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Changes in alcohol consumption associated with social distancing and self-isolation policies triggered by COVID-19 in South Australia: a wastewater analysis study

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ABSTRACT

Aim To assess the effects of social distancing and social isolation policies triggered by COVID-19 on alcohol consumption using wastewater analysis in Adelaide, South Australia. **Design** Longitudinal quantitative analysis of influent wastewater data for alcohol concentration. **Setting** Adelaide, South Australia. **Participants** Wastewater catchment area representative of 1.1 million inhabitants. **Measurements** Twenty-four hour composite influent wastewater samples were collected from four wastewater treatment plants in Adelaide, South Australia for 7 consecutive days (Wednesday–Tuesday) every 2 months from April 2016–April 2020. The alcohol metabolite ethyl sulfate was measured in samples using chromatography–tandem mass spectrometry. Data were population-weighted adjusted with consumption expressed as standard drinks/day/1000 people. Weekly consumption and weekend to mid-week consumption ratios were analysed to identify changes in weekday alcohol use pattern. **Findings** Estimated weekend alcohol consumption was significantly lower (698 standard drinks/day/1000 people) after self-isolation measures were enforced in April 2020 compared with the preceding sampling period in February 2020 (1047 standard drinks/day/1000 people), $P < 0.05$. Weekend to midweek consumption ratio was 12% lower than the average ratio compared with all previous sampling periods. April 2020 recorded the lowest alcohol consumption relative to April in previous years, dating back to 2016. **Conclusions** Wastewater analysis suggests that introduction of social distancing and isolation policies triggered by COVID-19 in Adelaide, South Australia, was associated with a decrease in population-level weekend alcohol consumption.

Keywords Alcohol consumption, Australia, COVID-19, Social distancing, Stress, Wastewater analysis.

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INTRODUCTION

The majority of governments around the world imposed city lockdowns and self-isolation measures on its citizens as a mechanism to combat the spread of COVID-19. In Australia, the federal government implemented policies to close all 'non-essential' services by midday March 23, 2020, including registered and licensed clubs, licensed premises in hotels and pubs, with cafes and restaurants restricted to takeaway only [1]. Subsequently, the purchase of alcohol was limited to standalone liquor outlets, because these retailers were exempt from trading restrictions. It is expected changes to the patterns of behaviour associated with alcohol sales and consumption in the context of self-isolation may ensue.

The literature contains conflicting epidemiological evidence correlating the degree of alcohol use following a catastrophic event, although alcohol consumption generally tends to increase in the short term [2]. In times of stress, individuals may be enticed to increase their consumption of alcohol above normal levels, because it may provide a perceived relief (reward) from the stressor [3]. However, alcohol use can compound and impair the physiological and psychological responses to stress resulting

from disturbance in neuroendocrine homeostasis [4]. Predisposition to anxiety and depression can exacerbate the problem leading to secondary consequences including anti-social behaviours (e.g. self-harm and domestic violence [5]), therefore escalating the public health crisis.

Recently, the Australian media reported on results from a survey commissioned by the Foundation for Alcohol Research and Education (FARE), which focused on alcohol sales and use in the initial phase of COVID-19-related self-isolation in Australia [6]. The survey polled 1045 individuals aged 18 years and over residing in Australia. Key findings suggested 20% of households were purchasing more alcohol than usual and of those households, 70% reported consuming more alcohol compared to normal. The results implied alcohol sales and use had increased since the unfolding of the COVID-19 catastrophe in Australia.

Surveys constitute one method for establishing alcohol (and other substance) use among the population. However, such methods may give rise to response biases in the assessment of alcohol use [7]. On the other hand, wastewater analysis (WWA) is a proven, effective tool for providing objective evidence for spatio-temporal assessment of alcohol consumption among populations [8–10]. The typical pattern of alcohol consumption according to wastewater-based epidemiology includes lower consumption during the weekdays, followed by a weekend peak that is attributable to social and binge drinking [8,11,12]. These patterns provide a basis for comparing alcohol consumption during rare, catastrophic events like the COVID-19 pandemic.

