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A Comparison of two Case-crossover Methods for Studying the Dose-Response Relationship Between Alcohol and Injury

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Abstract

Background: This study compares dose-response injury risk estimates for two control periods defined as the same 6-hour period the week prior and the set of all non-sleeping 6-hour periods over the past year.

Method: Dose-response injury risk estimates for the multiple match controls are generated via the application of a maximum-likelihood approach.

Results: Injury risk associated with any (i.e., 1 drink or more) drinking 6 hours prior to injury was similar for the two control choices (last week and usual frequency). For 1-4 drinks, risk estimates were similar across control period definitions; for 5+ drinks, risk using the week prior as the control was nearly double that using the past 12 months as the control.

Conclusions: Although studies with smaller ns may benefit from the increase in precision from the use of the multiple control periods, results indicate that heavy drinking injury risk estimates should be used with caution.

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Keywords

relative risk; case-crossover; dose-response; control period definition

Introduction

The risk of injury associated with alcohol use is a function of the simultaneous combination of a number of factors (Gmel and Daeppen, 2009). One of the most important and easily identifiable is the degree to which the drinkers' cognitive and/or motor functions are influenced, which is a function not only of how much and the manner in which the alcohol is consumed (e.g., evenly spread out vs. concentrated at the end of the drinking period), but also factors such as the drinker's gender, age, height and weight, and level of tolerance to the effects of alcohol. Although some of these characteristics are easier to measure than others, even if all were available and measured with high precision, the level of risk to which alcohol use exposes the drinker can still be quite variable due to the influence of a number of other key measured or unmeasured factors for which control may be difficult, such as context of injury (location and activities in which the injury subjects participate), impulsivity/mood, others' drinking, and weather/road conditions/condition of vehicles, etc. (Gmel and Daeppen, 2009).

One epidemiologic approach used in an attempt to quantify the risk of injury associated with alcohol use is to compare, in a sample experiencing an injury, the amount consumed over a period of fixed length prior to injury to the same individuals' consumption during a *single* control period of similar duration in which an injury did not occur. This technique, described as a pair-matched case-crossover approach, was first proposed in a study of the risk of myocardial-infarction associated with the onset of an acute risk factor (Maclure, 1991; Mittleman et al., 1995). A noteworthy advantage of this control definition is that it rules out potential effects associated with all time-invariant characteristics of the injury patients under study, a potentially serious source of bias which must be addressed when using patients as controls who differ from those injured. Risk of injury during an idealized control period would be the same as that during the period prior to the actual injury (other than the risk contributed by alcohol use); respondents would find themselves in the same contexts and participating in the same activities as those at the time of injury. Common choices for control periods that acknowledge such an ideal are the same 6-hour period the day (Vinson et al., 2003) or week (Borges et al., 2006b) prior to injury. Although increasingly collected in new studies, a substantial number of ED studies currently used to estimate the risk of injury world-wide did not assess consumption for single control periods (Zeisser et al., 2013;Cherpitel, 2005).

An alternative control choice is the combined set of 6-hour periods over the past 12 months (Borges et al., 2004; Borges et al., 2013; Cherpitel et al., 2005) where usual frequency of drinking over this period is used to determine the number of exposed and un-exposed 6-hour periods. Some implementations of this approach remove one 6-hour period per day to account for sleeping time (Ye et al., 2013), when risk of injury is thought to be low. A sizeable advantage accompanying the use of such a large number of control periods is the dramatic increase in the efficiency of the resulting risk estimates (Mittleman et al., 1995). In addition, usual frequency (and frequency-pattern) measures are much more widely collected.

The use of 6-hour periods over the past 12 months as controls also has several potential drawbacks. One is that the injury risk distribution (e.g., driving a car vs. at a bar vs. at home) for this control definition varies within an individual (as opposed to the 6-hour period prior to injury or the day or week prior) and likely includes some periods with higher and others with lower injury risk compared to that present at the time of the injury. However, as some injuries will occur during periods when consumption and injury risk behaviors are less likely and other injuries may occur during periods in which they are more likely, it is not known a-priori whether the use of a larger set of heterogeneous control periods will result in biased estimates. Further, evidence consistent with the presence of recall bias has been found in risk estimates computed using 6-hour periods over the past 12 months as the control choice, along with frequency of any drinking as the indicator of exposure (Ye et al., 2013). Less is known, however, about whether 12-month control period consumption measures that assess frequency of exposure across several consumption levels also suffer from the same bias in recall.

