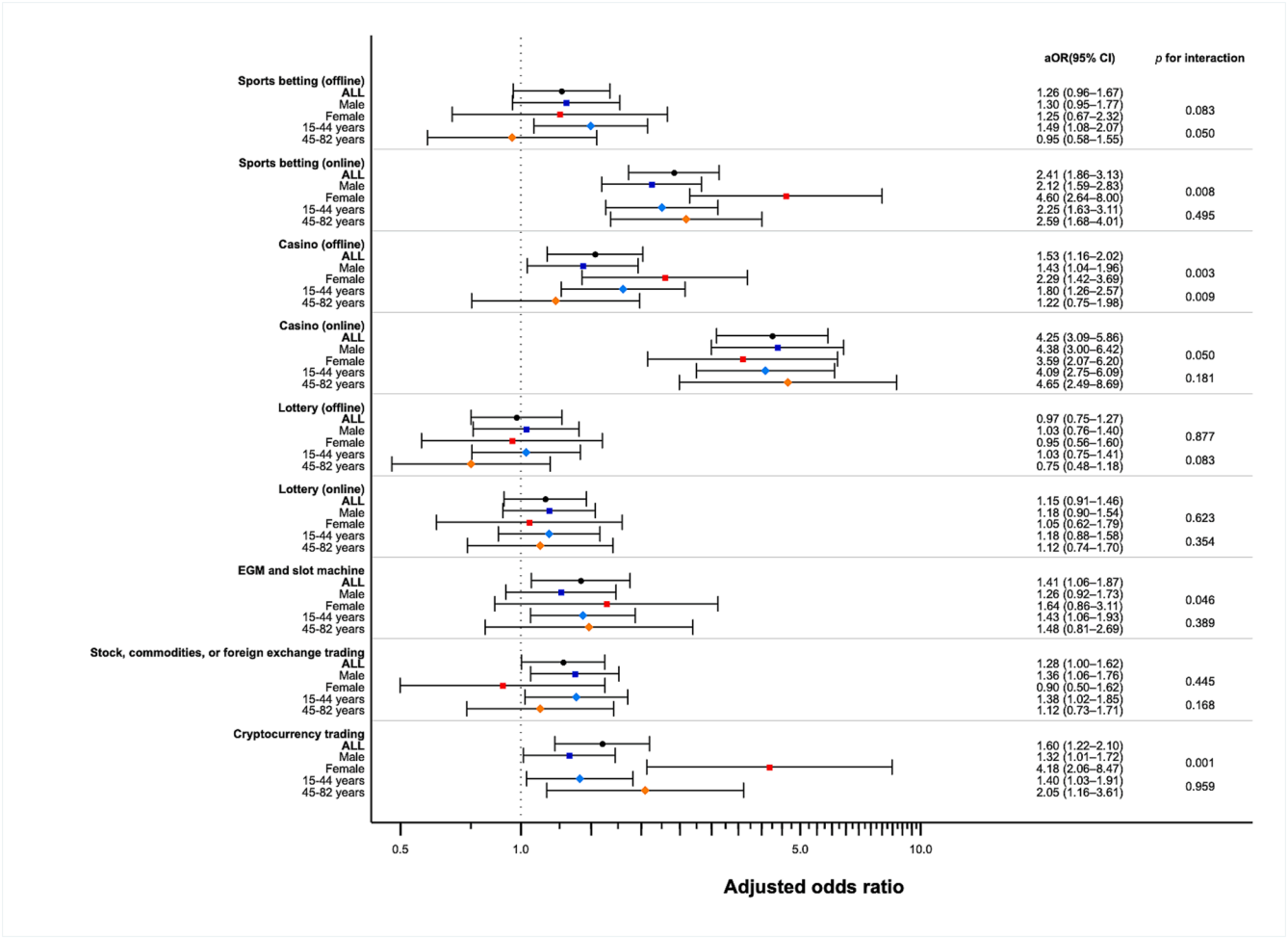

Fig. 3. Results of subgroup analyses Notes. EGM, electronic gaming machine.

