INTRODUCTION

A large literature exists which implicates alcohol as a major risk factor for injury internationally. Recent estimates of the global burden of disease found 32% of unintentional injury mortality and 28% of unintentional injury morbidity were attributable to alcohol (Rehm et al., 2003b). Much of the epidemiological evidence linking alcohol to injury has come from studies of probability samples of patients treated in emergency departments (EDs) (reviewed in Cherpitel, 1993a). While these studies have found injured patients more likely than non-injured to be positive for blood alcohol concentration (BAC) at the time of the ED visit and to report drinking prior to the event, the magnitude of these associations has varied across countries (Cherpitel, 1993a) and across regions within countries (Cherpitel, 1997a; Cherpitel et al., 1999), as well as by ED type within a region (Cherpitel, 1993b). Much of the observed variation in the association of alcohol and injury may be due to individual-level characteristics such as gender, age and usual drinking patterns, as well as to contextual-level variables related to socio-cultural factors of the society and to organizational and administrative factors of the emergency department.

The association of alcohol consumption with acute conditions, such as injuries, has been found to be related to both volume and pattern of drinking (Rehm et al., 2001a,b), with the impact of average volume partly moderated by the manner in which alcohol is consumed in a culture. This, in turn, is influenced by the cultural context of drinking and the level of integration of alcohol in the society (Room and Mäkelä, 2000). Organization variables, such as the type of ED (public or private) or the level of trauma care provided, may also explain associations of alcohol and injury found in emergency department samples. These variables can impact the population-based flow of cases to an ED and the likelihood of risk of injury, drinking and ED treatment in the population served by the emergency department.

To further explore the relationship between aggregate socio-cultural and organization variables with individual-level patient characteristics on the association of alcohol and injury, analysis is reported here, using hierarchical linear modeling (HLM), of data from the Emergency Room Collaborative Alcohol Analysis Project (ERCAAP), covering 31 ED sites across seven countries. A prior meta-analysis of the ERCAAP data from five countries found significant pooled odds ratios for injury close to 2.0 for both BAC and self-reported consumption prior to the event, although effect size was found to be heterogeneous across ED sites (Cherpitel et al., 2003). Effect size was moderated by gender, age and usual heavy alcohol use (drinking five or more drinks on an occasion at least monthly), and found to be most strongly associated (positively) with trauma center status, with some indication of an additional effect of socio-cultural variables suggestive of alcohol’s integration in the society. Meta-analysis does not allow for a direct examination of the interaction of individual-level variables or the interaction of individual-level with ED site-level variables, however. It also does not allow for assessing the magnitude of the variation in likelihood of injury across EDs after accounting for the effect of site-level variables. This paper will examine the relationship, separately for BAC and self-reported consumption, of age and gender, and the interaction of drinking patterns and contextual variables with BAC and self-report, on the likelihood of injury (compared to non-injury). It will also examine changes in the magnitude of remaining variation in the likelihood of injury across ED sites when contextual variables have been considered.

Socio-cultural variables analyzed are those thought to be related to the integration of alcohol in society (Room and Mäkelä, 2000), and include legal drinking age, legal level of intoxication, per capita consumption and detrimental drinking pattern (Rehm et al., 2003a,b). Per capita consumption has been...
found to be positively associated with integration of alcohol in society, while the two legal indicators are indicative of exposure to alcohol in the culture. Detrimental drinking pattern is a measure which taps those patterns expected to affect the impact of a given volume of drinking, with those societies in which alcohol is most integrated displaying the least detrimental patterns of drinking. This measure includes indicators of heavy drinking occasions, drinking with meals, and drinking in public places (Rehm et al., 2003a,b). Organizational variables analyzed include ED type and trauma center status. Trauma centers tend to treat a disproportionately larger number of more severe injuries which may be more likely to be alcohol involved than less severe injuries. Publicly funded EDs (with or without trauma centers) have been found to treat a larger proportion of those with alcohol-related problems compared to privately funded EDs, possibly due to differences in demographic composition of clientele served across types of EDs (Cherpitel, 1993b). These analyses will further our understanding of the association of usual drinking patterns with drinking in the event on injury occurrence and the impact of socio-cultural and organization variables on these associations.

