Alcohol and Alcoholism, 2018, 53(3) 245–250
doi: 10.1093/alcalc/agx118
Advance Access Publication Date: 10 January 2018
Article

OXFORD

Article

Judgement of Breath Alcohol Concentration Levels Among Pedestrians in the Night-Time Economy—A Street-Intercept Field Study

M. P. Cameron[1,2,*], M. J. Roskruge[3], N. Droste[4], and P. G. Miller[4]

[1]Department of Economics, University of Waikato, Private Bag 3105, Hamilton 3240, New Zealand, [2]National Institute of Demographic and Economic Analysis, University of Waikato, Private Bag 3105, Hamilton 3240, New Zealand, [3]School of Economics and Finance, Massey University, Private Bag 102904, Auckland 0745, New Zealand, and [4]School of Psychology, Faculty of Health, Deakin University Geelong, Locked Bag 20001, Geelong, Victoria 3220, Australia

*Corresponding author: Department of Economics, University of Waikato, Private Bag 3105, Hamilton 3240, New Zealand. Tel: +64-7-838-5082; E-mail: mcam@waikato.ac.nz

Received 4 July 2017; Revised 13 December 2017; Editorial Decision 14 December 2017; Accepted 16 December 2017

Abstract

Aims: To evaluate how well people in the night-time economy can assess their own breath alcohol concentration (BrAC), in the context of a change in breath alcohol limits for driving.

Methods: We conducted a field study of 242 participants over 5 nights in the central business district of a university town in New Zealand. Participants completed a short survey, which included questions on their self-reported level of intoxication and the self-estimated BrAC. At the conclusion of the interview each participant was breath-tested. We compared actual and self-estimated BrAC using a scatter plot and multiple regression methods.

Results: The average BrAC error was 61.7 μg/l, meaning that on average participants overestimate their BrAC. Participants with a BrAC below 487 μg/l tended to overestimate their BrAC on average, and those with a BrAC above 487 μg/l tended to underestimate their BrAC on average. Regression results supported this observation, but also found that men who are not 'out on a typical night' overestimate their BrAC by more.

Conclusions: Drinkers in this naturalistic setting have little idea of their level of intoxication, as measured by BrAC. However, this uncertainty may be advantageous to public health outcomes, since if drinkers are uncertain about their level of intoxication relative to the legal limit, this may lead them to avoid drunk driving.

Short Summary: A field study of drinkers in the night-time economy of a New Zealand university town was conducted to evaluate how well drinkers can assess their breath alcohol concentration (BrAC). Drinkers in this setting inaccurately estimate their intoxication, and those with higher BrAC tended to underestimate their BrAC on average.

INTRODUCTION

Despite decades of health promotion activities, heavy intoxication and drunk driving remain significant sources of health and economic burden (World Health Organization, 2013). Almost all countries have laws against drunk driving (notable exceptions include Kenya and several other countries in Africa). Drunk driving laws are based on an objective standard for blood alcohol concentration (BAC) or breath alcohol concentration (BrAC), against which a sample (of blood or breath, respectively) is measured. Guidelines are typically provided for drinkers, which provide some indication of how many 'standard drinks' can be safely consumed over some time period while avoiding exceeding the legal limit for driving. For example, Hospitality New Zealand note that the 'rule of thumb for men is three standard drinks over 2 h (3 over 2), and for women two standard drinks over 2 h (2 over 2)' (http://www.hospitalitynz.org.nz/industry/know-your-limit.html).

Impairment of driving ability begins at very low levels of intoxication (Moskowitz and Burns, 1990; Mann, 2002), but precisely how the consumption of alcohol translates into BAC or BrAC is complex, and depends on a variety of event- and individual-specific factors such as whether food has been consumed (Ramchandani *et al.*, 2001), drinking history (Lewis *et al.*, 1995), and body water content, which is in turn affected by factors such as gender (Baraona *et al.*, 2001), age (Bielefeld *et al.*, 2015), height and body weight (Irwin *et al.* 2014). Moreover, there is likely to be significant within-subject variability in both peak BrAC and the time to reach this peak (Fraser *et al.*, 1995). This creates substantial uncertainty for drinkers in terms of estimating their own BAC or BrAC levels, and in terms of a dichotomous decision about whether they are legally allowed to drive (Williams, 1991). This uncertainty is exacerbated because self-perceived alcohol impairment (e.g. in terms of ability to drive) is imperfectly related to BAC or BrAC (Beirness, 1987; Wicki *et al.*, 2000), and because the accuracy of BAC or BrAC estimates tends to decrease as alcohol consumption and intoxication level increase (Bullers and Ennis, 2006).

