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Changes in Alcohol Consumption Behaviour in a Large Population of Japan during the COVID-19 Pandemic

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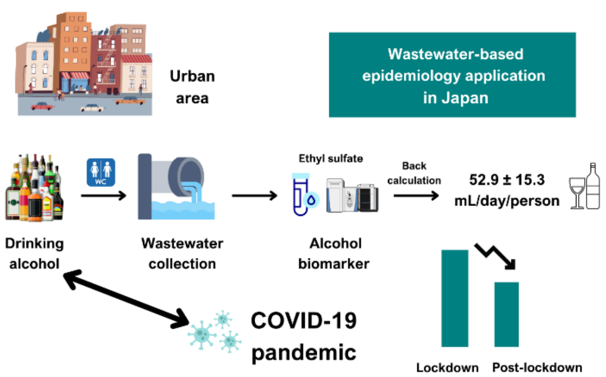
Highlights

- First application of wastewater surveillance to estimate alcohol consumption in Japan
- The average alcohol consumption was 52.9 ± 15.3 mL/day/person
- The level of alcohol consumption was lower after the COVID-19 lockdown period
- Higher alcohol use during lockdown is likely due to increased drinking at home

Abstract: Alcohol consumption poses a significant public health risk but alcohol may also be used as an anti-anxiolytic by the public. Understanding the actual change in alcohol consumption behaviour is therefore important to formulate appropriate public health policies. This study, for the first time, employed wastewater-based epidemiology (WBE) to estimate alcohol consumption in a catchment of approximately 1.8 million inhabitants in the Kanto region, Japan. Twenty-four-hour composite wastewater samples were collected over four weeks from September to October 2021, during and after a COVID-19 lockdown period. Twenty-seven influent wastewater samples were analysed for ethyl sulfate (EtS), an alcohol biomarker, using the Liquid Chromatography-Tandem Mass Spectrometry (LC-MSMS) method and used to estimate alcohol consumption. EtS was detected in all samples, with concentrations ranging from 11.8 to 45.5 µg/L. The average estimated alcohol consumption in the study population was 52.9 ± 15.3 mL/day/person, which is higher than wastewater data from other countries. Alcohol consumption remained stable throughout the week. Additionally, consumption decreased after the lockdown ($p < 0.001$), and a strong positive correlation was observed between alcohol intake and daily reported COVID-19 cases (r = 0.735, $p < 0.001$), likely reflecting population mobility and behavioural responses to restrictions. Higher alcohol consumption during the lockdown was likely due to increased use in private settings rather than public spaces. This study provides the first objective evidence of alcohol consumption prevalence in Japan and warrants a broader wastewater monitoring program to inform policies reducing alcohol-related harm.



1. Introduction

Alcohol consumption, particularly heavy episodic drinking remains a major public health concern in Japan. The World Health Organization estimated per-capita alcohol consumption among drinkers aged ≥15 years in Japan at 14.1 L of pure alcohol in 2016, with 40% of drinkers reporting heavy episodic drinking (≥60 g of pure alcohol on at least one occasion in the past 30 days) [1]. A nationwide study reported that 13.7% of adults engaged in hazardous and harmful alcohol use and 5.7% in higher-risk alcohol use or likely alcohol dependence [2]. Large Japanese cohorts further associated alcohol use with adverse health outcomes, including an increased risk of breast cancer among premenopausal women [3], a higher incidence of type 2 diabetes [4], and atherogenic lipid changes [5]. Paradoxically, the Japanese government has launched a campaign encouraging alcohol consumption among the young population. This initiative aimed at boosting the economy during the COVID-19 crisis by reducing taxes on alcohol products from 3% in 2011 to 1.7% in 2020 [6].

Understanding alcohol consumption behaviour of Japanese population is essential to inform policies aimed at tackling risky alcohol use and reducing alcohol-related harm in the community. Traditional monitoring approaches including self-report national surveys and sales/taxation data have been providing important information but have their own limitations. In Japan, the National Health and Nutrition Survey reports annually drinking frequency and proportions at different risk levels but does not provide accurate estimates of absolute intake [7]. National survey data are also subject to recall bias, restricted to representative samples and were disrupted by the COVID-19 pandemic (2020–2021). Sales and taxation records reflect alcohol availability rather than actual consumption and do not capture unrecorded consumption.

Wastewater-based epidemiology (WBE) addresses these limitations by providing objective estimates of per capita consumption using biomarker concentrations, wastewater flow, population size and correction factor [8]. WBE has been widely applied to monitor alcohol consumption in several countries and is now integrated into national wastewater monitoring programs in some Western countries [9–11]. In Japan, some WBE studies were conducted to estimate pharmaceuticals and daily-use compounds [12,13] but none have assessed alcohol consumption. Importantly, WBE also enables continuous monitoring during disruptions such as the COVID-19 pandemic when conducting national surveys was difficult.