It is paramount that any response to a public health issue arising from broad-scale effects inflicted by a catastrophe like COVID-19 is backed by rigorous, reproducible and objective data. Here, we report evidence for localised differences of alcohol consumption during the COVID-19 pandemic. A case study constituting a 4-year longitudinal analysis of alcohol consumption across the broader metropolitan area of Adelaide, South Australia showed the impact of COVID-19-related social restrictions on alcohol consumption as well as the change in the pattern of use compared with the period before an imposed self-isolation regime.

METHODS AND MATERIALS

Samples and sample treatment

Our group have been analysing alcohol consumption in South Australia since April 2016. Every 2 months, influent wastewater samples were collected and analysed. Twenty-four hour composite influent wastewater samples were collected from four wastewater treatment plants (WWTPs) in Adelaide, South Australia for 7 consecutive days (Wednesday–Tuesday) every 2 months from April 2016–April 2020. These plants cover more than 1.1 million inhabitants, based on census data, representing 75% of the of the State's population. The samples were predominantly collected in the first week of each sampling month and avoided public holidays and festival periods. During each sampling period, samples were acidified on collection (pH 2) and refrigerated until the final sample had been collected, after which all samples were transported to our laboratory for analysis. Samples were brought to room temperature on arrival in the laboratory, then filtered under vacuum using glass microfiber filters GF/A 1.6 mm (Whatman, Kent, UK). Filtered samples were refrigerated until sample treatment, which was within 24 hours for all samples.

The analytical method used to measure the urinary excretion product of alcohol, ethyl sulfate (EtS) was adopted from a previously validated method [8]. Briefly, filtered wastewater (2 mL) was combined with 100 µL ultrapure water then spiked with 40 µL of the internal standard EtS-d_5 (2.5 mg/L) to account for any matrix effects and instrumental losses, vortex mixed and transferred to a glass vial for liquid chromatography with tandem mass spectrometry (LC-MS/MS) analysis. A seven-point calibration curve (2960–58411 ng/L; internal standard concentration, 46729 ng/L) was used for quantification. Standards and internal standards mixture were spiked in 2 mL of composite wastewater from each WWTP, and accuracy was checked by subtracting average area ratio of two blanks. Quality assurance and quality control (QA/QC) samples consisting of ultrapure water spiked with EtS (23 364 ng/L) and EtS-d_5 (46729 ng/L) were injected with the calibration curve prior to the samples. EtS has previously been established to be stable for at least 1 week at room temperature and 4°C [13] and therefore, stability was not investigated in this study.

LC-MS/MS method

To evaluate alcohol consumption, EtS was analysed using a Sciex Exion LC coupled to a Sciex 6500 + QTrap (Toronto, Canada), fitted with a TurboSpray IonDrive source. Two multiple reaction monitoring transitions were monitored in negative mode for EtS (124.7 > 96.8 and 124.7 > 79.7) and one for EtS-d_5 (129.7 > 97.7). Chromatographic separation was carried out using a Synergi Hydro-RP column (150 × 4.6 mm) with an internal diameter of 4 µm connected to a C18 guard column (SecurityGuard ULTRA; 4 × 2.0 mm; Phenomenex, Torrance, CA) at a flow rate of 0.5 mL min^{-1} and a 5 µL injection volume. The mobile phases used were 100% water, 5 mM ammonium formate, 0.1% formic acid (solvent A) and 50% methanol, 50% acetonitrile (solvent B). The initial percentage of B was 0% and over 4 minutes was linearly increased to 100%, followed by a 0.2-minute isocratic period, then returned to initial conditions in

0.8 minutes and remained steady for the final 3 minutes. The total run time was 8 minutes. All data were acquired using Analyst and were processed with MultiQuant 2.1.1.