Drinkers use a combination of internal cues (e.g. physical and emotional states) and external cues (e.g. number of drinks consumed) to estimate their level of intoxication (Williams and Burroughs, 1995), and the importance of cues depends on situation (Williams and Burroughs, 1994). External cues may be hampered by poor recall, especially while intoxicated (Hustad and Carey, 2005), and internal cues may be affected by whether the drinker is on the ascending or descending arm of the alcohol exposure curve (Addicott *et al.*, 2007). Moreover, drinkers can easily be misled by their past experiences of intoxication associated with pre-drinking or drinking in bars, and expect their level of intoxication to be high as a result (Laberg, 1986; Williams, 1991). Despite this, people are often more accurate in estimating their level of impairment than in estimating their BAC level (Nicholson *et al.*, 1994; Lewis *et al.*, 1995).

Several studies investigate discrepancies between actual BAC and BAC modelled using self-reported or observed consumption data (Hustad and Carey, 2005; Clapp *et al.*, 2006, 2009). Fewer studies consider discrepancies between actual and self-estimated BAC. In a recent review, Aston and Liguori (2013) summarized the literature on self-estimation of BAC. They noted that experimental (laboratory) studies have demonstrated that people have difficulty in estimating their own BAC or BrAC level (Shapiro *et al.*, 1980; Martin *et al.*, 1991). More recent studies have shown similar results (Corazzini *et al.*, 2014). However, such laboratory-based studies have been criticized for low ecological validity (Fromme *et al.*, 1997), small sample sizes, and lack of a control group (Aston and Liguori, 2013). This suggests that these studies may not necessarily translate into more naturalistic settings such as the night-time economy, which Wickham (2012, p.3) defines as 'economic activity which occurs between the hours of 6 pm and 6am and involves the sale of alcohol for consumption on-trade (e.g. bars, pubs and restaurants)'.

Field studies present a more appropriate naturalistic setting for understanding whether drinkers can correctly evaluate their own BrAC or BAC levels. In an early study, Russ *et al.* (1986) evaluated the accuracy of estimated BAC for 93 college-age students in Virginia, USA. They found that BAC estimates were correlated with actual BAC levels, but that the most intoxicated students were more likely to overestimate their BAC level. Other studies have found the opposite—that the most intoxicated were more likely to underestimate their BAC (Beirness, 1987; Beirness *et al.*, 1993). Thombs *et al.* (2003) surveyed 641 college students in Ohio on return to their residence hall from a night out. They found that, below an actual BAC of 70 mg/dl participants tended to overestimate their BAC, between 70 and 90 mg/dl estimates were fairly accurate, and above 100 mg/dl participants tended to underestimate. Regression analysis revealed that the relationship between actual and estimated BAC was stronger for men than for women. Grant *et al.* (2012) surveyed 225 American college students in various locations (such as exiting bars or returning to their dormitories). They also found that those with the lowest BAC levels (0.00–0.08%) slightly overestimated their BAC, while those with the highest BAC levels (0.161% and over) underestimated their BAC. Meier *et al.* (1987) found that more intoxicated college-aged people in a field setting tended to overreport their level of alcohol consumption, while Wicki *et al.* (2000) found that self-reported BrAC was consistently overreported in a group of Swiss soldiers. However, all of these studies suffer from being based on small and/or unrepresentative (e.g. college student or soldier) samples, and only Grant *et al.* (2012) considered differences by gender.

Williams (1991) examined a general sample of social drinkers with a reasonable sample size ($n = 99$) in a small southern town in the USA. They found that the least intoxicated (BAC < 0.05%) and most intoxicated (BAC > 0.10%) participants were the most accurate in assessing whether they were over the legal driving limit (0.08%). Women were found to be more accurate than men, but this may have been because their BAC levels were generally lower. However, the measure of accuracy used in that study was simply dichotomous, i.e. whether or not the participant was over the legal BAC for driving.