Two common biomarkers, ethyl glucuronide and ethyl sulfate (EtS), are used to back-calculate alcohol consumption from wastewater analysis [14]. Ethyl glucuronide proved to be less suitable due to its instability in wastewater compared to EtS [15]. Notably, EtS is regarded as a more reliable biomarker because it is only produced in humans after alcohol consumption and is not generated from ethanol present in wastewater [16]. Moreover, EtS are formed in small amounts after alcohol intake, excreted in urine for a long time, making them sensitive alcohol biomarkers. In this study, we applied WBE to estimate the alcohol consumption in a large metropolitan area of Japan in 2021. The study focused on targeted ethyl sulfate (EtS) as a targeted alcohol biomarker. These findings provide complementary evidence to traditional approaches, offering more accurate estimates to inform alcohol harm-reduction policies.

2. Materials and Methods

2.1. Target Analytes and Sample Collection and Preparation

High-purity (>98%) analytical standards (EtS) and their corresponding internal standards (ethyl sulfate-d5 (EtS-D5) were obtained from Sigma-Aldrich (Darmstadt, Germany). Influent wastewater samples were collected from a large sewage treatment plant (STP) in the Kanto region of Japan, with a treatment capacity of approximately 750,000 m^3/day. The catchment serves about 1.8 million inhabitants covering 1.3% of Japan's population.

Sampling was conducted over four weeks from 17 September to 13 October 2021, spanning the lockdown and post-lockdown period. An autosampler was used to collect 24-h time-proportional subsamples (40 mL every 30 min). These subsamples were combined to prepare two separate composite samples for each day consisting of daytime samples (8 AM–6 PM) and nighttime samples (6 PM–8 AM). A total of 54 composite samples (27 daytime and 27 nighttime) were prepared. Immediately after collection, all samples were acidified to pH 2.0 with 1M HCl to minimise biological degradation.

Wastewater samples were transported to Ochanomizu University (Tokyo, Japan), filtered through single-use 0.2 μm syringe filters with regenerated cellulose membranes (Minisart RC 4, Sartorius™, Göttingen, Germany). The filtrates were transferred into 1.5 mL glass amber vials. Samples were frozen at −70 °C, shipped on ice to the Queensland Alliance for Environmental Health Sciences (QAEHS), The University of Queensland (Woolloongabba, QLD, Australia), and stored at −20 °C until analysis.

2.2. Sample Analysis by Liquid Chromatography–Tandem Mass Spectrometry (LC–MS/MS)

Before LC–MS/MS analysis, frozen vials were thawed at room temperature, vortexed, and spiked with 10 μL of internal-standard mix (EtS-D5, 0.5 μg/mL). A 10 μL aliquot was injected into a SCIEX 6500 QTrap triple-quadrupole/linear-ion-trap mass spectrometer (Sciex, Concord, ON, Canada) equipped with an electrospray ionisation source in positive-ion mode, coupled to a Nexera UHPLC system (Shimadzu Corp., Kyoto, Japan).

Chromatographic separation was performed using a Kinetex Biphenyl column (50 × 2.1 mm, 1.7 µm) with a Kinetex EVO C18 guard column (30 × 2.1 mm, 5 µm) at 45 °C. Mobile phases were (A) 5 mM ammonium acetate + 0.1% formic acid in water and (B) 5 mM ammonium acetate + 0.1% formic acid in methanol; the gradient was 0–2.5 min (5 → 25% B), 2.5–5.5 min (25 → 55% B), 5.5–6.2 min (55 → 95% B), 6.2–7.9 min (hold 95% B), 7.9–8.0 min (return to 5% B), with re-equilibration to 10 min at 5% B, all at 0.45 mL/min. Data acquisition was performed using Analyst 1.7.1, and quantification was carried out in MultiQuant 3.0, utilising relative response factors between native analytes and their isotopically labelled internal standards.

2.3. Quality Assurance and Quality Control (QA/QC)

Sample analysis followed strict quality assurance and quality control (QA/QC) protocols. Quantification used ten-point calibration curves (0.1–20 µg/L; Milli-Q water, pH 2.0) with $R^2 > 0.99$ and linearity was confirmed with a twelve-point curve. Calibration standards were analysed at the start and end of each batch, with additional spiked wastewater samples, procedural blanks, and random calibration standards (0.5, 1, 5, 20 µg/L) plus solvent blanks injected every 20 samples to monitor instrument carry-over.

Accuracy was assessed from the recovery of native standards (1 µg/L, n = 7) in acidified Milli-Q water while precision was expressed as the relative standard deviation (RSD) of replicate measurements normalised to 1 µg/L. Matrix effects were evaluated by post-spiking wastewater samples (20 µg/L) and comparing them with un-spiked samples, as follows:

$$Matrix\ effect\ (\%) = \frac{Con_{Post\ spike} - Con_{un-spiked} - Cal_{20}}{Cal_{20}} \times 100\% \quad (1)$$

Values of 0% indicated no matrix effect, >0% ion enhancement, and <0% ion suppression.

