**Reducing the standard serving size of alcoholic beverages prompts reductions in alcohol consumption**

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**Abstract**

**Aims:** We tested whether reducing the standard serving size of alcoholic beverages would reduce voluntary alcohol consumption in a laboratory (study 1) and a real-world drinking environment (study 2). Additionally, we modelled the potential public health benefit of reducing the standard serving size of on-trade alcoholic beverages in the UK.

**Design:** Studies 1 and 2 were cluster-randomised experiments. In study 1, **participants were randomly assigned to receive standard or reduced serving sizes (by 25%) of alcohol during a laboratory drinking session. In study 2, customers at a bar** were served alcohol in either standard or reduced serving sizes (by 28.6% – 33.3%). **Finally, we used the Sheffield Alcohol Policy Model to estimate the number of deaths and hospital admissions that would be averted per year in the UK if a policy that reduces alcohol serving sizes in the on-trade was introduced.**

**Setting: A semi-naturalistic laboratory** (study 1), a bar in Liverpool, UK (study 2).

**Participants:** Students and university staff members (study 1: *N* = 114, mean age 24.8 years, 74.6% female), residents from local community (study 2: *N* = 164, mean age 34.9 years, 57.3% female).

**Measurements:** Outcome measures were units of alcohol consumedwithin one hour (study 1) and up to three hours (study 2). Serving size condition was the primary predictor.

**Findings:** In study 1, a 25% reduction in alcohol serving size led to a 20.7% - 22.3% reduction in alcohol consumption. In study 2, a 28.6% - 33.3% reduction in alcohol serving size led to a 32.4% - 39.6% reduction in alcohol consumption. Modelling results indicated that decreasing the serving size of on-trade alcoholic beverages **by 25%** could reduce the number of alcohol-related hospital admissions and deaths per year in the UK by 4.4% - 10.5% and 5.6% - 13.2%, respectively.

**Conclusions:** Reducing the serving size of alcoholic beverages leads to a reduction in alcohol consumption within a single drinking occasion. **Reducing the standard serving sizes of alcoholic beverages may reduce alcohol consumption and alcohol-related harm at the population level.**

**Key words:** Alcohol consumption, Alcohol policy, Drinking environment, Nudge, Serving size

Alcohol consumption contributes to premature death and ill health (1), and alcohol-related harm places a substantial burden on society (2). Approximately 25% of alcohol consumers in England drink at higher risk levels, and 20% of high risk drinkers attempt to reduce their alcohol consumption (3). However, attempts to cut down often do not lead to actual reductions in alcohol consumption (4,5). Therefore, changes to the environment that make it easier for people to drink less could have a substantial impact on public health (6,7).

One potential environmental influence on alcohol consumption that is yet to be examined is serving size. Nutrition research consistently shows that portion sizes affect how much a person eats (8,9). People eat more if they are given a relatively large portion of food compared to smaller portions, but they do not compensate for this by eating less afterwards (10). Similarly, people drink more if they are served a large non-alcoholic beverage with their meal compared to a smaller serving of that beverage (11,12).

There is a small amount of evidence indicating that the way that alcohol is served may affect drinking behaviour. A field study showed that the size of glass that people drink from may affect wine consumption (13), although this finding was not fully replicated at another venue (14). However, the effect that alcoholic beverage serving size has on alcohol consumption has not been examined. Given that serving size has a robust effect on food intake and consumers do not appear to later compensate for changes in food serving size, we hypothesised that the serving size of alcohol beverages may have a causal effect on voluntary alcohol consumption. If alcoholic beverage serving size does have a causal influence on alcohol consumption, then reductions to standard serving sizes could be an effective way of decreasing population-level alcohol consumption and harm.

We aimed to investigate if reducing the serving size of alcoholic beverages would reduce alcohol consumption. In study 1, participants consumed alcohol from standard vs. reduced serving sizes in a laboratory setting. The aims were to (1) compare total alcohol consumption from reduced servings and standard servings and (2) test whether there were any differences in the perceived ‘normality’ of the provided serving size between conditions. In study 2, participants consumed alcohol from standard vs. reduced serving sizes in a local bar and subsequently reported any alcohol consumption that occurred after the study finished in order to examine whether participants compensated for the reduced serving sizes in later drinking occasions. The aims were to (1) compare total alcohol consumption from reduced servings with standard servings and (2) test whether there were any group differences in self-reported alcohol consumption after the intervention period. We then used the findings from studies 1 and 2 to inform modelling of the effect of reductions in the serving size of on-trade alcoholic beverages on alcohol-related harm using the Sheffield Alcohol Policy Model (15). The aim was to estimate reductions in alcohol-attributable deaths and hospital admissions as a result of serving size reductions.