In this article, we report on the findings of a field study of actual and self-estimated BrAC in a university town in New Zealand, in the context of a change in the legal drink-driving limit. On 1 December 2014, New Zealand lowered the breath alcohol limit for driving from 400 to 250 μg/l. This was accompanied by a significant public information campaign (e.g. see http://www.transport.govt.nz/land/bloodalcoholqanda/). Thus, at the time of the study, BrAC would be salient to many drinkers in New Zealand. Our study provides a number of contributions to the literature beyond the simple comparison of actual and self-estimated BrAC. First, we disaggregate our analysis by gender, which Aston and Liguori (2013) note as important for improving our understanding of BrAC estimation. Second, we avoid the use of categorical levels of BrAC by using a continuous measure. Third, we reduce the selection bias that might be introduced by surveying only subgroups of the population such as students, whose drinking behaviour differs from the population more generally, by using a street-intercept survey.

METHODS

Data collection

During November–December 2014, we conducted a field study in the central business district of a university town (population 150,000) in New Zealand. Following Miller *et al.* (2013), we used a street-intercept survey approach (described below) to capture a representative sample of pedestrians active during the night-time economy. Data collection occurred between 7 pm and 2:30 am across three consecutive nights in November (Wednesday, Thursday and Friday) and 2 consecutive nights in December (Thursday and Friday). Data collection on the Wednesday evening in December was aborted due to heavy rain, and Saturday night data collection was not possible due to unavailability of research team members. The choice of dates is important, because as noted in the introduction the legal blood alcohol limit for driving was lowered from 0.08 to 0.05% on 1 December 2014.

The data were collected at a busy intersection located between two streets containing a substantial number of bars, nightclubs, eateries and restaurants, and close to taxi facilities. This intersection was selected during pre-testing and was supported by the New Zealand Police as it is an area of high foot traffic, well-monitored by police and security staff and with good lighting. While license conditions require most bars to close at 3 am, our sampling ended at 2:30 am in order to avoid the period of high congestion and elevated risk for the research team that would occur when the bars close.

Data collection was undertaken by two teams of two survey assistants, each accompanied by a senior researcher. The survey assistants administered the survey questionnaire, while senior researchers provided health and safety and coordination roles, and administered a breathalyzer test at the conclusion of each interview. Each survey team occupied a different part of the intersection, allowing for the capture of pedestrians from all directions with limited overlap. The survey team monitored foot traffic and every seventh pedestrian was offered the opportunity to participate in the survey in one of two ways: (a) by inviting them either to 'guess their breath alcohol concentration' or (b) inviting them to participate in a survey on alcohol. The former invitation was extended when the survey team member making the approach judged it likely that the potential participant had been drinking. If a potential participant declined the offer, the declined offer was noted and the count restarted. To be eligible for inclusion in the study, participants needed to be pedestrians passing through the selected intersection and aged 18 years or over. Participants who chose to take part were provided details about the survey and verbal consent was obtained. Participants were also provided with a card including contact details of the lead researcher, and a web link to further information about the study.

Measures

The structured interviews were ~2–3 min long, and collected demographic (age, gender, location of residence) data. Participants were then asked 'Would you say this is a typical night out for you', with possible responses 'Yes', 'No, I usually have bigger nights' (i.e. this night involved less drinking than a 'typical night') and 'No, I usually have smaller nights' (i.e. this night involved more drinking than a 'typical night').

Participants were also asked to self-evaluate their level of intoxication with a subjective question: 'Can you rate how intoxicated you feel right now on a scale of 0 to 10' (where 10 represented the highest level of intoxication). This was followed by the question 'The legal breath alcohol limit for drink driving will decrease (has decreased) from 400 to 250 µg of alcohol per litre of breath on the 1 December. Can you guess your breath alcohol concentration?'. Providing details of the current drunk driving limit was intended to anchor participants' estimates of their BrAC. We included both a subjective question about intoxication and self-estimated BrAC in the study, in order to test whether self-reported subjective level of intoxication was a better predictor of actual BrAC than self-estimated BrAC. Participants then had their BrAC measured by one of the senior researchers using a recently calibrated Andatech Precision+™ breathalyser (Andatech Pty Ltd., Melbourne, Australia; accuracy to ±0.005). Participants were informed that this was not a legal test, and that they should avoid driving if they had consumed any alcohol that evening. As per the breathalyser operating instructions, no breath tests were undertaken within fifteen minutes of the participant's last drink. The study methods and protocols were approved by the Waikato Management School Human Research Ethics Committee, as well as the local New Zealand Police alcohol harm reduction officer.