Limits of detection (LOD) and quantification (LOQ) were based on replicate injections of the seven lowest calibration levels. Values were considered acceptable when accuracy was within 80–120% and precision within 20%. LOD and LOQ were further supported by signal-to-noise (S/N) ratios of 3 and 10, respectively, based on normalised standard solution concentrations.

2.4. Back Estimation of Alcohol Consumption

The total daily per capita consumption (V_{total}, in mL/day/person) was calculated by summing the separately calculated consumption for the daytime and nighttime periods:

$$V_{total} = V_{day} + V_{night} \quad (2)$$

The consumption of alcohol for each period (V_{period}) was back-calculated according to the following formula as per [17]:

$$V_{period} = \frac{C_{EtS\_period} \times F_{period} \times CF_{alcohol}}{P \times \rho_{alcohol}} \quad (3)$$

where:

V_{period} is the consumption of alcohol per capita during that specific period (day or night) in ml/person. C_{EtS_period} is the concentration of ethyl sulfate (EtS) as an alcohol biomarker in the wastewater for the period (µg/L), F is the total volume of the influent flow during that specific period (L), $CF_{alcohol}$ is the correction factor applied (4000) [17], P is the population served by STP, $\rho_{alcohol}$ is the density of alcohol (0.789 g/mL).

2.5. Statistical Analysis

This study assessed differences in alcohol consumption between weekdays and weekends using an Analysis of Covariance (ANCOVA). The total daily alcohol consumption was the dependent variable, the day of the week was the categorical factor, and the sampling day number was included as a covariate to control for the overarching temporal trend observed during the study period. Additionally, changes in per capita consumption during and after the COVID-19 lockdown were further examined with a *t*-test. The number of daily confirmed COVID-19 cases for the studied period was extracted from the Ministry of Health, Labour and Welfare website [18]. Spearman's rank correlation was applied to evaluate the association between alcohol consumption and daily COVID-19 cases over the same period. Statistical significance was set at $p < 0.05$ and all analyses and plots were performed in RStudio software (version 4.4).

3. Results and Discussion

3.1. Concentration of Alcohol Biomarker in Wastewater Samples

EtS was consistently detected in all samples throughout the study period. The mean EtS concentration was 30.4 ± 8.5 µg/L, with values ranging from 11.8 to 45.5 µg/L. A higher mean concentration was observed during the lockdown period (36.5 ± 5.6 µg/L) compared to the post-lockdown period (24.8 ± 6.7 µg/L). The mean mass load of EtS was 10.4 ± 3.0 mg/day/person, ranging from 4.5 to 16.9 mg/day/person. The analytical method met all acceptance thresholds, including a LOD of 10 ng/L, a LOQ of 20 ng/L, an accuracy of 98%, a precision of 1% RSD, and a matrix effect of 4.1%, confirming the reliability of the results.

3.2. Weekly Consumption Patterns and Day and Nighttime Consumption

The findings indicated that alcohol consumption remained stable throughout the week during the study period ($p = 0.158$) (Figure 1). This pattern is consistent with WBE studies from Vietnam and China [9,11,19], but contrasts with findings from many Western countries where consumption is typically highest on weekends [20–22]. A multinational survey of regular drinkers across 14 countries revealed a general tendency to drink after 5 p.m. and on weekends, forming a so-called "universal clock" of drinking [23]. However, the weekly rhythm and the consequences of drinking at specific times differ substantially across cultures. In Japan, drinking after work or "nomikai" is a common cultural practice and an important part of social and professional life which may partly explain the absence of a weekend drinking peak. Moreover, while a lower educational background has been associated with a higher risk of hazardous drinking, higher socioeconomic status among men and working women was associated with a higher risk for heavy episodic drinking [24]. These results emphasise that day-of-the-week consumption patterns cannot be generalised across societies but must be interpreted within Japan's unique cultural and socioeconomic context.

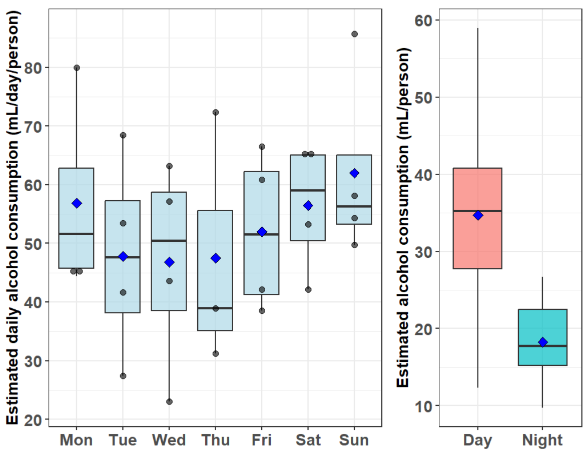


Figure 1. Estimated per capita alcohol consumption across days of the week and comparison of daytime and nighttime consumption. Blue diamond represents the mean value.