Prior studies using the set of 6-hour periods over the past 12 months as the control choice have all assessed control period exposure using usual frequency of drinking, which can be used to assess any but not level of exposure. More recently, case-crossover methods (Marshall and Jackson, 1993; Marshall et al., 2000) capable of utilizing usual drinking pattern measures over a set of multiple matched control periods, have been developed to assess risk of injury at each of several specific quantity levels prior to injury. In recognition of the advantages of efficiency and availability of the 6-hour periods over the past 12 months as the control of choice, the main objectives of the present work were to apply this multiple-matched approach and to compare resulting injury risk estimates to those produced from methods utilizing single control periods only.

Methods

Sample

The data used here include emergency department (ED) samples from 13 countries, including Argentina, Belarus, Brazil, Canada, China, the Czech Republic, India, Ireland, Korea, Mexico, New Zealand, Sweden, and Switzerland. Data from each ED study were collected using a similar methodology and included patients arriving at the ED within 6 hours of the injury event leading to the ED visit (Cherpitel et al., 2003; Cherpitel et al., 2012a; WHO Collaborative Study Group, 2005). Data for all EDs were collected in 2001-2002 except for Ireland (2003-2004), Switzerland (2006-2007), and Korea (2009). For each study, a probability sampling design was implemented that equally represented each 8-hour shift for each day of the week. Injury patients 18 years of age or older were selected from ED admission forms, including walk-in patients as well as those arriving by ambulance, and reflected consecutive arrival at the ED. Once selected and as soon as possible after admission to the ED, patients were approached with an informed consent to participate, and were then administered a questionnaire approximately 25 minutes in length by trained interviewers while they were in the waiting room or treatment area and/or following treatment. Patients who were too severely injured to be interviewed in the ED and who were subsequently hospitalized were interviewed later after their condition had stabilized. Only those reporting any drinking in the past 12 months (i.e., current drinkers) were retained for the comparative analyses presented here (n=7,543).

Measures

Five alcohol consumption items were utilized from the combined ED samples across countries. These included 1) the number of drinks consumed within 6 hours prior to the injury leading to the ED visit; 2) the number of drinks consumed during the same 6-hour period the week prior; 3) the usual frequency (UF) of drinking (i.e., 'In the past 12 months, how often did you typically drink any kind of alcoholic beverage?'); 4) the frequency of drinking 5-11 drinks/day (i.e., '..., how often did you drink between 5 and 11 drinks on one occasion?') and; 5) the frequency of drinking 12 or more drinks/day (i.e., '..., how often did you drink 12 or more drinks on one occasion?').

Each of the three 12-month measures: usual frequency (UF) of drinking, frequency of drinking 5-11 drinks, and frequency of drinking 12+ drinks, were asked as categorical variables with 9 response categories: "Every Day", "Nearly Every Day", "3-4 Times/Week", "1-2 Times/Week", "2-3 Times/Month", "About Once/Month", "6-11 Times/Year", "1-5 Times/Year", and "Never During Last 12 Months". Variables were assigned quantified values meant to represent the number of days (here forward, 'days' is substituted for 'occasions') for each category as the midpoint of the range except for that indicating a single frequency (i.e., "Never" or "Every Day" which were assigned the values of 0 and 365, respectively). The quantified values for the number of 5-11 and 12+ days were summed together to obtain a single measure of the number of days drinking 5+ drinks. After obtaining the frequency of 5+ measure, the frequency of drinking 1-4 drinks/day was estimated as the maximum of 0 and the quantity (UF – # 5+ days); the number of days in which no alcohol was consumed was estimated as the maximum of 0 and the quantity (365 – (# 1-4 days + # 5-11 days + # 12+ days)) where UF is the quantified usual frequency of drinking.