BrAC was measured in terms of micrograms of alcohol per litre of breath (µg/l), in line with testing practices of New Zealand Police.

Table 1. Analysis of BrAC error (dependent variable) for total sample and by gender

Variables	(Model 1) Total sample N = 242	(Model 2a) Women only N = 78	(Model 2b) Men only N = 164
Actual BrAC	−0.679 (−0.842 to −0.515)	−0.777 (−1.155 to −0.400)	−0.651 (−0.832 to −0.471)
Male dummy	24.43 (−19.70 to 68.56)		
Age	0.325 (−9.984 to 10.63)	5.901 (−14.69 to 26.50)	−3.603 (−15.96 to 8.751)
Age squared	0.009 (−0.122 to 0.140)	−0.039 (−0.294–0.216)	0.051 (−0.107 to 0.209)
Resides locally	1.376 (−51.12 to 53.87)	5.265 (−114.4 to 125.0)	−17.13 (−81.13 to 46.87)
Typical night is normally smaller	52.50 (1.513–103.5)	−17.62 (−109.7 to 74.48)	98.03 (33.13–162.9)
Typical night is normally larger	55.35 (4.200–106.5)	−20.56 (−91.27 to 50.15)	91.51 (25.56–157.5)
Self-rated intoxication	47.22 (34.72–59.73)	41.27 (17.82–64.72)	51.33 (36.04–66.62)
Adjusted R-squared	0.394	0.386	0.414

Notes: Night-specific controls not reported. Robust 95% confidence intervals in parentheses.

Non-zero measurements of <50 µg/l were assumed to be 25 µg/l, due to limitations of the breathalyser in measurement for very low BrACs. Excluding these observations makes no qualitative differences in sign or significance to our results (compare Supplementary Online Material, Tables S2 and S3, with Tables 1 and 2). The level of BrAC error was calculated by subtracting the actual measured BrAC level for each participant from their subjectively estimated BrAC. A positive value of 'BrAC error' denotes an overestimate by the participant and a negative value denotes an underestimate.

Data analysis

The data were analysed by first plotting the estimated and actual BrAC values in a scatter plot to visualize differences between estimated and actual values. The factors associated with BrAC error were then evaluated using simple and multivariate ordinary least squares (OLS) regression, with BrAC error as the dependent variable and a threshold for statistical significance of $P < 0.05$. In multivariate analyses, explanatory variables included individual-specific variables (gender, age, age squared, whether the person was a local resident), night-specific variables (day of the week, and month), and event-specific variables (actual BrAC reading, self-reported level of intoxication, and whether the participant considered this was a 'typical night out'). The inclusion of both age and age squared allows the effects of age in the analysis to be non-linear. Quantitative analyses were conducted in Stata v13.

RESULTS

In all, 337 pedestrians answered the survey, of which 247 (73.3%) had consumed alcohol on that day. A further five observations (1.5%) were lost due to incomplete data or overestimated BrAC by more than 1000 µg/l, resulting in a final sample of 242. The sample included 78 women (32.2%) and 164 men (67.8%). The average age was 27.7 years (SD = 11.2), 27.2 for women (SD = 11.7) and 27.9 for men (SD = 11.0). The average BrAC reading was 318.0 µg/l (SD = 241.2; range: 0–994), 237.7 µg/l for women (SD = 191.0; range: 0–697) and 356.2 µg/l for men (SD = 253.5; range: 0–994). This difference in BrAC reading by gender was statistically significant ($P < 0.001$). The average estimated BrAC was 379.7 µg/l (SD = 239.9; range: 0–1400), 313.2 µg/l for women (SD = 194.6; range: 0–800) and 411.3 µg/l for men (SD = 253.1; range: 0–1400). This difference in estimated BrAC by gender was statistically significant ($P = 0.003$). The average BrAC error was 61.7 µg/l (SD = 204.7; range: −834 to +560), denoting that on average participants overestimate their BrAC, by an amount equivalent to about one quarter of the new (lower) legal drink-driving limit for New Zealand (250 µg/l). For women, the average BrAC error was 75.5 µg/l (SD = 191.5; range: −452 to +483) and for men was 55.1 µg/l (SD = 210.9; range: −834 to +560). This difference was not statistically significant ($P = 0.47$).