In our study, alcohol consumption differed significantly between daytime (8:00–18:00) and nighttime (18:00–8:00) with higher levels observed during the daytime ($p < 0.001$) (Figure 1). This pattern may be explained by the excretion kinetics of EtS, a short-lived metabolite of ethanol with a median half-life of 3.6 h [25] which reflects recent consumption. EtS can still be detected in urine for up to 25 h and longer depending on the amount of alcohol intake [26]. A study in four European cities showed that blood alcohol concentration levels in drinking environments rose significantly within five hours after the initiation of drinking [27]. Therefore, higher levels observed during the daytime may reflect the presence of EtS in wastewater resulting from alcohol consumption during the preceding nighttime hours. Pandemic-related restrictions also likely influenced these patterns. From early 2021, the Tokyo Metropolitan Government required pubs and restaurants to close at 8 PM. and prohibited alcohol sales. Our sampling coincided with the fifth state of emergency, which extended across all 27 prefectures including Tokyo and restrictions were only lifted on 30 September 2021 (day 14 of sampling) after six months of repeated extensions.

3.3. Prevalence of Alcohol Consumption

The estimated alcohol consumption in this study was 52.9 ± 15.3 mL/day/person (~41.7 ± 12.1 g/day/person) which is comparable to findings from a previous wastewater study in Turkey [28]. However, the levels observed here were higher than those reported in WBE studies conducted in China, the United States, and several Western countries (Table 1). A systematic review on WBE studies also showed that alcohol consumption in many Northern European countries reached up to 118 mL/day/person, while the lowest level was found in China [14]. Some of the differences between this study and the previous ones may be explained by methodological differences in the back-calculation process. In this study, we applied a CF of 4000, which was refined using national alcohol sales data with national EtS mass load data from a national wastewater monitoring program in Australia [17]. This updated CF accounts for both the EtS excretion rate and degradation during sewer transport, thereby improving the accuracy of alcohol consumption estimates by WBE. To minimise the influence of CF variability, the excreted mass load (mg/day/person) was also included in Table 1 to enable direct cross-study comparison. Overall, the findings consistently support that the level of alcohol consumption estimated in this study aligns with higher levels observed in other countries.

Strict government control policies have been shown to play an important role in reducing alcohol use in many countries [29]. In Japan, alcohol consumption patterns are also shaped by demographic and social factors with heavy and moderate drinking linked to the ages 40–49 [30]; however, younger generations tend to drink less than their parents. In response, the Japanese government recently launched a campaign to promote drinking among young adults in an effort to revitalise the alcohol industry. In contrast, Japan's legal blood alcohol concentration limit for driving remains higher than that of many other Asian countries, such as China and Vietnam [19,31]. Besides, there are no legally binding regulations on alcohol advertising across any media platforms in Japan [32]. These factors may partly explain the relatively high alcohol consumption levels observed in this study.

Table 1. Alcohol consumption in WBE studies.

Country, City	Sampling Description	Correction Factor (CF)	Mass Load of EtS (mg/Day/Person)	Daily Consumption (mL/Day/Person)
Innsbruck, Austria [33]	2016–2020	CF = 3046	4.1 ± 1.5	15.9 ± 6.1
	March to April 2020 (lockdown)		3.3 ± 0.7	12.6 ± 2.8
Spain and Portugal [34]	March to July 2020	CF = 3047	3.9 ± 1.3 to 7.2 ± 4.5	20–28
3 communities in the U.S [35]	March 2015–March 2016	CF = 3047	7.6	29.4
All states and territories in Australia [10]	2016–2023	CF = 3043.8	3.7 3.73 4.8	14.3 (major cities) 14.4 (Inner Regional areas) 18.6 (Outer Regional and Remote category sites)
Istanbul city, Turkey [28]	March 2019	CF = 3047	11.8	49.8
	June 2019		12.8	54.9
Southern China [11]	2017–2018	CF = 4000	0.27 ± 0.11	1.4 ± 0.6
Hanoi, Vietnam [9]	2018–2023	CF = 4000	0.59 ± 0.24	3.0 ± 1.2
This study	September–October 2021	CF = 4000	10.4 ± 3.0	52.9 ± 15.3

Furthermore, differences in drinking culture and demographic factors could also influence alcohol consumption level. For example, a WBE study in Australia reported higher alcohol consumption in rural compared to urban areas [10]. In Japan, alcohol use is common in the workplace and social culture, particularly through "nomikai" for socialising and networking. Daily commuting from the catchment area to Tokyo for work and leisure, followed by a return to residential areas, may further influence local consumption patterns. Moreover, national data on taxable beverage sales also highlight the popularity of cheap, high-alcohol beverages such as chū-hai in Japan. The 2022 National Tax Agency reported that liqueurs/chū-hai accounted for the highest per capita volumes, reaching 61.1 mL/day/person [36]. A nationwide survey further confirmed the popularity of this beverage, reporting that 56.2% had consumed strong chū-hai, which are flavoured alcoholic drinks sold at about half the price of beer but with a high alcohol content (8–9%) [2]. Importantly, the study indicated that among current alcohol users, strong chū-hai consumption was associated with hazardous and harmful alcohol use. This preference for chū-hai which are consumed more smoothly and in larger quantities may therefore explain the high alcohol consumption levels.