**Study 1**

**Methods**

**Design**

Pairs of participants attended a laboratory session and both members of the pairs were randomized to receive alcoholic beverages in standard vs. reduced serving sizes. Ad-libitum alcohol consumption was measured over the course of one hour. We used cluster-randomization to ensure that participants were blind to the experimental manipulation. We aimed to recruit a minimum of 50 participants per condition to have sufficient power to detect a medium to large effect size (d = 0.57) in a two-tailed t-test (α = 0.05) at 80% power, based on the effect sizes reported by Zlatevska et al. (8). We did not formally account for potential clustering in our sample size calculation, but we recruited slightly over the required minimum to increase power.

**Participants**

One-hundred and fourteen participants were recruited in pairs (57 pairs) from students and staff of the University of Liverpool. Participant pairs knew each other and were eligible if they were 18 years or older, regularly consumed alcohol (at least 10 UK units per week; 1 UK unit = 8g of ethanol), and had a breath alcohol content (BAC) of zero upon arrival in the lab. Pairs were not constrained with regard to their gender composition. However, after testing 102 participants, there appeared to be a gender imbalance across conditions. We then stratified randomization by the pairs’ gender composition for the remaining participants to attenuate the gender imbalance. The study received ethical approval from the University of Liverpool ethics committee. Testing took place between July 2015 and March 2016.

**Serving size**

Pairs of participants were randomly assigned to a standard serving size condition or a reduced serving size condition (between-subjects). Participants had access to three types of alcoholic beverage: Magners cider (4.5% ABV), Sol lager (4.5% ABV), and Isla Negra Sauvignon Blanc white wine (12.5% ABV). The beverages in the standard serving size condition contained 2.07 units per serving, which is equivalent to a typical UK serving of beer or wine. Beverages in the reduced serving size condition contained 1.55 units (a 25% reduction). See Table 1 for volume served and glassware capacity for the different drink types. The glasses used in the two conditions were of the same shape and width (Figure 1), which resulted in glasses looking comparably full in both conditions.

[INSERT FIGURE 1 HERE]

[INSERT TABLE 1 HERE]

**Procedure and Measures**

The experiment took place on weekdays between 12:00 and 17:30 in a semi-naturalistic laboratory designed to mimic a home environment that included a sofa, soft furnishings and a television. Participants were told that they were taking part in a study examining how social drinking affects opinions. After providing informed consent, participants’ BAC and body weight were measured. Pairs of participants were randomly allocated to the serving size condition. The researcher was not blind to allocation. Participants were asked to order one alcoholic beverage at the start of the study and consume at least some of it. After this, they could order more beverages at any time during the study by pressing a serving button to notify the experimenter. To prevent adverse events, the experimenter monitored participants’ alcohol consumption via webcam to make sure that participants consumed no more than 0.8g of alcohol per kg of body weight. After participants ordered their first beverage, to corroborate the cover story they completed an attitudes questionnaire on religion and human rights. The experimenter then started a one-hour TV programme on religion and human rights (16). Thirty minutes into the programme, the experimenter returned with another attitudes questionnaire and asked whether participants would like another beverage. After one hour, the experimenter returned with a final attitudes questionnaire. Participants then completed a questionnaire battery with 1) an open-ended question to assess what participants thought the aims of the study were; 2) two 5-point Likert items to investigate whether participants considered their own alcohol consumption during the study and the provided serving size to be ‘normal’ (anchors ‘strongly disagree’ and ‘strongly agree’); 3) the Restrict subscale of the Temptation and Restraint Inventory (TRI; (17)) as a measure of motivation to reduce drinking; 4) the Alcohol Use Disorders Identification Test (AUDIT; (18)) as a measure of hazardous drinking; and 5) a single item to assess weekly alcohol consumption in UK units. Finally, participants were thanked and debriefed. Each session lasted approximately 1.5 hours and participants received £10 shopping vouchers or course credit as reimbursement for their time. All participants completed the study.