Figure 1 charts the estimated and actual BrAC for the sample. Each dot in the scatter plot represents one observation of actual and self-estimated BrAC. The solid 45° line represents what would be a perfectly accurate estimate, with observations above this line representing overestimates and observations below this line representing underestimates. The dashed line is the linear trend line for all observations, and its upward slope suggests a positive correlation between estimated and actual BrAC (Pearson's $r = 0.64$). Those below a BrAC of 487 µg/l tend to overestimate their BrAC on average and those above 487 µg/l tend to underestimate their BrAC on average. A simple linear regression model (equivalent to the trendline in Fig. 1) confirms this (not shown). Separate simple linear regression models for men and women suggest that this 'switching point' (the point where BrAC estimates on average switch between overestimation and underestimation) occurs at a BrAC of 515 µg/l for men and 394 µg/l for women.

Table 1 shows the results of three multivariate OLS regression models. The dependent variable for each model is BrAC error. Model 1 shows the results for the full sample, while Models 2a and 2b restrict the sample to women and men, respectively. In all models, actual BrAC has a negative and statistically significant relationship with BrAC error, meaning that drinkers with higher BrAC were more likely to underestimate their actual BrAC (Model 1: $\beta = -0.679$, 95% C.I. = (−0.842, −0.515); Model 2a: $\beta = -0.777$, 95% C.I. = (−1.155, −0.400); Model 2b: $\beta = -0.651$, 95% C.I. = (−0.832, −0.471)). This result is consistent with Figure 1. The only other statistically significant variables are the self-reported level of intoxication (Model 1: $\beta = 47.22$, 95% C.I. = (34.72, 59.73)) and whether the 'typical night' is normally smaller (Model 1: $\beta = 52.50$, 95% C.I. = (1.513, 103.5)) or larger (Model 1: $\beta = 55.35$, 95% C.I. = (4.200,106.5)).

Table 2 shows the results of two multivariate OLS regression models, where we separately evaluate self-rated intoxication and estimated BrAC as predictors of actual BrAC. In these models, the control variables are the same as those in Table 1 (full regression results are shown in Supplementary Online Material, Table S1). The key variables of interest are self-estimated BrAC (in Model 3a) and self-reported level of intoxication (in Model 3b). Both self-estimated BrAC ($\beta = 0.554$, 95% C.I. = (0.452, 0.656)) and self-reported level of intoxication ($\beta = 50.03$, 95% C.I. = (39.88, 60.18)) are positively and statistically significantly associated with actual BrAC. However, comparing the adjusted R-squared values across these two models suggests that self-estimated BrAC may be a slightly better predictor of actual BrAC than self-reported level of intoxication (0.47 vs. 0.45), although this difference is not statistically significant (Vuong (1989) likelihood-ratio test, $P = 0.586$).

Table 2. Analysis of actual BrAC (dependent variable) for alternative measures of self-assessed level of intoxication

Variables	(Model 3a) $N = 242$	(Model 3b) $N = 242$
Estimated BrAC	0.554 (0.452–0.656)	
Self-rated intoxication		50.03 (39.88–60.18)
Adjusted R-squared	0.471	0.447

Notes: Control variables and constant terms not reported (more complete results are shown in Supplementary Online Material, Table S1). Robust 95% confidence intervals in parentheses.