Calculation of alcohol consumption rates and statistics

Alcohol consumption based on ethyl sulfate was calculated using previously reported methods [8,14], with consumption reported as standard drinks/day/1000 people in this work. The in-sample concentration of EtS (ng/L) was used to back-calculate the number of standard drinks/day/1000 people. Briefly, the in-sample concentration (ng/L) was multiplied by the daily flow volume (megalitres) to give the total daily excretion (mg/day) that was normalised against the population served by the treatment plants to give the estimated population mass load (mg/day/1000 people). A back-calculation factor of 3043.82 (based on the urinary excretion of EtS of 0.012% [10,12]) allowed the amount of ethanol consumed (g/day/1000 people) to be estimated. Finally, standard drinks (10 g ethanol) were used to convert this to standard drinks/day/1000 people. Unless otherwise specified, quantified levels at each of the four plants were combined and presented as the population-weighted average of the four plants. To evaluate statistical changes between sampling periods, two-tailed, two-sample *t*-tests assuming equal variances were applied. All calculations were performed using Microsoft Excel. The research question and analysis plan were not pre-registered on a publicly available platform, and the results should be considered exploratory.

RESULTS

Figure 1 shows that April 2020 had one of the lowest levels of alcohol consumption since we began our analysis. The inset shows the weekly trend of April 2020 is far flatter than the preceding collection period in February 2020, indicating decreased weekend consumption of alcohol, emphasised by statistically significant difference ($P < 0.05$).

It is also clear from Fig. 1 that alcohol consumption is generally lowest in the month of April year to year. To understand the degree of consumption in April 2020 relative to other years, April 2020 was compared with other April collections (2016, 2017, 2018 and 2019). Statistically significant differences ($P < 0.05$) were seen for each time period compared to 2020 (Fig. 2).

The above two figures consider the entire week (i.e. Monday–Sunday). However, this data does not reveal the pattern of consumption across the week. In all months, there is a distinct weekend trend, with increased alcohol consumption seen on Saturday and Sunday, along with Friday and Monday. To determine if any deviation existed in this weekend trend during April 2020 compared to previous months, a ratio between peak weekend consumption (Saturday and Sunday) and low midweek consumption (Tuesday and Wednesday) was calculated, with results