Epidemiological evidence further supports the high prevalence of alcohol use in Japan. The 2019 National Health and Nutrition Survey conducted among 2558 Japanese participants reported that about 35.8% consumed <180 mL sake/day (~ 23 g ethanol), 36.3% consumed 180–360 mL/day (~23–46 g ethanol), 18.0% consumed 360–540 mL/day (~46–69 g ethanol), and 9.9% consumed >540 mL/day (>69 g ethanol) [7]. A 13-year cohort study of 102,802 adults in Osaka reported that 36.9% consumed <22 g/day, 17.7% consumed 22–<39 g/day, 8.7% consumed 39–<66 g/day, and 1.6% consumed ≥66 g/day, with heavy intake linked to increased type 2 diabetes risk among individuals with BMI < 25 kg/m^2 [4].

3.4. The Effect of COVID-19 Restrictions On Substance Consumption

Our analysis revealed significantly lower levels of alcohol consumption during the post-lockdown period compared to the restrictions period ($p < 0.001$). A possible explanation could be catchment population dynamics, strongly influenced by the socioeconomic structure of the Greater Tokyo Area (including our Kanto region). There is a pronounced spatial imbalance between residential and employment areas, with most residents living in the surrounding suburbs (our catchment) while workplaces are concentrated in central Tokyo [37]. Moreover, a decreased commute burden associated with remote work during COVID-19 in the Kanto area (Tokyo, Chiba, Kanagawa, and Saitama) was observed, which could be a key factor in shifting regional population dynamics [38]. After restrictions were lifted, more people resumed commuting to workplaces in central Tokyo, thereby reducing the number of residents contributing to wastewater in our catchment. This shift may explain the observed decrease in per capita alcohol consumption estimates during the post-lockdown period [39].

A strong positive correlation was observed between estimated alcohol consumption and daily reported COVID-19 cases in the catchment area ($r = 0.735$, $p < 0.001$; Figure 2A). Both variables showed similar declining trends over time with higher levels during the lockdown period (Figure 2B). This alignment suggests that alcohol use patterns may have been closely linked to pandemic dynamics and public health measures. However, it is notable to emphasise that this dataset cannot establish causality between COVID-19 case numbers and alcohol consumption.

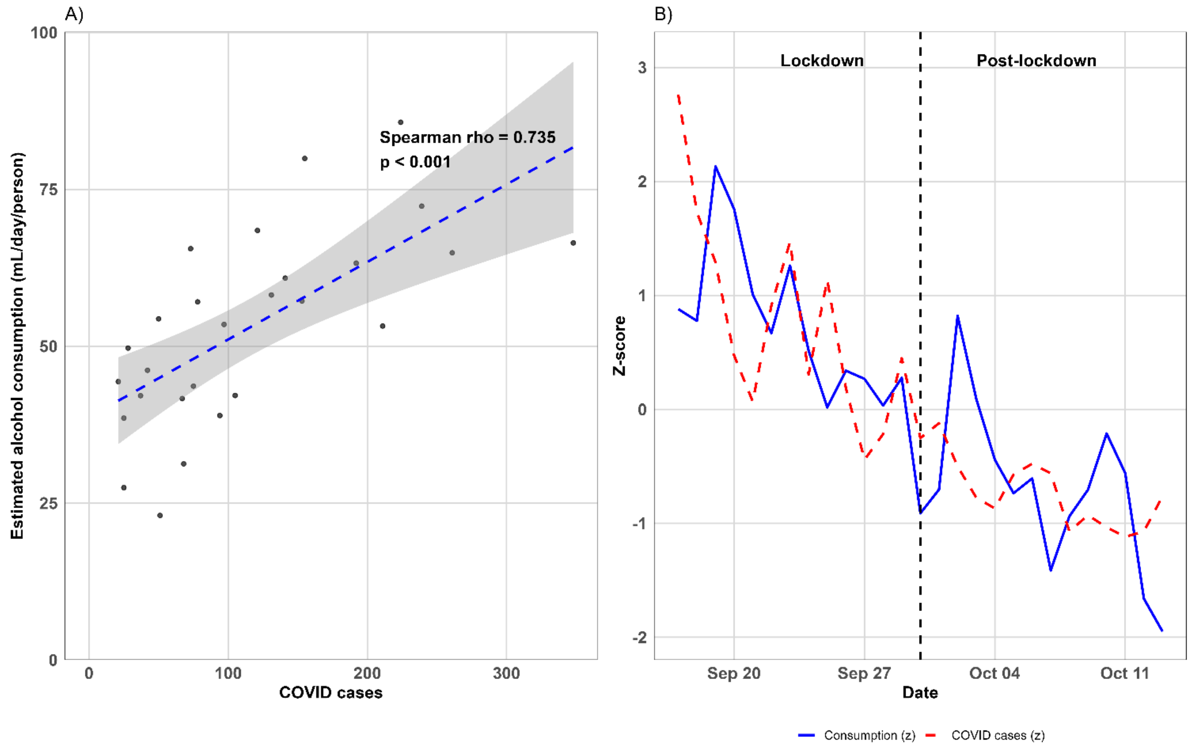


Figure 2. (**A**) Association between estimated alcohol consumption and daily reported COVID-19 cases in the catchment area; (**B**) Time series of alcohol consumption and COVID-19 cases expressed as z-scores (standardised values; mean = 0, SD = 1) to enable comparison of relative fluctuations.