DISCUSSION

This study builds on the important and underresearched area of the accuracy of self-assessed intoxication relative to objectively measured BrAC. Our results, based on a street-intercept survey of a sample of all pedestrians in a naturalistic setting, demonstrate that drinkers cannot accurately estimate their BrAC. On average, they tend to overestimate their BrAC, by an amount equivalent to about one quarter of the new legal drink-driving limit for New Zealand

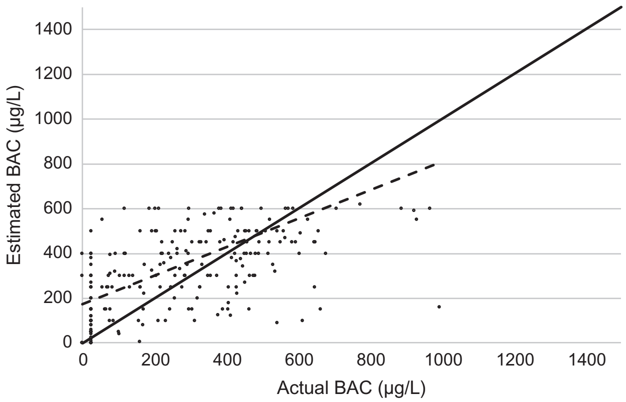

Fig. 1. Actual vs. estimated BrAC. *Notes*: Each dot represents one observation of both actual breath alcohol concentration (BrAC) and self-estimated BrAC. The solid 45° line represents what would be a perfectly accurate estimate, with observations above this line representing overestimates and observations below this line representing underestimates. The dashed line is the linear trend line for all observations.

(250 µg/l). The degree of overestimation was similar for men and women, despite men being more intoxicated on average.

BrAC error was positive (an underestimation) for those who had lower actual BrAC, but negative (an overestimation) for those with higher actual BrAC. These findings confirm those found in previous field studies (Thombs *et al.*, 2003; Grant *et al.*, 2012), and may arise because participants overestimate when they are still in the ascending arm of the blood alcohol curve (Jones *et al.*, 1997). However, unlike previous studies we estimate the actual BrAC level above which underestimation occurs on average, being a BrAC of 515 µg/l for men and 394 µg/l for women.

Policymakers may be concerned that intoxicated people underestimate their BrAC level and may be tempted to drive when over the legal limit for driving. Our results suggest that underestimation occurs on average at levels close to double the new legal limit for driving (250 µg/l). This suggests that underestimation may not be a serious policy consideration as drivers at that level of intoxication are much less likely to be misled about whether they are legally allowed to drive. In contrast, people whose BrAC is close to the legal limit on average overestimate their BrAC. This may be because participants were particularly concerned about underestimating their BrAC due to the change in the legal breath alcohol limit for driving. However, in settings where the legal limit for drunk driving is higher (such as in New Zealand prior to December 2014, where the limit was 400 µg/l), drunk driving (as legally defined) arising as a result of the inability of people to judge their level of intoxication relative to the limit may be more of an issue. Our survey suggests that drunk driving was not a serious problem for this sample. When asked about transport intentions at the end of the night, none of the drinkers in our sample suggested that they would be driving home. This must be seen in the context of the recent legal change that may have made people more averse to the risk of being caught drunk driving, or it may represent social desirability bias in the responses. Moreover, it is possible that participation in the survey had a direct effect on participants' driving intentions, given that during the survey they were reminded of the change in the legal limit for driving.

BrAC error was higher (a greater overestimate) for men who reported that this was not a 'typical night' for them, than for those who did not report this. Previous literature identifies that situational cues are important for people to evaluate their level of intoxication (Williams and Burroughs, 1994) and our results support that view, but only for men. Surprisingly, this was the case regardless of whether they were consuming more, or less, than they would on a typical night. The statistical insignificance of this variable for women may have arisen because of the smaller sample size for women, leading to reduced statistical power. However, we note that the size of the standard errors and confidence intervals were similar for men and women (see Model 2a and 2b in Table 1).

Controlling for actual BrAC reading, people with a higher self-reported level of intoxication (on a 0–10 scale) overestimated their BrAC reading by more than those with a lower self-reported level of intoxication. This is unsurprising, since how intoxicated a person feels is likely to be a primary indication to themselves of their BrAC level. These results have implications for clinical and alcohol service contexts. Drinkers in the current study were shown to have poor ability to estimate their intoxication level. As such, clinical interventions which are designed to reduce risky drinking behaviour may seek to encourage drink-counting practices and awareness of contextual drinking cues, rather than relying on the individuals' subjective perception of their intoxication as a cue to stop drinking. Likewise, these results further emphasize the importance of consistent and adequately enforced Responsible Service of Alcohol practices. When it is considered that participants in the current study were more likely to underestimate their intoxication at high BrAC levels, the responsibility for safe consumption behaviour becomes increasingly that of the service provider.