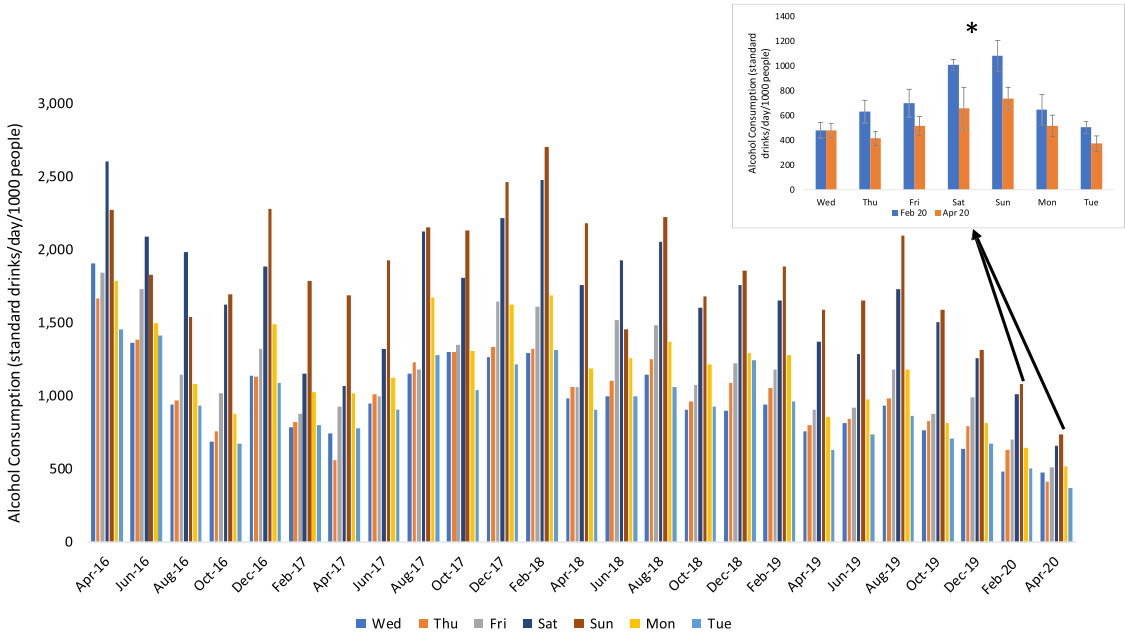

Figure 1 Alcohol consumption in South Australia from April 2016–April 2020. Each column represents the population normalised mean alcohol consumption across four different WWTPs in South Australia and is presented as Wednesday–Tuesday inclusive. The inset highlights the daily differences between February 2020 and April 2020 (including SE). Asterisk in the inset indicated statistically significant weekend differences between February and April ($P < 0.05$). [Colour figure can be viewed at wileyonlinelibrary.com]

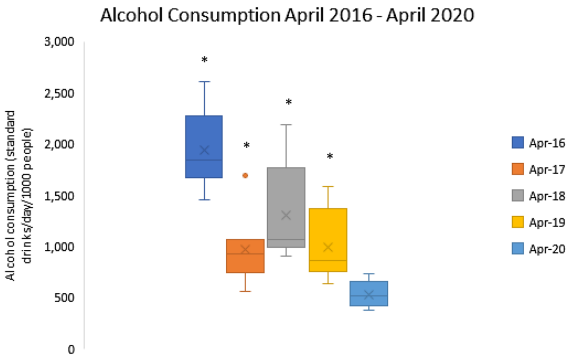

Figure 2 Daily alcohol consumption over the weekly sampling periods in April from 2016–2020. Each box and whisker represent population normalised mean alcohol consumption across four different WWTPs in South Australia. The whiskers comprise the lower and upper consumption values. *Statistically significant difference from 2020 ($P < 0.05$). [Colour figure can be viewed at wileyonlinelibrary.com]

shown in Fig. 3. The higher the number, the higher the weekend consumption. April 2020 recorded the lowest ratio (1.6:1) since mid-2016, indicating decreased weekend alcohol consumption. It was 12% lower than the average ratio for all April data (1.9:1) from 2016–2019 as well as all sampling periods (1.9:1).

DISCUSSION

There has been discussion that alcohol consumption would increase during the enforced COVID-19 triggered social restrictions, in part because of increased sales [15]. In Australia, specific restrictions to prevent panic buying of alcohol and stop excess drinking during the outbreak were introduced, however, limits on the quantity of different liquor types varied among each state and territory (e.g. each customer could purchase up to two of the following, per day: three bottles of wine, one carton of beer, cider or pre-mix spirits, one litre of spirits, one litre of fortified wine) [16,17].

Our data demonstrate that alcohol consumption in South Australia actually decreased following these enforced restrictions. What is most interesting is not only did overall weekly consumption decrease, but the weekend spike that is conventional for alcohol consumption was also flatter than usual. This suggests that the population under investigation heeded government advice to stay home and self-isolate, therefore resulting in decreased social and binge drinking occurring in pubs and clubs, which WWA has shown generally correlates with the weekend social behaviour [8]. Furthermore, such venues principally attract young people whose drinking is tied to social interaction.