Estimating Drinking for Different Control Period Definitions—Case-crossover methods require measures of risk exposure during both an injury as well as a control (i.e., non-injury) period for each individual. For the present analyses, two sets of matched control periods are considered. The first is the same 6-hour period prior to injury the week prior. The second is the set of all non-sleeping 6-hour intervals over the past year (Maclure and Mittleman, 2000), resulting in 365•(4-1)=1,095 6-hour control periods.

Two drinking pattern variables are examined here: any drinking and drinking 1-4 or 5+ drinks, each vs. no drinking. Using the same 6-hour period the week prior, construction of these two drinking variables is obtained from the reported number of drinks consumed during this period. However, using the set of all 6-hour periods over the past year, it is assumed that for each of the days during which 1-4 or 5+ drinks are consumed, all drinks are consumed during a single 6-hour period. Under this assumption, respondent-specific probabilities, indicating the proportion of the 1,095 6-hour periods spent drinking at each of the 3 levels (i.e., 0, 1-4, or 5+ drinks), are then constructed from the 12-month drinking pattern measures.

Consider, as an illustrative example of the coding scheme described above, that a respondent reporting usually drinking any quantity 3-4 times/week (quantified as 182 6-hour periods in the past year), drinking 5-11+ drinks 1-2 times/week (78 periods in the past year), and drinking 12+ drinks 1-2 times in the past 12 months (1.5 periods in the past year). For such a drinker, the number of 5+ drink 6-hour periods would be quantified as 78 + 1.5 = 79.5; the number of 1-4 drink periods would be quantified as 182 – 79.5 = 102.5; and the number of 0 drink periods would be quantified as 1,095 – 182 = 913.

Analysis

Using as the matched control period, the same 6-hour period the week prior, the relative risk (RR) of injury associated with drinking was estimated for each of the two definitions of exposure, defined as (a) any vs. no drinking, producing a single RR estimate, and (b) drinking 1-4 or 5+ drinks (each vs. no drinks) producing two additional RR estimates. The Mantel-Haenszel (MH) estimator, defined as the ratio of a) the number of respondents who drank 6 hours prior to injury but not during the same period the week prior to injury to b) the number of respondents who did not drink 6 hours prior to injury but did drink during the same period the week prior, was used to estimate the RR associated with any drinking (Maclure, 1991). Conditional logistic regression was used to estimate the two RRs associated with the three possible drinking levels (Rothman and Greenland, 1998).

Defining instead the set of 1,095 non-sleeping 6-hour periods over the last 12 months as the set of matched control periods, the RR associated with any drinking was first estimated using the Mantel-Haenszel estimator via the usual frequency of drinking to measure the number of 6-hour periods during which individuals were exposed. Then, the RRs for 1-4 and 5+ drinks were estimated by maximizing the likelihood function for the proportional hazards (PH) model described in Marshall and Jackson (1993) and Marshall, Wouters, and Jackson (2000).

This model generates the likelihood function by assuming that (a) the respondent-specific probability of drinking at a given quantity level during any given 6-hour period follows a multinomial distribution with probabilities estimated from each respondent’s survey data, and that (b) a proportional hazards model for injury holds where the hazard function only involves the quantity of alcohol consumed within a 6-hour period. Using m+1 levels of exposure and respondent-specific exposure probabilities $p_{i,0}$, ..., $p_{i,m}$ estimated from 12-month consumption measures, the maximum likelihood estimating equation that can be iteratively solved for RR=β_j is defined, for each j=1,.., m=2, as:

$$\Sigma_{i=1}^{n} x_{i,j} = \Sigma_{i=1}^{n} \frac{p_{i,j}\beta_j}{p_{i,0}+p_{i,1}\beta_1+\cdots+p_{i,m}\beta_m}$$

where $x_{i,j}$ is an indicator variable that takes the value 1 if respondent *i* reported consuming a number of drinks that falls within the quantity range *j* in the 6 hours prior to injury. For comparative purposes, the RR associated with any drinking was also estimated using the proportional hazards model for the set of 6-hour periods over the last 12 months as the control.