Our study has several limitations. First, we did not objectively measure alcohol impairment, which should be the primary variable of interest because it more directly relates to, for example, impaired driving ability. Future studies could usefully include measures of observable impairment such as slurred speech, or difficulty walking or standing, to complement subjective and objective measures of intoxication. Second, our subjective measure of self-rated intoxication could have been interpreted differently by different participants. Future studies might consider anchoring such measures of self-rated intoxication by providing participants with guidance on characteristics of self-perceived intoxication corresponding to levels of the subjective measure. Third, with the exception of measured BrAC, our results are based on self-reports and may be subject to response bias. Fourth, we report significant differences in BrAC error between men and women after controlling for night-level, event-level and other individual-level variables, but our results are silent on the reasons for these differences. Future research should explore these differences in more detail, to identify the specific mechanisms that underlie them.

Our survey was undertaken at a time when the legal drunk driving limit was in the news because it was changing, and may have been more salient for our participants as a result. It is possible that this salience may have led to our participants overestimating their BrAC level. Based on our discussions with participants, the change in the legal drunk driving limit increased uncertainty about whether participants were too intoxicated to drive, and in some cases dissuaded them from driving. The qualitative question of the effect of uncertainty on driving behaviour could usefully be addressed in future research, but leads us to conclude that uncertainty is not necessarily negative. Fewer intoxicated drivers, whether through uncertainty about their level of intoxication or some other mechanism, is undoubtedly a positive outcome for society overall.

SUPPLEMENTARY MATERIAL

Supplementary data are available at *Alcohol And Alcoholism* online.

ACKNOWLEDGEMENTS

This research was funded by the Waikato Management School Health Research Network. The authors are grateful to Monice Cunningham, Rebecca Palmer, Zack Pentecost and Logan Walsh for assistance with data collection, to Sialupapu Siameja for excellent research assistance, and to the editor and three anonymous reviewers for helpful comments and suggestions. Any remaining errors are the responsibility of the authors.

FUNDING

This research was funded by the Waikato Management School Health Research Network.

CONFLICT OF INTEREST STATEMENT

None declared.

REFERENCES

Addicott MA, Marsh-Richard DM, Mathias CW, *et al.* (2007) The biphasic effects of alcohol: comparisons of subjective and objective measures of stimulation, sedation, and physical activity. *Alcohol Clin Exp Res* **31**:1883–90.

Aston ER, Liguori A. (2013) Self-estimation of blood alcohol concentration: a review. *Addict Behav* **38**:1944–51.

Baraona E, Abittan CS, Dohmen K, *et al.* (2001) Gender differences in pharmacokinetics of alcohol. *Alcohol Clin Exp Res* **25**:502–7.

Beirness DJ. (1987) Self-estimates of blood alcohol concentration in drinking driving context. *Drug Alcohol Depend* **19**:79–90.

Beirness DJ, Foss RD, Voas RB. (1993) Drinking drivers' estimates of their own blood alcohol concentration. *J Traffic Med* **21**:73–8.

Bielefeld L, Auwärter V, Pollak S, *et al.* (2015) Differences between the measured blood ethanol concentration and the estimated concentration by Widmark's equation in elderly persons. *Forensic Sci Int* **247**:23–7.

Bullers S, Ennis M. (2006) Effects of blood-alcohol concentration (BAC) feedback on BAC estimates over time. *J Alcohol Drug Educ* **50**:66–87.

Clapp JD, Min JW, Shillington AM, *et al.* (2006) Environmental and individual predictors of error in field estimates of blood alcohol concentration: a multilevel analysis. *J Stud Alcohol* **67**:620–7.

Clapp JD, Min JW, Trim RS, *et al.* (2009) Predictors of error in estimates of blood alcohol concentration: a replication. *J Stud Alcohol Drugs* **70**:683–8.

Corazzini L, Filippin A, Vanin P (2014). Economic behaviour under alcohol influence: an experiment on time, risk, and social preferences. *IZA Discussion Paper No. 8170*. Bonn: Institute for the Study of Labor (IZA).

Fraser AG, Rosalki SB, Gamble GD, *et al.* (1995) Inter-individual and intra-individual variability of ethanol concentration-time profiles: comparison of ethanol ingestion before or after an evening meal. *Br J Clin Pharmacol* **40**:387–92.