Despite the restrictions imposed, survey data have shown that Australian households were buying more alcohol than usual following the COVID-19 outbreak [6]. These findings are consistent with the wastewater results if it is assumed that people who may otherwise have consumed alcohol outside of their homes on the weekend, instead purchased a greater than usual quantity of alcohol to drink at home. However, it does not preclude the possibility that younger people may have decreased their drinking as a result of limited access to licensed premises whereas at least some other members of the population may have increased consumption. Although there was disagreement between our WWA data and that of the national survey [6], it is important to recognise the differences between the two methods. For example, alcohol consumption of more than 1.1 million South Australian inhabitants were included in our study compared to the 1045 national respondents of the survey; daily composite sampling of wastewater for seven consecutive days versus an online questionnaire active for 3 days as well as differences in local and national demographics. Although uncertainties around WWA are known and acknowledged [18], the aim of our study to

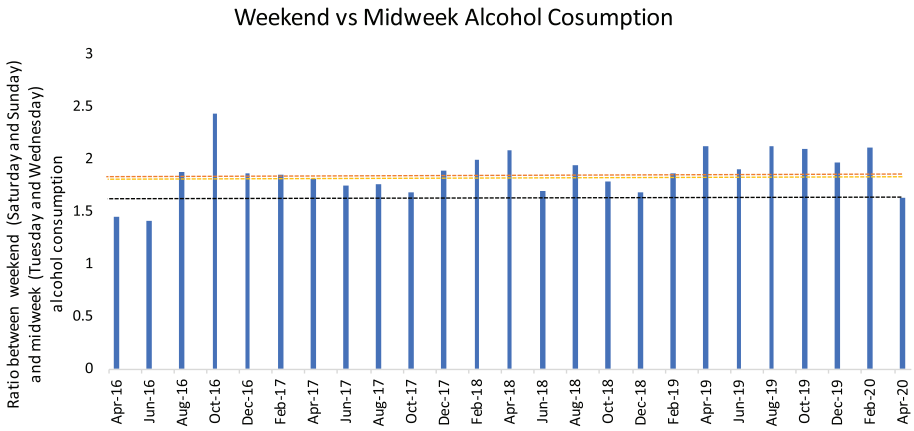

Figure 3 Each column represents the ratio between peak weekend (Saturday and Sunday) alcohol consumption and low weekday (Tuesday and Wednesday) alcohol consumption. The black line shows the level of April 2020, the yellow line is the average for all April periods (April 2016, 2017, 2018 and 2019) and the orange line is the overall average of all sampling periods from April 2016–December 2019. [Colour figure can be viewed at wileyonlinelibrary.com]

show the impact of social restrictions on alcohol consumption is still valid.

The evidence presented here supports a localised, short-term effect of closing venues and the cancellation of events associated with social drinking behaviour, which appears to have a significantly reduced alcohol consumption. There may have been some compensatory increase in alcohol purchased from bottle stores, but any such increase was less than the decline associated with the onset of the COVID-19 outbreak. However, in the absence of longer-term data, it would be premature to speculate this pattern of behaviour would last throughout an extended period of lock-down. Although it is beyond the scope of this report, follow-up studies could look to correlate the current data with weekend alcohol-related violent crime and accidents, to ascertain whether these also reduced during the crisis.

In conclusion, the WWA data presented in this paper contrasts recent reports in Australian media that suggested Australians were consuming more alcohol than usual since the COVID-19 outbreak, in part as a mechanism to cope with anxiety and stress resulting from a rapidly changing social and economic landscape and future uncertainties. Our data demonstrate that any increase in purchasing did not lead to an increase in consumption and instead, there was a decrease in the population level of alcohol consumption. This decrease is best explained as a decline in drinking in licensed premises and in other social gatherings. As the public health impact of alcohol is closely linked with the overall level of its consumption in the population, it is likely that the major impact of the COVID-19 epidemic may be a decline in alcohol-related problems.

Declaration of interests

The authors declare no conflict of interest.

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Author Contributions

Richard Bade: Conceptualization; data curation; formal analysis; validation. **Bradley Simpson:** Conceptualization; formal analysis; visualization. **Maulik Ghetia:** Data curation; investigation; methodology. **Lynn Nguyen:** Investigation; methodology. **Jason White:** Conceptualization. **Cobus Gerber:** Conceptualization; funding acquisition; project administration; supervision.

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