Table 4
Multivariable logistic regression analysis to estimate the odds ratios of each gambling activity for at least moderate-risk gambling for the first sensitivity analysis.

At least moderate-risk gambling(PGSI ≥ 5 points)	Model 1			Model 2			Model 3		
	OR	95 % CI	*p*-value	aOR	95 % CI	*p*-value	aOR	95 % CI	*p*-value
Engagement of the gambling type (ref. not engaged)									
Sports betting (offline)	1.35	(1.09–1.67)	0.006	**1.43**	**(1.15–1.78)**	**0.001**	1.31	(1.04–1.65)	0.020
Sports betting (online)	**2.98**	**(2.44–3.63)**	**<0.001**	**2.55**	**(2.08–3.13)**	**<0.001**	**2.32**	**(1.87–2.89)**	**<0.001**
Casino (offline)	1.22	(0.98–1.52)	0.078	1.38	(1.10–1.74)	0.006	1.17	(0.91–1.52)	0.222
Casino (online)	**6.79**	**(5.23–8.83)**	**<0.001**	**5.70**	**(4.33–7.50)**	**<0.001**	**4.14**	**(3.00–5.72)**	**<0.001**
Lottery (offline)	0.75	(0.60–0.95)	0.016	0.91	(0.71–1.16)	0.433	0.90	(0.70–1.15)	0.410
Lottery (online)	1.19	(0.98–1.45)	0.076	1.23	(1.01–1.51)	0.039	1.12	(0.91–1.38)	0.273
EGM and slot machine	**1.93**	**(1.52–2.44)**	**<0.001**	**2.07**	**(1.62–2.65)**	**<0.001**	**1.78**	**(1.37–2.31)**	**<0.001**
Stock, commodities, or foreign exchange trading	1.27	(1.05–1.53)	0.013	1.24	(1.02–1.51)	0.028	1.28	(1.04–1.57)	0.018
Cryptocurrency trading	**2.09**	**(1.70–2.56)**	**<0.001**	**1.54**	**(1.24–1.93)**	**<0.001**	**1.45**	**(1.14–1.85)**	**0.003**

Notes. aOR, adjusted odds ratio; CI, confidence interval; EGM, electronic gaming machine; PGSI, Problem Gambling Severity Index.
Model 1: Crude model.
Model 2: Adjusted for gender, age, educational attainment, marital status, employment, household equivalent income, and urbanization level in residential area.
Model 3: Adjusted for gender, age, educational attainment, marital status, employment, household equivalent income, combustible cigarette use, heated tobacco product use, alcohol use, depression, other psychiatric disorder, psychological distress, and urbanization level in residential area.

evidence is informative, previous studies have some limitations. First, they constructed separate multivariable models and did not consider engagement in multiple gambling activities. Second, they did not include important confounders such as individual comorbidities in their multivariable models. Third, they did not evaluate cryptocurrency trading, which is an emerging type of gambling. Fourth, previous studies generally had limited sample sizes, presenting the limitation of having few samples for individual gambling activities. Fifth, most previous studies neglected those who reported regular gambling, which is the most important population for clinicians. This study is the first to compensate for all these limitations. Specifically, this study focuses on various gambling activities currently available in Japan, including trading. In addition, this study conducted multivariable analyses that comprehensively included important confounding factors such as place of residence and individual comorbidities. The secondary analyses, which focused on respondents who reported regular gambling in the

Table 5
Multivariable logistic regression analysis to estimate the odds ratios of each gambling activity for problem gambling for the second sensitivity analysis.