**Data analysis**

We calculated how much beer, cider and wine participants consumed by subtracting the volume of any leftover beverage from the amount of beverages that were ordered. The total alcohol consumption in UK units was calculated by multiplying the volume consumed of each beverage type (in litres) with the beverages’ ABV. Alcohol consumption was normally distributed. We used multilevel regression modelling to evaluate the amount of alcohol consumed across conditions, whilst controlling for data clustering within participant pairs. To investigate whether the effect of serving size on alcohol consumption was robust, we also controlled for gender (between-subjects factor), AUDIT scores, and TRI Restrict scores (covariates), because these covariates are likely to influence alcohol consumption. Finally, we used multilevel regression modelling to evaluate perceived normality of the serving size and the amount of alcohol that participants consumed across conditions. All analyses were conducted in SPSS 24 (19). Analyses not accounting for clustering are reported in the supplementary materials.

**Results**

**Alcohol consumption**

Table 2 shows participant characteristics in both serving size conditions. The results of the multilevel modelling showed a non-significant reduction in alcohol consumption attributed to the reduced serving size condition (B = -0.80 [-1.69, 0.09], SE = 0.44, t(57) = 1.80, p = 0.08). However, this reduction became significant when controlling for gender, AUDIT scores, and TRI Restrict scores (B = -1.33 [-2.46, -0.20], SE = 0.48, t(109.70) = 2.33, p = 0.02) (Table 3). Estimated means show that participants in the reduced serving size condition drank 20.7%-22.3% less alcohol than participants in the standard serving size condition (Table S3, Figure 2).

[INSERT TABLE 2 HERE]

[INSERT TABLE 3 HERE]

 [INSERT FIGURE 2 HERE]

**Perceived normality of serving size**

On average, participants considered the provided serving sizes and the amount of alcohol that they consumed to be relatively ‘normal’ (average score greater than 3 out of 5). There was a trend for participants to perceive the smaller servings as less normal (B = -0.35 [-0.77, 0.06], SE = 0.21, t(57) = 1.70, p = 0.10), but participants in both conditions perceived their own alcohol consumption during the study as comparably normal (B = -0.11 [-0.53, 0.30], SE = 0.21, t(57) = 0.54, p = 0.59). See Table 4 for estimated means.

[INSERT TABLE 4 HERE]

**Study 2**

We conducted study 2 to investigate the effect of serving size over a longer drinking period in a real-world drinking environment.

**Methods**

**Design**

Participants attended one of four quiz nights in a bar in the centre of Liverpool. We randomly allocated nights so that standard sized beverages would be served on two nights and reduced sized beverages on two nights. The unadjusted analysis in study 1 showed a medium effect size (d = 0.45, Table S1). Based on this, we needed a sample size of N = 128 to detect a medium effect (d = 0.50) in a two-tailed t-test (α = 0.05) with 80% power. To allow for drop-outs and no shows, we recruited up to the bar’s capacity (n = 50 per night, total N = 200). We used a cluster-randomized design to ensure that participants were blind to the experimental manipulation. We measured how much alcohol participants consumed during the quiz (up to 3 hours) and participants later self-reported any further alcohol consumption during the same evening. This permitted us to examine whether any reduction in alcohol consumption was subsequently compensated for.

**Participants**

 One hundred and sixty-six participants attended one of the quiz nights. Participants were recruited in teams of two to five participants from the Liverpool area (e.g. on local social media pages, local radio, mailing lists from local organisations). Participants were eligible to take part if they were 18 years or older. The study received ethical approval from the University of Liverpool ethics committee. Testing took place in April and May 2017.

**Serving size manipulation**

Quiz nights were assigned to a standard serving size condition or a reduced serving size condition in a counterbalanced order. Four types of beer/cider (average 4.85% ABV) and three types of wine (average 12% ABV) were available to purchase each night. On nights allocated to the standard serving size condition, beer and cider were served in non-branded pint glasses (568ml; 2.75 UK units/serving) and wine was served in 175ml servings in medium wine glasses (2.19 UK units/serving). On nights allocated to the reduced serving size condition, beer and cider were served in non-branded 2/3 pint glasses (379ml; 1.84 UK units/serving) and wine in 125ml servings in small wine glasses (1.50 UK units/serving). Participants could also order a variety of soft drinks, which were served in the same type of glass as beer and cider. The cost of each beverage was proportional to serving size and displayed near the bar.