METHODS

ED data

Table 1 lists the EDs and characteristics of the ED sites analyzed in this paper from the ERCAAP. Data from all of the EDs were collected using a similar methodology developed by Cherpitel (1989). Probability samples of patients 18 years and older were obtained from ED admission forms which reflected consecutive arrival to the ED. While various sampling ratios were used across ED studies, each sample reflected an equal representation of each shift for each day of the week during the study period. Patients who gave informed consent to participate in the study were then interviewed, and a BAC estimate obtained as soon as possible after admission to the emergency department. Completion rates for interviews were above 72%, ranging to 93%, except for Poland that had completion rates of 68% for Warsaw and 65% for Sosnowiec. Reasons for non-interviews included refusing, incapacitation, leaving prior to completing the interview, police custody and language barriers. Patients who were too severely injured or ill to be approached in the ED were followed into the hospital and interviewed once their condition had stabilized. A cadre of trained interviewers at each site obtained the BAC estimate merged into a single data file. The availability of data on primary data from each of the ED sites were cleaned and merged into a single data file. The availability of data on individual patients allows a unified approach to the analysis across EDs utilizing the same set of variables in each analysis and ensures comparability of resulting estimates across sites.

BAC was estimated, in all but the Canadian studies, using the Alco-Sensor III breathalyzer which provides estimates that are highly correlated with chemical analysis of blood (Gibb et al., 1984). In the Canadian sites BAC was estimated from urine samples that were assessed for ethanol using KDA enzymatic testing, and standardized to the unit measure quantifying BAC estimated from breath samples.

Usual drinking patterns were obtained from a series of questions regarding the frequency of any drinking and the frequency of consuming five or more drinks (5+) at a time during the last year. Four drinking patterns are analyzed here: any drinking weekly; 5+ drinking at least weekly; 5+ drinking at least monthly; 5+ drinking at least once during the last year.

Contextual data

Contextual data on per capita consumption of ethanol, legal drinking age and legal level of intoxication while driving were obtained from the collaborators for each ED site for the time period during which the ED data were collected. Per capita consumption in liters was obtained for the region or area in which the ED study was conducted, and ranged from 4.6 in the Mexican sites to 15.3 in Mar del Plata (Argentina). Legal drinking age ranged from 16 in Spain and Italy to 21 in all US sites, and legal level of intoxication ranged from 0.02 in Poland to 0.10 in all US sites expect Santa Clara, where data were collected following a national decrease in legal level of intoxication. The type of ED (whether public or private) and level of trauma care delivered was also obtained. Collaborators were asked whether the facility was equipped to treat the most severely injured patients, and if so, the facility was considered a ‘Trauma Center’ and coded dichotomously.

Detrimental drinking patterns were based on a survey of key informants selected by the World Health Organization in each country and used in a comparative risk assessment of the global burden of disease (Bijleveld and Van Der Burg, 1998; Rehm et al., 2003b; Rehm et al., in press). Detrimental impact scores range from 1 to 4, with the higher the score the higher the postulated detrimental effect of the same per capita consumption of alcohol resulting in harm (Rehm et al., 2003a,b). Since distinct regional variations in drinking patterns have been found within a country in Canada, Quebec was assigned a lower detrimental pattern level than the country as a whole, while Alberta was assigned a higher level. In the US, Californian ED sites were assigned a lower level than the country as a whole, while Mississippi was assigned a higher detrimental pattern level.

Analysis

Primary data from each of the ED sites were cleaned and merged into a single data file. The availability of data on individual patients allows a unified approach to the analysis across EDs utilizing the same set of variables in each analysis and ensures comparability of resulting estimates across sites.

Self-reported injury (compared to a medical condition) was used as the dependent variable throughout the analysis. The main focus of this analysis is on the association between injury and the use of alcohol in the event, both controlling and not controlling for age and gender, as well as the extent to which this association is modified by usual drinking patterns and by site-specific contextual variables. Acute use of alcohol in the event was measured by BAC at the time of ED admission and self-reported drinking within 6 h prior to the event, with separate analyses conducted for each. BAC and self-report were coded dichotomously (Cherpitel et al., 2003). Using multi-level logistic regression models, an exploratory analysis of a categorized BAC variable (BAC levels 0, 0.001–0.009, 0.01–0.049, 0.05–0.149, and 0.15) was examined to predict odds of injury across sites. Odds of injury did not differ for the first two BAC categories, but increased significantly for all BAC levels ≥0.01. In addition, odds did not differentially increase across BAC levels ≥0.01, suggesting that an indicator variable for BAC ≥0.01 was a more appropriate predictor to
use in the multi-level logistic regression models than a continuous BAC variable. BAC analyses were restricted to those on whom a BAC estimate could be obtained within 6 h of the event which brought the patient to the ED and who reported no drinking following the event.