Results

Table 1 shows the number of current drinkers within each ED used in analyses along with the proportion reporting any drinking within 6 hours prior to injury and any drinking during the same 6-hour period the week prior. For each country, the Mantel-Haenszel (MH) estimate of the RR of injury associated with any drinking 6 hours prior to injury was derived by using any drinking the week prior as the control period and is shown in the fourth data column of Table 1. Substantial variability in risk estimates was found across countries, with RR estimates ranging from 0.8 to 40.0 with an overall estimate of 5.79. Using instead the set of matched 6-hour periods over the last 12 months, RRs associated with any drinking were estimated using the Mantel-Haenszel estimator and, separately, the proportional hazard model and are shown in the last 2 columns of Table 1. Generally, the Mantel-Haenszel and proportional hazard estimates were found to be similar within countries when using 6-hour periods over the past 12 months as the set of controls. However, also within countries, larger differences were found between estimates from the two control period choices (last week and usual frequency).

Results from analyses estimating the combined RR of injury associated with any vs. no drinking are shown in Table 2 along with their respective confidence intervals. In the combined sample, 24.8% reported drinking within 6 hours prior to their injury. Using the same 6-hour period last week as the control, 9.6% reported any drinking overall compared to the last 12 months, where 7.8% of the control periods involved drinking. Rates of any drinking are also provided, conditional on whether the respondent reported any drinking within 6 hours prior to their injury. These conditional distributions suggest that exposure 6 hours prior to injury is more similar to exposure during the control period when defined as the same 6-hour period the week prior than when defined using the more generic set of 6-hour periods during the past 12 months. Those reporting not drinking 6 hours prior to injury were only slightly less likely to report drinking during the same period the week prior (4.2%) when compared to the proportion of 6-hour intervals in the last year in which drinking occurred (6.5%). However, the set of respondents reporting not drinking prior to their injury comprises 75% of the total sample, and therefore a seemingly small 1.3% difference in rates (i.e., 6.5-4.2) translates into a large numerical difference across the two control periods considered. This expresses itself in the number of respondents reporting not drinking prior to injury, but drinking during the control period(s) and increases the size of the denominator of the Mantel-Haenszel estimator.

Overall, the Mantel-Haenszel RR estimate for any drinking was 5.79 using the same 6-hour period last week as the control. Using the combined set of 6-hour periods over the last 12 months and usual frequency as the number of exposed 6-hour periods, the corresponding proportional hazards RR estimate was 5.09, not too dissimilar from the estimate produced using the same 6-hour period the week prior as the control.

RR estimates for the two levels of alcohol consumption defined as 1-4 and 5+ drinks (each compared to 0 drinks), are shown in Table 3. Using last week as the control period, RR estimates were 3.22 (95% CI: (2.73, 3.80)) for 1-4 drinks and 11.48 (95% CI: (9.29, 14.19)) for 5+ drinks. Using instead the past 12 months as the control period, analogous estimates were 3.00 (95% CI: (2.74, 3.29)) for 1-4 drinks and 6.38 (95% CI: (5.89, 6.90)) for 5+ drinks, indicating an increase of nearly 80% in the estimated risk for 5+ when using the same 6-hour period the week prior compared to the set of 6-hour periods during the last 12 months as the control choice.

The difference between risk estimates for 5+ drinks obtained for the two control period choices is mirrored in their respective conditional distributions where conditioning is performed based on the number of drinks consumed within 6 hours prior to injury. The marginal drinking distributions for the two control periods were quite similar, with the only difference for 1-4 drinks a rate 0.9% higher for last week compared to the proportion of 6-hour periods over the last 12 months (i.e., 5.1% vs. 4.2%). However, the conditional distributions indicate much more of the mass at each consumption level 6 hours prior to the injury lies on what is effectively the diagonal of the conditional distribution when using last week compared to the collection of 6-hour periods over the last 12 months as the control choice. That is, the quantity consumed within 6 hours prior to the injury and the quantity consumed in the control period are more concordant when using the week prior compared to the set of 6-hour periods over the past 12 months.