**Observing alcohol consumption**

Researchers covertly recorded individual participants’ alcohol consumption during the quiz. Additionally, one member of staff serving at the bar and one researcher recorded the total number of beverages that were sold on each night and the amount of wastage. All observers were aware of the study hypotheses. See supplementary materials for a detailed description of observation methods.

**Procedure**

The study and analysis protocol was registered at <http://osf.io/2tmu6> prior to data collection. Testing took place in the function room of a local bar, on Tuesday and Wednesday evenings between 19:30 and 22:30. To obscure the real aims of the study, participants were informed that they would be taking part in a study investigating how personality characteristics affected group performance in a quiz. Upon arrival, participants gave verbal consent, provided their age and gender, and completed a short bogus personality questionnaire. Participants were asked to only purchase beverages from the private bar in the function room and not from the bar’s main area.[[1]](#footnote-2) The quiz lasted approximately 1 hour and 40 minutes (see supplementary materials). Participants could arrive up to 30 minutes prior to the quiz and were asked to leave 45 minutes after the quiz ended (a minimum of 1 hour and 40 minutes and a maximum of 3 hours to order and consume beverages).

The following day, participants completed an online questionnaire that included the AUDIT-c (20) as a measure of typical alcohol consumption. Participants also reported the brand/type and serving size of any alcoholic beverages they consumed before, during, and after the quiz. We used the brand and serving size information to calculate the number of UK units in each beverage. If participants were not able to remember the exact brand they consumed, we calculated the number of UK units based on the average ABV for each beverage type (21). To corroborate the cover story, these measures were embedded in questionnaires about participants’ contribution to their quiz team. Responses to the follow-up questionnaire that were submitted more than seven days after the quiz were excluded from analysis due to concerns about reduced recall accuracy (22). All participants were debriefed and informed about the real aims of the study seven days after the final quiz night took place.

**Data analysis**

*Observed alcohol consumption during the quiz*

We used multilevel regression modelling to evaluate the amount of alcohol consumed across conditions, whilst controlling for data clustering within teams and quiz nights. In an adjusted analysis, we also controlled for gender (between-subjects factor), AUDIT-c scores, and self-reported alcohol consumption prior to the quiz (covariates). Because observed alcohol consumption was not normally distributed, we created 1000 bootstrap samples to estimate bias-corrected and accelerated 95% confidence intervals for the model parameters (BCa 95% CIs). Analyses not accounting for clustering are reported in the supplementary materials.

*Self-reported alcohol consumption after the quiz*

To examine whether participants would compensate for the reduced servings by consuming more alcohol after the study, we analysed the effect of serving size condition on self-reported alcohol consumption after the quiz using a Bayesian t-test for independent samples. We also analysed the effect of serving size condition on self-reported alcohol consumption after the quiz, whilst controlling for gender, AUDIT-c scores, and self-reported alcohol consumption prior to the quiz using a Bayesian ANCOVA. We used Bayesian analysis because we hypothesized that the serving size manipulation would not significantly affect consumption after the study (23). Bayesian analyses were conducted in JASP 0.8.1.1 (24). All other analyses were conducted in SPSS 24 (19).

**Results**

**Participant characteristics**

As per study protocol, two participants were excluded from all analyses because they guessed that their alcohol consumption was being observed during the study. The final sample consisted of 164 participants (see Table 5). One participant did not complete the questionnaire during the study. Sixteen participants did not complete the follow-up questionnaire. These participants were excluded where applicable using listwise exclusion.

[INSERT TABLE 5 HERE]

**Observed alcohol sales**

The bar sold on average 28.07% less alcohol on nights with reduced servings (Mean = 77.9 UK units, SD = 14.3) than on nights with standard servings (Mean = 108.3 UK units, SD = 6.1; means weighted for number of attendees).

**Observed alcohol consumption**

The results of the multilevel modelling showed a significant reduction in alcohol consumption attributed to the reduced serving size condition (B = -1.14 [-1.68, -0.60], SE = 0.28, p = 0.001). However, this reduction (B = -0.73 [-1.78, 0.27], SE = 0.52, p = 0.14) became non-significant when controlling for gender, AUDIT-c scores, and self-reported alcohol consumption prior to the quiz (Table 6). Inspection of the estimated means shows that participants in the reduced serving size condition drank 32.4%-39.6% less alcohol than participants in the standard serving size condition (Table S4, Figure 2).