Behavioural shifts during the COVID-19 pandemic also likely influenced alcohol consumption in Japan. Restrictions limited drinking at bars and restaurants, reducing social drinking opportunities and shifting alcohol use to the home [9,40]. Previous surveys reported that binge drinking during the COVID-19 pandemic was associated with worsening household finances and depressive symptoms [41] and prolonged hazardous alcohol use persisted into later phases [42]. The most commonly reported reason for changes in drinking behaviour during the COVID-19 pandemic among Japanese adults was an increase in both the frequency and quantity of drinking at home [43]. Interestingly, increased alcohol consumption in Japan during COVID-19 was also linked to higher flourishing index scores, reflecting attempts to improve life satisfaction during stressful periods [44], while another study found associations with anxiety and depression [45]. Moreover, a nationwide Internet-based survey in 2023 showed that remote work frequency was associated with a higher prevalence of hazardous alcohol use [46].

3.5. Limitations

We acknowledge the following limitations in this study. Firstly, influent wastewater samples were obtained from a single STP in the Kanto region of Japan, which limits the generalizability of the findings. However, our catchment is substantial, serving approximately 1.8 people, which provides objective evidence across a significant metropolitan population segment. Secondly, the relatively short sampling period restricted our ability to assess long-term consumption patterns. Finally, a fixed catchment population was used for back-calculations while population mobility could affect the accuracy of estimates.

4. Conclusions

This study provides the first assessment of alcohol consumption based on wastewater analysis in Japan. The alcohol biomarker EtS was consistently detected in all wastewater samples. The mean estimated consumption is higher than wastewater data from other countries. In contrast to Western countries, no significant weekly pattern in alcohol consumption was observed in Japan. Additionally, consumption decreased after the lockdown, and a strong positive correlation was observed between alcohol intake and daily reported COVID-19 cases, likely reflecting population mobility and behaviour dynamics during the pandemic. This study highlights the need to apply WBE to monitor alcohol consumption during the long-term period in Japan, serving as a complementary approach to traditional methods.

Author Contributions

H.K.T.N.: Formal analysis, Visualization, Writing—original draft, Writing—review & editing; Q.T.T.D.: Data curation, Writing—original draft, Writing—review & editing; Q.Z.: Formal analysis, Methodology, Writing—

review and editing; O.M.: Supervision, Methodology, Writing—review and editing; P.K.T.: Supervision, Methodology, Conceptualization, Writing—review & editing. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement

Not applicable.

Informed Consent Statement

Not applicable.

Data Availability Statement

Due to the nature of the research and legal confidentiality agreements, the supporting data cannot be made publicly available.

Conflicts of Interest

Given the role as Associate Editor, P.K.T. had no involvement in the peer review of this paper and had no access to information regarding its peer-review process. Full responsibility for the editorial process of this paper was delegated to another editor of the journal.

Use of AI and AI-assisted Technologies

No AI tools were utilized for this paper.