The increased concordance between drinking 6 hours prior to injury and last week compared to the last 12 months means that, among those not reporting drinking 5+ drinks 6 hours prior to injury, the proportion reporting 5+ drinking during the same 6-hour period the week prior is *smaller* than the average proportion of 6-hour intervals over the past year in which 5+ drinks were consumed. Such a proportion represents the denominator of the Mantel-Haenszel RR estimator for dichotomous exposures and it is precisely these individuals who typically represent the smallest sample sizes available for RR estimation (e.g., n=72 cases reporting drinking 5+ drinks last week who reported not drinking 6 hours prior to the injury from a total sample of 7,543 patients). This is especially problematic for samples in which the proportion of respondents not exposed to the risk factor is high (75% in our combined sample), as RR estimates are sensitive to variability in exposure prevalence rates during the control period among those not exposed prior to injury.

Discussion

Although a number of prior studies have examined injury risk across multiple levels of alcohol exposure using a single control period, the present work is the first to examine properties of dose-response RR estimates that use the set of non-sleeping 6-hour periods over the past 12 months as the control choice. Regardless of using the week prior or the set of 6-hour periods over the past 12 months as the control choice, the RR estimate for 1-4 drinks was roughly similar, approximately 3 for each method. However, for 5+ drinks, the RR estimate produced from the week prior control period was nearly double that produced from use of the collection of all 6-hour periods over the past 12 months as the control choice. A key factor in the difference between risk estimates for the two control periods is the observed difference in the rates of heavy drinking during the control period(s) among injured patients who reported not drinking prior to injury (i.e., the conditional probabilities of 1.3 for last week and 3.0 for 6-hour period over the past year as shown in Table 3). Examination of these two rates can be helpful for any study considering their use as an assessment of the uniqueness associated with heavy drinking for the injury relative to the control periods. As prior work estimating dose-response injury risk estimates has exclusively used single control periods (several studies also using a subset of the data used here), it is not surprising that such work would produce estimates that are more closely aligned with results found here with use of last week as the control. For example, utilizing data from 10 of the 13 countries reported here (but here, with the data from the three additional countries, nearly doubling the sample size available for analyses from the 10) and using last week as the control choice, Borges (2006b) estimated the risk of injury using conditional logistic regression for each of 1, 2-3, 4-5, and 6+ drinks within 6 hours prior to injury (compared to 0 drinks) as 3.3, 3.9, 6.5, and 10.1, respectively. Although such consumption levels are not identical to those used here, risk estimates for the first two levels appear to be roughly consistent with both the last week and 12-month RR estimates for the 1-4 drinks range. Risk estimates for the 6+ drinks level were more similar to the RR estimate for the 5+ level using last week as the control. Another study (Vinson et al., 2003) of patients from 3 EDs in Missouri (data not used here) considered consumption during the same 6-hour period the day prior to injury as the control and estimated the RR of injury for 1-2, 3-4, 5-6, and 7+ drinks (compared to 0) as 1.8, 6.2, 9.5, and 17, respectively. Again, at the highest consumption levels, these risk estimates appear to better reflect those produced from the use of the last week compared to 6-hour periods over the past 12 months as the control choice.

However, not all studies have produced uniformly consistent results. Using data from two sites in Vancouver, BC (also not used for the present analyses), Cherpitel (2012b) examined risk of injury associated with 1-2, 3-4, and 5+ drinks using the same 6-hour period yesterday, last week, and the two periods combined. For last week, risk estimates were 2.4, 5.4, and 6.5; for yesterday estimates were 1.6, and 8.1 (effect not estimable for 5+ drinks for yesterday separately). These risk estimates for heavy drinking using last week as the control are closer to those produced here for all 6-hour periods over the past 12 months than for the last week as the control. However, when yesterday and last week were used together as a multiple control, this study found RR estimates of 1.8, 5.8, and 13.8; more representative of our findings for heavy drinking with last week as the control.