[INSERT TABLE 6 HERE]

**Self-reported alcohol consumption after the study**

The Bayesian analysis was inconclusive in an unadjusted analysis (BF10 = 0.36). However, after controlling for gender, AUDIT-c scores, and self-reported consumption before the study, there was sufficient evidence that serving size condition did not affect self-reported alcohol consumption after the study (BF10 = 0.29). See Table 7 for (un)adjusted means.

[INSERT TABLE 7 HERE]

**Policy model**

We used the Sheffield Alcohol Policy Model (SAPM) version 3.1 (15) to estimate the potential effect of systematic reductions in the serving size of all beverages served in the on-trade on alcohol-related harm. As the effect size in study 2 was substantially larger than in study 1, we based the policy model on the more conservative effect size from study 1.

SAPM is a deterministic mathematical simulation model that models how alcohol policies such as pricing and taxation changes (25) affect alcohol consumption and the resulting changes in alcohol-attributable mortality and morbidity. The model methodology is extensively described elsewhere (15,26). SAPM uses alcohol consumption data from the 2014 Health Survey for England (HSE) to represent baseline consumption in the model. These data are combined with alcohol purchasing data from the 2010-14 Living Costs and Food Surveys to estimate the proportion of each HSE respondent’s consumption which falls into 10 categories: on- and off-trade beer, cider, wine, spirits and Ready-to-Drinks (RTDs) (pre-mixed beverages often referred to as ‘alcopops’) – see (27) for full details of this apportionment process. Based on the results of study 1 we estimated that a 25% reduction in serving size could lead to an approximate reduction in alcohol consumption of 20.7%. We modelled the effect of this reduction in on-trade alcohol consumption, as well as a more conservative estimate (a 10.3% decrease – half the effect size in study 1), to account for the possibility that the population effect size is substantially smaller. See supplementary materials for full details. For each scenario we modelled the long-term (20-year (27)) impact on alcohol-attributable deaths and hospital admissions from 43 different alcohol-related health conditions and compared these to a counterfactual scenario where alcohol consumption remained unchanged. The modelled scenarios resulted in an estimated 5.6% - 13.2% reduction in deaths per year and an estimated 4.4% - 10.5% reduction in hospital admissions per year compared to the baseline scenario (see Table 8).

[INSERT TABLE 8 HERE]

**General Discussion**

We investigated the effect of alcoholic beverage serving size on alcohol consumption. In study 1, we demonstrated that reduced serving sizes led to a 20.7% - 22.3% decrease in alcohol consumption in the laboratory over a one hour drinking period. In study 2, we showed that reduced serving sizes led to a 32.4% - 39.6% decrease alcohol consumption in a real-world drinking environment over a longer drinking period (up to three hours). Additional sensitivity analyses indicated a reduction of 17.4% - 31.9% attributed to the reduced serving size. People did not compensate for the serving size reductions by consuming more alcohol after the study. These findings support our hypothesis that serving size has a causal effect on alcohol consumption.

The exact magnitude of the reduction in alcohol consumption was dependent on the analysis used. The analysis adjusting for clustering of alcohol consumption within participant pairs/teams showed a 20.7% and 39.6% reduction in alcohol consumption in study 1 and study 2, respectively. Because clustering occurred in both studies, we believe this to be the best approximation of the effect of serving size on alcohol consumption in the present studies.

Whilst the reduction in serving size led to a reduction in alcohol consumption in both studies, the reduction in alcohol consumption was somewhat larger in study 2 (where standard serving sizes of 2.8 units for beer/cider and 2.2 units for wine were reduced by 28.7% - 33.3%) than in study 1 (where standard serving sizes of 2.1 units were reduced by 25%). One explanation is that greater serving size reductions will prompt greater reductions in alcohol consumption. However, given the differences between the two study designs, other factors may partially explain this difference. A further difference between the two studies is that in study 1 participants were required to consume at least some alcohol and only had access to alcoholic beverages, whereas participants in study 2 were able to consume non-alcoholic beverages and were not required to drink any alcohol at all.

These studies are the first to demonstrate that reducing the serving size of alcoholic beverages prompts reductions in alcohol consumption. This is consistent with research demonstrating that food portion size has a causal effect on energy intake (28) and consumers do not compensate for the effect that portion size has on total energy intake (10,29). In the present studies we examined alcohol consumption over relatively short periods. However, in study 2 we found that reduced serving sizes led to decreased alcohol consumption over 3 hours; a length of time that is comparable to most drinking occasions in the UK population (30). In study 2 we also found no evidence that participants consumed more alcohol during the remainder of the night if they had been earlier provided with reduced serving size alcoholic beverages. It would now be informative for future research to investigate the long-term effect of reducing the standard serving sizes of alcoholic beverages on alcohol consumption.