References

1. World Health Organization (WHO). *Alcohol Japan 2019 Country Profile*; World Health Organization (WHO): Geneva, Switzerland, 2019.
2. Yoshioka, T.; So, R.; Takayama, A.; et al. Strong chū-hai, a Japanese ready-to-drink high-alcohol-content beverage, and hazardous alcohol use: A nationwide cross-sectional study. *Alcohol Clin. Exp. Res.* **2023**, *47*, 285–295.
3. Iwase, M.; Matsuo, K.; Koyanagi, Y.N.Y.; et al. Alcohol consumption and breast cancer risk in Japan: A pooled analysis of eight population-based cohort studies. *Int. J. Cancer* **2021**, *148*, 2736–2747.
4. Takahashi, F.; Okada, H.; Hashimoto, Y.; et al. Association between alcohol consumption and incidence of type 2 diabetes in middle-aged Japanese from Panasonic cohort study 12. *Sci. Rep.* **2024**, *14*, 20315.
5. Suzuki, T.; Fukui, S.; Shinozaki, T.; et al. Lipid Profiles After Changes in Alcohol Consumption Among Adults Undergoing Annual Checkups. *JAMA Netw. Open* **2025**, *8*, e250583.
6. BBC News Japan Urges its Young People to Drink More to Boost Economy. Available online: https://www.bbc.com/news/world-asia-62585809 (accessed on 16 September 2025).
7. Ministry of Health, Labour and Welfare. *The National Health and Nutrition Survey (NHNS) Japan*; Ministry of Health, Labour and Welfare: Tokyo, Japan, 2019.
8. Zuccato, E.; Chiabrando, C.; Castiglioni, S.; et al. Cocaine in surface waters: A new evidence-based tool to monitor community drug abuse. *Environ. Health* **2005**, *4*, 14.
9. Anh, P.N.; Ngo, H.K.T.; Wang, Z.; et al. Six years of alcohol consumption in Hanoi, Vietnam, by wastewater analysis: Assessing changes impacted by socio-economical factors. *Public Health* **2025**, *245*, 105771.
10. Tscharke, B.; Livingston, M.; O'Brien, J.W.; et al. Seven-years of alcohol consumption in Australia by wastewater analysis: Exploring patterns by remoteness and socioeconomic factors. *Drug Alcohol Depend.* **2024**, *259*, 111317.
11. Zheng, Q.; Chan, G.C.K.; Wang, Z.; et al. Assessing alcohol consumption in a Chinese urban population and a university town using high temporal resolution wastewater-based epidemiology. *Drug Alcohol Depend.* **2022**, *230*, 109178.
12. Azuma, T.; Otomo, K.; Kunitou, M.; et al. Environmental fate of pharmaceutical compounds and antimicrobial-resistant bacteria in hospital effluents, and contributions to pollutant loads in the surface waters in Japan. *Sci. Total Environ.* **2019**, *657*, 476–484.
13. Kadokami, K.; Miyawaki, T.; Iwabuchi, K.; et al. Inflow and outflow loads of 484 daily-use chemicals in wastewater treatment plants across Japan. *Environ. Monit. Contam. Res.* **2021**, *1*, 1–16.
14. Rousis, N.; Bade, R.; Gracia-Lor, E. Wastewater-based epidemiology as a surveillance tool to assess human consumption of psychotropic substances: Alcohol, nicotine and caffeine as case studies. *TrAC Trends Anal. Chem.* **2023**, *167*, 117230.
15. Gao, J.; Li, J.; Jiang, G.; et al. Stability of alcohol and tobacco consumption biomarkers in a real rising main sewer. *Water Res.* **2018**, *138*, 19–26.
16. Reid, M.J.; Langford, K.H.; Mørland, J.; et al. Analysis and interpretation of specific ethanol metabolites, ethyl sulfate, and ethyl glucuronide in sewage effluent for the quantitative measurement of regional alcohol consumption. *Alcohol. Clin. Exp. Res.* **2011**, *35*, 1593–1599.
17. Thai, P.K.; Tscharke, B.J.; O'Brien, J.W.; et al. Estimating Alcohol Consumption by Wastewater-Based Epidemiology: An Assessment of the Correction Factor for Ethyl Sulfate Using Large-Scale National Monitoring Data. *Environ. Sci. Technol. Lett.* **2021**, *8*, 333–338.
18. Ministry of Health, Labour and Welfare. Open Data on COVID-19. Available online: https://www.mhlw.go.jp/stf/covid-19/open-data.html (accessed on 8 September 2025).