At least moderate-risk gambling (PGSI ≥ 5 points)	Model 1			Model 2			Model 3		
	OR	95 % CI	*p*-value	aOR	95 % CI	*p*-value	aOR	95 % CI	*p*-value
Engagement of the gambling type (ref. not engaged)									
Sports betting (offline)	1.35	(1.02–1.78)	0.035	1.43	(1.08–1.90)	0.013	1.31	(0.98–1.76)	0.073
Sports betting (online)	**3.61**	**(2.83–4.62)**	**<0.001**	**2.91**	**(2.26–3.75)**	**<0.001**	**2.46**	**(1.87–3.23)**	**<0.001**
Casino (offline)	**1.92**	**(1.51–2.44)**	**<0.001**	**2.07**	**(1.61–2.67)**	**<0.001**	**1.56**	**(1.17–2.09)**	**0.002**
Casino (online)	**10.06**	**(7.78–13.02)**	**<0.001**	**7.17**	**(5.46–9.43)**	**<0.001**	**4.08**	**(2.92–5.70)**	**<0.001**
Lottery (offline)	0.82	(0.63–1.07)	0.151	1.02	(0.78–1.35)	0.870	0.99	(0.75–1.30)	0.927
Lottery (online)	1.30	(1.03–1.64)	0.026	1.32	(1.04–1.66)	0.021	1.11	(0.86–1.43)	0.417
EGM and slot machine	**1.71**	**(1.29–2.28)**	**<0.001**	**1.89**	**(1.41–2.54)**	**<0.001**	**1.52**	**(1.13–2.04)**	**0.005**

Notes. aOR, adjusted odds ratio; CI, confidence interval; EGM, electronic gaming machine; PGSI, Problem Gambling Severity Index.
Model 1: Crude model.
Model 2: Adjusted for gender, age, educational attainment, marital status, employment, household equivalent income, and urbanization level in residential area.
Model 3: Adjusted for gender, age, educational attainment, marital status, employment, household equivalent income, combustible cigarette use, heated tobacco product use, alcohol use, depression, other psychiatric disorder, psychological distress, use of trading activities, and urbanization level in residential area.

survey, are novel and noteworthy. Those who report regular gambling represent both an at-risk population for problem gambling and potentially include individuals who meet diagnostic criteria for gambling disorder. Therefore, the findings of the secondary analysis have dual implications: they inform public health prevention strategies and highlight the clinical importance of facilitating access to specialized treatment facilities regardless of individuals' treatment-seeking behavior.

However, this study has several limitations. First, due to the cross-sectional study design, the temporal relationship between gambling activities and their modalities and problem gambling remains unproven. Regardless of the temporal direction, the findings provide information on access to specific gambling activities for policymaking. Second, the survey included neither the frequency nor spending intensity of each gambling activity., which prevented us from exploring why online gambling showed higher ORs for PG than offline gambling. Further studies including this information are warranted. Third, concerns about external validity to the general population in or outside Japan have been raised because the results are based on a non-probability internet survey conducted in Japan. However, this study reclassified gambling activities to express global standard classifications and selected as many confounders as possible on the basis of a well-designed meta-analysis. Consequently, this study identified associated gambling activities, such as online gambling and casinos, that were compatible with those in Western countries, such as Canada and Italy (Scalese et al., 2016; Williams et al., 2021). Fourth, this study did not provide a "prefer not to answer" option for some sensitive questions (*e.g.*, those related to comorbidities). There may be misreporting on these sensitive questions, although the extent of potential misreporting may vary based on how embarrassed or reluctant participants felt about disclosing certain information (Tourangeau & Yan, 2007). Additionally, concerns regarding nonresponse bias warrant consideration. Evidence from substance use surveys indicates that respondents, compared to non-respondents, tend to be married, female, non-elderly, and more educated (McCabe & West, 2016). Although the impact of nonresponse bias on the estimates remains unclear (Dawson et al., 2014), it may have limited the generalizability of the findings. Fifth, some residual confounding factors in other important associations examined may be identified, although covariates were selected for the multivariable regression model on the basis of meta-analyses of PG in adults in general. For example, Parkinson's disease was not included among the health-related comorbidities. Evidence shows that both Parkinson's disease and its treatment medications are associated with PG (Crockford et al., 2008). Therefore, future studies that consider these factors are warranted. Sixth, the classification of trading as gambling activity warrants further discussion. Although both established screening tools (SOGS and PGSI) include stocks, options, and commodity trading in their assessments (J. Ferris & Wynne, 2001; Lesieur & Blume, 1987), additional analyses were conducted by treating trading activities separately. These analyses yielded consistent results showing significant associations between PG and online sports betting, offline casinos, and online casino activities. These results support the robustness of the main findings, regardless of trading classification.