 As the aim of the present research was to examine the causal influence of serving size on alcohol consumption, we did not make participants explicitly aware of the serving size reductions made. Instead, we used cover stories in both experiments, limiting the likelihood that our findings can be explained by demand characteristics (31). We cannot completely rule out demand characteristics in either study, because participants in the reduced serving size conditions may have been conscious of the fact that they were receiving a smaller than usual serving of alcohol. If serving size reductions to on-trade alcoholic beverages were to be implemented as a policy, this would require transparency. It is possible that unfavourable opinions towards systematic alcohol serving size reductions would lead to psychological reactance to the policy (32), limiting its effectiveness. It would therefore be informative to examine public acceptability of serving size reductions to alcoholic beverages and whether awareness of serving size reductions affects their influence on alcohol consumption.

 Our methodology had some limitations. First, observers in study 2 were aware of the study aims. This could have influenced the way they coded alcohol consumption. However, in line with recommendations (33), the observers were well-trained and each participant was observed by two independent observers. Second, glass size varied between serving size conditions to ensure that glasses appeared similarly full. People may consume more alcohol from larger glasses (14,34). Therefore, future work may benefit from controlling for glass size when examining the effect of serving size. Third, participants in study 1 were primarily university students and despite recruiting from the local community for study 2, the sample may not be representative of the UK population. Future research should investigate the effect of serving size reduction in more diverse populations and examine whether the effect is moderated by demographic characteristics.

The typical serving size of beer in the UK (568ml) is larger than serving sizes used in many other countries (35) and the size of on-trade wine servings in the UK has increased over recent decades (36). It is therefore feasible that existing serving size legislation (37) could be adapted to introduce a cap on available serving sizes and accommodate the sales of smaller servings. We used the Sheffield Alcohol Policy Model to estimate the potential public health benefit of reducing the default serving sizes of alcoholic beverages in the on trade. Our most conservative estimates suggest that serving size reductions might reduce alcohol-related deaths and hospital admissions to a similar extent as a £0.50 minimum unit price (15). However, it is important to acknowledge that these estimates are subject to limitations of our studies outlined above. Additionally, whilst the aggregate effects of serving size reductions and minimum unit pricing may be similar, the cheap alcohol that would be affected by minimum unit pricing is consumed by different demographics than the on-trade alcohol that would be affected by serving size reductions. Therefore, the distribution of effects would likely be very different for both policies. Nevertheless, our findings highlight alcoholic beverage serving size as a potential target for public health interventions.

 To conclude, this research is the first to demonstrate that the serving size of alcoholic beverages affects alcohol consumption. Reducing the standard serving sizes of alcoholic beverages may be an effective way to reduce alcohol consumption at the population level.

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| **Table 1.** Study 1 and 2. Volume served and glassware capacity in the standard and reduced serving size condition. |
| Study | Drink type | Serving size condition | Volume served (ml) | Glass capacity (ml) |
| Study 1 | Wine | Standard | 165 | 310 |
| Reduced | 125 | 250 |
| Beer/cider | Standard | 460 | 530 |
| Reduced | 345 | 370 |
| Study 2 | Wine | Standard | 175 | 245 |
| Reduced | 125 | 195 |
| Beer/cider | Standard | 568 | 568 |
| Reduced | 379 | 379 |

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| **Table 2.** Study 1. Participant characteristics by serving size condition. |
|  |  | Serving size condition |
|  | Total (*N* = 114) | Reduced (*n* = 60) | Standard (*n* = 54) |
| Age; Mean (SD) | 24.82 (10.48) | 23.28 (8.61) | 26.52 (12.08) |
| Gender; n male/female | 29/85 | 11/49 | 18/36 |
| AUDIT; Mean (SD) | 13.96 (6.06) | 14.30 (6.52) | 13.57 (5.54) |
| TRI Restrict; Mean (SD) | 9.70 (5.40) | 9.55 (5.26) | 9.87 (5.58) |
| UK Units per week; Mean (SD) | 17.72 (12.27) | 19.27 (12.99) | 16.01 (11.29) |
| *Note:*AUDIT = Alcohol Use Disorders Identification Test. AUDIT scores range between 0 and 40. TRI =Temptation and Restraint Inventory. TRI Restrict scores range between 3 and 21.  |