19. Bui, T.X.; Ngo, H.K.T.; Vu, G.T.; et al. Assessing the impact of stricter drink driving policy on alcohol consumption in a population of Hanoi, Vietnam using wastewater analysis. *Drug Alcohol Rev.* **2025**, *44*, 70–79.
20. Wilson, M.K.; Phung, K.; Chappell, A.; et al. Wastewater-based Epidemiology to Investigate Spatio-Temporal Trends in Alcohol Consumption in Aotearoa, New Zealand. *Chem. Asian J.* **2024**, *19*, e202301120.
21. Zheng, Q.; Tscharke, B.J.; Krapp, C.; et al. New approach for the measurement of long-term alcohol consumption trends: Application of wastewater-based epidemiology in an Australian regional city. *Drug Alcohol Depend.* **2020**, *207*, 107795.
22. López-García, E.; Pérez-López, C.; Postigo, C.; et al. Assessing alcohol consumption through wastewater-based epidemiology: Spain as a case study. *Drug Alcohol Depend.* **2020**, *215*, 108241.
23. Room, R.; Mäkelä, P.; Benegal, V.; et al. Times to drink: Cross-cultural variations in drinking in the rhythm of the week. *Int. J. Public Health* **2012**, *57*, 107–117.
24. Kinjo, A.; Kuwabara, Y.; Minobe, R.; et al. Different socioeconomic backgrounds between hazardous drinking and heavy episodic drinking: Prevalence by sociodemographic factors in a Japanese general sample. *Drug Alcohol Depend.* **2018**, *193*, 55–62.
25. Høiseth, G.; Morini, L.; Polettini, A.; et al. Blood kinetics of ethyl glucuronide and ethyl sulphate in heavy drinkers during alcohol detoxification. *Forensic Sci. Int.* **2009**, *188*, 52–56.
26. Høiseth, G.; Bernard, J.P.; Stephanson, N.; et al. Comparison between the urinary alcohol markers EtG, EtS, and GTOL/5-HIAA in a controlled drinking experiment. *Alcohol Alcohol.* **2008**, *43*, 187–191.
27. Hughes, K.; Quigg, Z.; Bellis, M.A.; et al. Drinking behaviours and blood alcohol concentration in four European drinking environments: A cross-sectional study. *BMC Public Health* **2011**, *11*, 918.
28. Asicioglu, F.; Kuloglu Genc, M.; Tekin Bulbul, T.; et al. Investigation of temporal illicit drugs, alcohol and tobacco trends in Istanbul city: Wastewater analysis of 14 treatment plants. *Water Res.* **2021**, *190*, 116729.
29. Guindon, G.E.; Li, C.; Trivedi, R.; et al. The effectiveness and cost-effectiveness of population-level policies to reduce alcohol use: A systematic umbrella review. *Can. J. Public Health* **2025**. https://doi.org/10.17269/s41997-025-01013-9.
30. Okui, T. An analysis of predictors for heavy alcohol drinking using nationally representative survey data in Japan. *BMC Public Health* **2021**, *21*, 359.
31. World Health Organization (WHO). *Global Status Report on Alcohol and Health 2018*; World Health Organization (WHO): Geneva, Switzerland, 2018.
32. Kato, M.; Ishikawa, H.; Kiuchi, T.; et al. Patterns of alcohol and alcohol-flavoured non-alcoholic beverage advertisements over Japanese free-to-air television networks. *BMC Public Health* **2022**, *22*, 1864.
33. Reinstadler, V.; Ausweger, V.; Grabher, A.L.; et al. Monitoring drug consumption in Innsbruck during coronavirus disease 2019 (COVID-19) lockdown by wastewater analysis. *Sci. Total Environ.* **2021**, *757*, 144006.
34. Estévez-Danta, A.; Bijlsma, L.; Capela, R.; et al. Use of illicit drugs, alcohol and tobacco in Spain and Portugal during the COVID-19 crisis in 2020 as measured by wastewater-based epidemiology. *Sci. Total Environ.* **2022**, *836*, 155697.
35. Chen, J.; Venkatesan, A.K.; Halden, R.U. Alcohol and nicotine consumption trends in three U.S. communities determined by wastewater-based epidemiology. *Sci. Total Environ.* **2019**, *656*, 174–183.
36. Japan, N.T.A. *Alcohol Guidebook*; Japan, N.T.A.: Tokyo, Japan, 2024.
37. Bramson, A.; Hori, M.; Zha, B.; et al. Social and economic flows across multimodal transportation networks in the Greater Tokyo Area. *Appl. Netw. Sci.* **2020**, *5*, 7.
38. Schouten, A.; Kawano, Y. COVID-19 and the demand for transit access: Residential real estate prices in the Tokyo metropolitan area. *J. Transp. Geogr.* **2024**, *114*, 103742.
39. O'Brien, J.W.; Thai, P.K.; Eaglesham, G.; et al. A model to estimate the population contributing to the wastewater using samples collected on census day. *Environ. Sci. Technol.* **2014**, *48*, 517–525.
40. Hardie, I.; Stevely, A.K.; Sasso, A.; et al. The impact of changes in COVID-19 lockdown restrictions on alcohol consumption and drinking occasion characteristics in Scotland and England in 2020: An interrupted time-series analysis. *Addiction* **2022**, *117*, 1622–1639.
41. Stickley, A.; Shirama, A.; Inagawa, T.; et al. Binge drinking in Japan during the COVID-19 pandemic: Prevalence, correlates and association with preventive behaviors. *Drug Alcohol Depend.* **2022**, *234*, 109415.
42. Sugaya, N.; Yamamoto, T.; Suzuki, N.; et al. Change in Alcohol Use during the Prolonged COVID-19 Pandemic and Its Psychosocial Factors: A One-Year Longitudinal Study in Japan. *Int. J. Environ. Res. Public Health* **2023**, *20*, 3871.
43. Kishimoto, M.; Masuko, K.; Yamamoto, S.; et al. Changes in lifestyle-related behaviour during the COVID-19 pandemic in Japan: A questionnaire survey for examinees who underwent an annual health check-up. *J. Int. Med. Res.* **2023**, *51*, 03000605231184036.
44. Shibata, T.; Yamaoka, Y.; Nawa, N.; et al. Association of lifestyle and flourishing during the COVID-19 pandemic in Japan. *Front. Psychol.* **2024**, *15*, 1341711.
45. Capasso, A.; Jones, A.M.; Ali, S.H.; et al. Increased alcohol use during the COVID-19 pandemic: The effect of mental health and age in a cross-sectional sample of social media users in the U.S. *Prev. Med.* **2021**, *145*, 106422.
46. Sonoda, K.; Okawa, S.; Tabuchi, T. Association of remote work with tobacco and alcohol use: A cross-sectional study in Japan. *BMC Public Health* **2025**, *25*, 103.