Despite these limitations, this study has several implications. First, in the local context, based on a recent plan for casino resorts in Osaka (Imai, 2018), the results highlight the importance of policies for preventing PG in resorts. Second, in the global context, the results may support evidence-based preventive policies as they imply possible associations between engagement in specific gambling activities and PG, or between people engaging in PG and specific gambling activities. As an example of effective policies for online sports betting or cryptocurrency trading, the Japanese government is considering restricting access to online sports betting and imposing limits on betting amounts (Prime Minister's Office of Japan, 2022). As low-income individuals may be vulnerable to PG (Castrén et al., 2018), implementing restrictions or setting betting limits corresponding to individual income may be more effective.

5. Conclusion

Results demonstrate that online gambling (sports betting, online casinos, and cryptocurrency trading) and offline casinos were associated with PG. These findings emphasize to policymakers and public health leaders the importance of advertising restrictions, access controls, and betting limits or warnings for online gambling formats, along with increasing public awareness on casino illegality. Future longitudinal studies that assess temporal relationships and detailed gambling patterns (frequency and betting amount) will help guide targeted screening strategies and evidence-based regulations. Additionally, incorporating data on Japan's first land-based casino resort in Osaka into such longitudinal studies would enable an evaluation of its impact on gambling patterns, PG prevalence, and incidence rates across various gambling activities.

Declaration of Generative AI and AI-assisted technologies in the writing process

During the preparation of this study, the authors used ChatGPT-4, Claude 3 Opus, Claude 3.5 Sonnet, and DeepL Write for proofreading. Although these tools were used, this manuscript underwent proofreading by an English language editing company (Editage, https://www.editage.jp). All authors have reviewed the final version of the manuscript and take full responsibility for its content.

CRediT authorship contribution statement

Takashi Yoshioka: Writing – original draft, Visualization, Software, Resources, Project administration, Investigation, Formal analysis, Data curation, Conceptualization. **Ryuhei So:** Writing – review & editing,

Supervision, Investigation, Conceptualization. **Tatsuya Noda:** Writing – review & editing, Investigation, Conceptualization. **Moritoshi Kido:** Writing – review & editing, Validation, Resources, Investigation, Conceptualization. **Chieko Ito:** Writing – review & editing, Investigation, Conceptualization. **Tomoki Nakaya:** Writing – review & editing, Validation, Resources, Methodology, Data curation. **Satoshi Funada:** Writing – review & editing, Validation, Supervision, Methodology. **Shiori Tsutsumi:** Writing – review & editing, Validation, Investigation. **Takahiro Tabuchi:** Writing – review & editing, Validation, Resources, Project administration, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: TY has received the Japan Society for the Promotion of Science (JSPS) KAKENHI grant (grant number: 21K17228) and the National Cancer Center Research Grant (grant number: 2022-A-25), both of which are outside this work. RS has received research grants from the Osake-no-Kagaku Foundation for developing a computerized questionnaire for treatment-seeking heavy drinkers. He also received speaker's honoraria from Otsuka Pharmaceutical Co., Ltd. and Nippon Shinyaku Co., Ltd., which manufacture therapeutic drugs for alcohol dependence. He works at CureApp Inc., which is developing a digital therapeutic app for alcohol dependence with funds from the Japan Agency for Medical Research and Development. TN has received the JSPS KAKENHI grant (grant number: 20H00623) that has dealt with the disease definition in the database regarding addiction. MK has received a research grant from the JSPS KAKENHI grant (grant number: 20K14237) for developing the screening tool for gambling disorder. SF has received a research grant from the JSPS KAKENHI grant (grant number: 20K18964), the KDDI Foundation, and the Pfizer Health Research Foundation outside this project. ST has been supported by the Japan Science and Technology Agency (JST) SPRING grant (grant number: JPMJSP2123) outside this work. TT has been supported by the JSPS KAKENHI Grant (grant number: 21H04856) and the Health Labour Sciences Research Grants (grant number: 23FA1004), which aim to clarify the social impact of heated tobacco product use. Other authors have no conflict of interest to declare.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.abrep.2025.100595.

Data availability

Data will be made available on request.

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