Overall, dose-response injury risk estimates from the majority of prior studies appear to be more consistent with those found here with use of last week rather than the set of 6-hour periods over the past 12 months as the control choice. However, it should be noted that both methods likely contain bias from differing sources. For example, although Ye et al. (Ye et al., 2013) found evidence consistent with recall bias in injury risk estimates produced from the use of 6-hour periods over the past 12 months as the control, evidence for recall bias in alcohol self-reports has also been found across periods as short as one week (Gmel and Daeppen, 2007) and thus may also be present in risk estimates using last week as the control.

These studies examining bias have done so by examination of usual drinking behaviors either for non-injured control ED patients or by using ordered timeline follow-back measures across the week prior to injury for injured patients. Such specialty data which allow risk estimation using only non-injury periods or temporal declines in drinking reports over time are not available here and therefore, bias can be studied only indirectly by the comparison of injury risk estimates from different methods. Therefore, whether such control periods and the corresponding estimation methods used here have produced differential recall bias is not known. Sharing some of the same datasets, two studies by Borges et al. ((2006a) and (2006b)) found identical risk estimates of 5.7 associated with any alcohol use even though one used last week and the other used all 6-hour periods over the past 12 months as the control choice. Whether such results indicate the magnitudes of the respective bias is not known, although the consistency of their results with those found here is encouraging. Clearly, differential findings across the range of studies may also stem from the use of data from different sets of countries.

Although the expected desirable increases in efficiency were indeed observed in risk estimates produced using the set of 6-hour periods over the past 12 months as the control choice, the heterogeneity in heavy drinking injury risk estimates found in this and prior work makes it difficult to formulate a uniform recommendation. Nonetheless, this work points to the need for further study comparing estimates from the two methods while also considering the influence of context during both control and injury periods (i.e., where the respondents were and what they were doing). Considering context will contribute vital information, as it likely plays an important role in establishing the level of injury risk to which an individual is exposed, especially at higher levels of alcohol consumption.

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Table 1

Samples Used for Dose-Response Mantel-Haenszel (MH) and Proportional-Hazards (PH) Relative Risk Estimation

Country	N Available for Analysis[a]	% Drank 6 Hours before Injury	% Drank Alcohol Last Week	RR (95% CI) Last Week MH Estimated RR of Injury[b]	RR (95% CI) Usual MH Estimated RR of Injury[c]	RR (95% CI) Usual PH Estimated RR of Injury[d]
Argentina	342	27.5	13.2	5.90 (3.02, 11.53)	3.90 (3.03, 5.02)	4.76 (3.56, 6.37)
Belarus	400	34.3	4.5	24.80 (10.14, 60.64)	11.25 (8.98, 14.10)	15.58 (12.14, 19.99)
Brazil	325	16.3	5.8	9.50 (3.39, 26.62)	3.43 (2.53, 4.66)	3.82 (2.73, 5.34)
Canada	384	16.7	9.9	2.86 (1.55, 5.25)	2.12 (1.62, 2.78)	2.31 (1.70, 3.13)
China	1, 445	20.9	9.9	3.15 (2.42, 4.09)	3.83 (3.35, 4.36)	4.57 (3.93, 5.31)
Czech Republic	371	6.7	8.1	.80 (0.44, 1.44)	.77 (0.51, 1.17)	.77 (.50, 1.18)
India	92	77.2	34.8	40.00 (5.50, 290.97)	25.24 (13.42, 47.48)	24.15 (13.97, 41.73)
Ireland	1, 633	27.3	10.8	8.94 (6.27, 12.74)	3.83 (3.40, 4.31)	3.87 (3.44, 4.36)
Korea	1, 439	29.0	7.4	9.67 (6.86, 13.62)	7.21 (6.37, 8.15)	8.14 (7.14, 9.28)
Mexico	304	24.0	5.9	6.50 (3.34, 12.65)	19.34 (14.35, 26.09)	24.54 (17.97, 33.50)
New Zealand	115	41.7	20.0	6.00 (2.33, 15.46)	9.03 (6.15, 13.24)	13.88 (8.81, 21.86)
Sweden	402	15.4	4.7	8.17 (3.50, 19.06)	3.36 (2.57, 4.40)	3.91 (2.88, 5.33)
Switzerland	291	25.8	19.2	2.27 (1.23, 4.16)	2.82 (2.14, 3.71)	3.14 (2.31, 4.27)
Total	7, 543	24.8	9.6	5.79 (4.89, 6.40)	4.44 (4.20, 4.70)	5.09 (4.79, 5.41)