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| **Table 3.** Study 1. Unadjusted and adjusted multilevel regression model with serving size predicting observed alcohol consumption (UK units). Participants are clustered in pairs (level 2). |
|  |  | Unadjusted (*N =* 114) | Adjusted (*N =* 114) |
|  |  | B (SE) | [95% CI] | p | B (SE) | [95% CI] | p |
| Fixed components |
|  | Intercept | 3.87 (0.32) | [3.23, 4.52] | < 0.001 | 3.99 (0.48)  | [3.04, 4.95] | < 0.001 |
|  | Serving size condition (reference: Standard) | -0.80 (0.44)  | [-1.69, 0.09] | 0.08 | -1.33 (0.57)  | [-2.46, -0.20] | 0.02 |
|  | Gender (reference: Male) |  |  |  | -1.31 (0.37)  | [-2.04, -0.58] | 0.001 |
|  | Serving size x Gender  |  |  |  | 0.82 (0.55)  | [-0.28, 1.92] | 0.14 |
|  | AUDIT |  |  |  | 0.07 (0.02)  | [0.02, 0.11] | 0.003 |
|  | TRI Restrict |  |  |  | -0.02 (0.02)  | [-0.06, 0.03] | 0.47 |
| Random components |
|  | Level 2 variance (Pairs) | 2.48 (0.53) |  |  | 1.84 (0.41) |  |  |
|  | Level 1 variance (Participants) | 0.63 (0.12) |  |  | 0.57 (0.11) |  |  |
| Note: AUDIT = Alcohol Use Disorders Identification Test. AUDIT scores range between 0 and 40. TRI = Temptation and Restraint Inventory. TRI Restrict scores range between 3 and 21. |

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| **Table 4.** Study 1. Perceived normality of the amount of alcohol participants personally consumed during the study and the serving size provided in the standard and reduced serving size conditions. Means are estimated from multilevel regression model accounting for data clustering within participant pairs. |
|  | Serving size condition |
|  | Reduced (*n* = 60) | Standard (*n* = 54) |  |
|  | Mean (SE) | [95% CI] | Mean (SE) | [95% CI] | d |
| Normality of amount consumed during study | 3.80 (0.15) | [3.50, 4.10] | 3.68 (0.14) | [3.40, 3.97] | 0.11 |
| Normality of serving size | 3.70 (0.15) | [3.40, 4.01] | 3.35 (0.14) | [3.06, 3.64] | 0.32 |
| *Note:* Perceived normality was measured on a 5-point Likert scale, with greater scores indicating greater perceived normality.  |

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| **Table 5.** Study 2.Participant characteristics by serving size condition. |
|  |  | Serving size condition |
|  | Total (*N* = 164) | Reduced (*n* = 87) | Standard (*n* = 77) |
| Gendera; n male/female | 69/94 | 36/50 | 33/44 |
| Number of individual teams | 38 | 19 | 19 |
| Team size; Mean (SD) | 4.37 (0.98) | 4.63 (0.74) | 4.11 (1.12) |
| Agea; Mean (SD) | 34.89 (12.45) | 34.57 (11.58) | 35.25 (13.42) |
| AUDIT-c b; Mean (SD) | 4.43 (1.82) | 4.26 (1.84) | 4.64 (1.79) |
| Self-reported consumption before study (UK units)b; Mean (SD) | 1.75 (2.11) | 2.04 (2.22) | 1.36 (1.91) |
| Attrition; % lost to follow-up | 9.76% | 3.45% | 16.88% |
| *Note:* AUDIT = Alcohol Use Disorders Identification Test. AUDIT-c scores range between 0 and 12. a One participant did not complete the demographics questionnaire. Statistics for these variables are based on total *N* = 163 (Reduced *n* = 86, Standard *n* = 77). b AUDIT-c and self-reported consumption before the study were measured in the follow-up questionnaire. Means and SDs for these variables are based on total N = 148 (Reduced *n* = 84, Standard *n* = 64).  |