Fromme K, Katz E, D'Amico E. (1997) Effects of alcohol intoxication on the perceived consequences of risk taking. *Exp Clin Psychopharmacol* **5**:14–23.

Grant S, LaBrie JW, Hummer JF, *et al.* (2012) How drunk am I? Misperceiving one's level of intoxication in the college drinking environment. *Psychol Addict Behav* **26**:51–8.

Hustad JTP, Carey KB. (2005) Using calculations to estimate blood alcohol concentrations for naturally occurring drinking episodes: a validity study. *J Stud Alcohol* **66**:130–8.

Irwin C, Shum D, Desbrow B, *et al.* (2014) Comparing the effects of alcohol mixed with artificially-sweetened and carbohydrate containing beverages on breath alcohol concentration. *J Alcohol Drug Educ* **58**:27.

Jones AW, Norberg A, Hahn RG. (1997) Concentration-time profiles of ethanol in arterial and venous blood and end-expired breath during and after intravenous infusion. *J Forensic Sci* **42**:1088–94.

Laberg JC. (1986) Alcohol and expectancy: subjective, psychophysiological and behavioral responses to alcohol stimuli in severely, moderately and non-dependent drinkers. *Br J Addict* **81**:797–808.

Lewis MW, Merz JF, Hays RD, *et al.* (1995) Perceptions of intoxication and impairment at arrest among adults convicted of driving under the influence of alcohol. *J Drug Issues* **25**:141–60.

Mann RF. (2002) Choosing a national threshold for the definition of drunk driving. *Addiction* **97**:1237–8.

Martin C, Rose R, Obremski K. (1991) Estimation of blood alcohol concentrations in young male drinkers. *Alcohol Clin Exp Res* **15**:494–9.

Meier SE, Brigham TA, Handel G. (1987) Accuracy of drinkers' recall of alcohol consumption in a field setting. *J Stud Alcohol* **48**:325–8.

Miller P, Pennay A, Jenkinson R, *et al.* (2013) Patron offending and intoxication in night time entertainment districts (POINTED): a study protocol. *Int J Alcohol Drug Res* **2**:69–76.

Moskowitz H, Burns M. (1990) Effects of alcohol on driving performance. *Alcohol Health Res World* **14**:12–5.

Nicholson MF, Wang M, Mahoney BS. (1994) Perceived intoxication: implications for alcohol education. *J Alcohol Drug Educ* **40**:115–25.

Ramchandani VA, Kwo PY, Li TK. (2001) Effect of food and food composition on alcohol elimination rates in healthy men and women. *J Clin Pharmacol* **41**:1345–50.

Russ NW, Harwood MK, Geller ES. (1986) Estimating alcohol impairment in the field: implications for drunken driving. *J Stud Alcohol* **47**:237–40.

Shapiro AP, Nathan PE, Hay WM, *et al.* (1980) Influence of dosage level on blood alcohol level discrimination by alcoholics. *J Consult Clin Psychol* **48**:655–6.

Thombs DL, Olds RS, Snyder BM. (2003) Field assessment of BAC data to study late-night college drinking. *J Stud Alcohol* **64**:322–30.

Vuong Q. (1989) Likelihood ratio tests for model selection and non-nested hypotheses. *Econometrica* **57**:307–33.

Wickham M. (2012) Alcohol consumption in the night-time economy. *GLA Economics Working Paper 55*. London: Greater London Authority.

Wicki J, Gache P, Rutschmann OT. (2000) Self-estimates of blood-alcohol concentration and ability to drive in a population of soldiers. *Alcohol Alcohol* **35**:104–5.

Williams JG. (1991) Experience with alcohol and ability to discriminate legal intoxication status: a field study. *Addict Behav* **16**:355–62.

Williams JG, Burroughs WJ. (1994) Situational influences on cues used to judge intoxication. *J Stud Alcohol* **55**:751–3.

Williams JG, Burroughs WJ. (1995) Judgment of intoxication by untrained social drinkers across drinking settings. *Addict Behav* **20**:679–83.

World Health Organization. (2013) *Global Status Report on Road Safety 2013: Supporting a Decade of Action*. Geneva: World Health Organization.