[a]– To be used in comparative analyses, respondents who were current drinkers (drank in the past 12 months) must have reported valid, non-missing values for quantity consumed 6 hours prior to injury (≥ 0), usual quantity (≥ 0), frequency of 5-7 and 12+ drinks/day, and quantity consumed the week prior (≥ 0) during the same 6-hour period.

[b]– Mantel-Haenszel estimates of the RR of injury associated with any alcohol use 6-hours prior to injury using the same 6-hour period the week prior as the control period.

[c]– Mantel-Haenszel estimates of the RR of injury associated with any alcohol use 6-hours prior to injury using the set of 6-hour periods over the last 12 months as the control periods.

[d]– Proportional Hazards model estimates of the RR of injury associated with any alcohol use 6-hours prior to injury using the set of 6-hour periods over the last 12 months as the control periods.

Table 2

Case-Crossover Estimates of the RR of Injury Associated with Any vs. No Drinking 6-Hours Prior to Injury

		Consumption Level	
	Total N = 7, 543	**0**	**1+**
Drinking Distribution 6h prior to injury		**75.2 (N=5, 675)**	**24.8 (N=l, 868)**
Last Week Conditional Distribution for an in-the-event # of drinks of:	Overall	90.4	9.6
	0	95.8	4.2
	1+	74.1	25.9
Usual Pattern Conditional Distribution for an in-the-event # of drinks of:	Overall	92.2	7.8
	0	93.5	6.5
	1+	88.1	11.9
RR (95% CI), Same 6-hour Period Last Week[a]		--	5.79 (5.05, 6.64)
RR (95% CI), 12-Month Usual Frequency[b]		--	5.09 (4.79, 5.41)
RR (95% CI), 12 Month Pattern Distribution[c]		--	4.51 (4.25, 4.80)

[a] – RR of injury, estimated using the Mantel-Haenszel Estimator and drinking during the same 6-hour period the week prior as the control.

[b] – RR of injury, estimated using the Proportional Hazards model and usual frequency of drinking over the past 12 months as the control.

[c] – RR of injury, estimated using the Proportional Hazards model and the frequency of exposure defined within individual as the maximum of either the usual frequency of any drinking or of the sum of the number of days drinking 5-11 and 12+ (with the latter capped at 365 when the sum of the quantified days exceeded 365).

Table 3

Marginal and Conditional Control Period Drinking Distributions and Case-Crossover Estimates of the RR of injury associated with 1-4 and 5+ vs. 0 Drinks

		Consumption Level		
	Total N=7, 543	**0**	**1-4**	**5+**
Drinking Distribution 6h prior to Injury		75.2 (N=5, 675)	9.1 (N=687)	15.7 (N=l, 181)
Last Week Consumption Overall and Conditional Distribution for # of drinks 6h prior to injury of:	Overall	90.4	5.1	4.5
	0	95.8	2.9	1.3
	1-4	76.9	19.1	4.1
	5+	72.5	7.5	20.0
12 Month Pattern Overall and Conditional Distribution for # of drinks 6h prior to injury of:	Overall	91.4	4.2	4.5
	0	92.9	4.1	3.0
	1-4	88.3	7.5	4.3
	5+	85.7	2.8	11.6
RR (95% CI), Same 6-hour Period Last Week Quantity			3.22 (2.73,3.80)	11.48 (9.29, 14.19)
RR (95% CI), 12 Month Pattern Distribution			3.00 (2.74, 3.29)	6.38 (5.89, 6.90)