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| **Table 6.** Study 2. Unadjusted and adjusted multilevel regression model with serving size predicting observed alcohol consumption (UK units). Participants are clustered in teams (level 2) and quiz nights (level 3).  |
|  |  | Unadjusted (*N* = 164) | Adjusted (*n* = 148) |
|  |  | B (SE)  | [BCa 95% CI] | p | B (SE)  | [BCa 95% CI] | p |
| Fixed components |
|  | Intercept | 2.88 (0.23)  | [2.41, 3.36] | 0.001 | 1.59 (0.53)  | [0.43, 3.07] | 0.004 |
|  | Serving size condition (reference: Standard) | -1.14 (0.28)  | [-1.68, -0.60] | 0.001 | -0.73 (0.52)  | [-1.78, 0.27] | 0.14 |
|  | Gender (reference: Male) |  |  |  | -0.54 (0.57)  | [-1.59, 0.42] | 0.35 |
|  | Serving size x Gender |  |  |  | -0.31 (0.69)  | [-1.68, 1.05] | 0.66 |
|  | AUDIT-c |  |  |  | 0.30 (0.08)  | [0.14, 0.44] | 0.001 |
|  | Consumption before quiz |  |  |  | 0.03 (0.10)  | [-0.12, 0.17] | 0.73 |
| Random components  |
|  | Level 3\*2 variance (quiz night \* teams) | 1.38 (0.37) |  |  | 1.17 (0.37) |  |  |
|  | Level 1 variance (participants) | 2.84 (0.35) |  |  | 2.23 (0.28) |  |  |
| *Note:* AUDIT = Alcohol Use Disorders Identification Test. AUDIT-c scores range between 0 and 12.  |

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| **Table 7.** Study 2. Unadjusted and adjusted mean self-reported alcohol consumption (UK units) after the quiz in the standard and reduced serving size condition.  |
|  | Unadjusted  | Adjusteda |
| Serving size condition | Mean (SD) | [95% CI] | BF10 | Mean (SE) | [95% CI] | BF10 |
| Standard (*n* = 64) | 1.36 (2.58)  | [0.71, 2.00] | 0.36 | 1.36 (0.24) | [0.88, 1.84] | 0.29 |
| Reduced (*n* = 84) | 0.92 (1.74)  | [0.54, 1.30] |  | 1.02 (0.21) | [0.60, 1.44] |  |
| Note: a Means adjusted for gender, AUDIT-c scores and self-reported alcohol consumption before the quiz.  |

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| **Table 8.** Policy model. Annual effects of a 25% reduction in the serving size of alcohol sold in the on-trade on alcohol-related deaths and hospital admissions, compared to a ‘no policy’ baseline model, 20 years after policy implementation. |
| Policy scenario | Deaths per year | Hospital admissions per year |
|  | Absolute | Relative | Absolute | Relative |
| Baseline | 12,284 |  | 833,722 |  |
| 1) 20.7% reduction in all on-trade alcohol consumption | -1,616 | -13.16% | -87,853 | -10.54% |
| 2) 20.7% reduction on on-trade beer, cider and wine consumption only  | -1,360 | -11.07% | -73,244 | -8.79% |
| 3) 10.3% reduction in all on-trade alcohol consumption | -819 | -6.67% | -44,021 | -5.28% |
| 4) 10.3% reduction in on-trade beer, cider and wine consumption only  | -687 | -5.59% | -36,650 | -4.40% |

 

Reduced

A.

Standard

Reduced

Standard

B.

*Figure 1.* Study 1. Glassware used to serve wine (A.) and beer/cider (B.) in the standard and reduced serving conditions.



*Figure 2.* Study 1 and 2. Mean alcohol consumption (UK units) in the standard and reduced serving size condition in a laboratory setting (study 1) and a real-world setting (local bar, study 2). Bars represent raw means. Error bars indicate SEM.

1. The main bar served different beverage types than the private bar for the experiment, and beverages from the main bar were not included in the serving size manipulation. Unexpectedly, eighteen participants (all in the reduced serving size condition) purchased beverages from the main bar in the pub during the pub quiz (which was not subject to the serving size manipulation). Beverages purchased from the main bar were not included in the observed alcohol consumption score used in the primary analyses (per pre-registration protocol). We conducted two exploratory sensitivity analyses to investigate how this affected our main results. The results followed the same pattern as the primary analyses (see supplementary materials). Unadjusted analyses showed that participants consumed 23.2% - 31.9% less alcohol in the reduced serving size vs. standard size condition. Adjusted analyses controlling for gender, AUDIT-c scores and self-reported alcohol consumption prior to the quiz were not significant. [↑](#footnote-ref-2)