In order to account for the nested data structure of individuals within EDs in the following analyses, Hierarchical Linear Modeling techniques (Snijders and Bosker, 1999) were utilized and estimation was performed using MLwiN (Rasbash et al., 2000). An important feature of these models is their ability to analyze variation in the likelihood of injury across EDs after accounting for site-level contextual variables.

More specifically, the model estimated was a multi-level logistic regression model. The dependent variable in this model was the logit of the true probability of injury for an individual patient nested within an ED, and the predictor was BAC or self-report, included separately. The individual-level variables of gender, age and usual drinking pattern were also included in subsequent models. In these models, the likelihood of injury associated with drinking in the event was allowed to vary across EDs. In addition, these models allowed for an unexplained residual variation in likelihood of injury associated with drinking in the event across EDs after controlling for site-level variables. Assessments of both the strength of the site-level variables in the prediction of variation in the likelihood of injury across EDs and of their ability to reduce the resulting unexplained variation were made.

Four models (see Appendix) are presented for both BAC (Table 2) and self-report (Table 3). Model 1 is the base model and includes as individual-level covariates only an intercept and a drinking in the event variable. Model 2 adds gender and age as individual-level controls. The goal of Models 1 and 2 is

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1Investigator(s) representing the study in the Collaborative Project.
2Principal investigator of study if different from collaborator.
3Co-principal investigator of study.
4Follow-up patients were not included in the analyses.
to provide pooled estimates of the likelihood of injury associated with acute alcohol use, uncontrolled (Model 1) and subsequently controlling (Model 2) for gender and age.

Both Models 3 and 4 build on Model 2. Model 3 includes the individual-level interaction between drinking in the event and usual drinking pattern. Variables measuring frequency of drinking (weekly drinking at any quantity level; weekly 5+; monthly 5+; yearly 5+) were included in separate logistic regression models. For Model 4, the variability in the likelihood of injury associated with drinking in the event was predicted from site-level variables (included separately and shown in the second columns of Tables 2 and 3). It is expected that including such variables will help explain the variability in the likelihood of injury across ED sites and thus reduce the magnitude of the resulting unexplained variation.

RESULTS

Results of BAC and self-reported consumption are presented in Tables 2 and 3, respectively. The coefficient for log odds (β) and the odds ratio (OR) are shown in the second and third columns of Tables 2 and 3. The last column shows the variability of log-odds of injury across EDs associated with a positive BAC or self-report. In Model 3, the variability of the log-odds across EDs is not shown (the last columns in Tables 2 and 3) because the focus is on the interaction of individual-level usual drinking patterns with drinking in the event, and not on the ability of site-level variables to predict differences in the likelihood of injury across EDs.

**BAC**

Results from Model 1 indicate that a positive BAC has a protective effect on the likelihood of injury associated with acute alcohol use, uncontrolled (Model 1) and subsequently controlling (Model 2) for gender and age. The average effect across EDs was moderate (OR = 1.68) and dropped slightly to 1.51 after controlling for patients’ contextual variables with BAC in the prediction of log-odds of injury across ED sites. In this model, only detrimental drinking (weekly drinking at any quantity level; weekly 5+; monthly 5+; yearly 5+) were included in separate logistic regression models. For Model 4, the variability in the likelihood of injury associated with drinking in the event was predicted from site-level variables (included separately and shown in the second columns of Tables 2 and 3). It is expected that including such variables will help explain the variability in the likelihood of injury across ED sites and thus reduce the magnitude of the resulting unexplained variation.
drinking pattern was significantly predictive. In those societies with greater detrimental patterns, patients with a positive BAC were more likely to be admitted to the ED with an injury compared to those societies with lower detrimental patterns. Table 2 also shows that, after adjusting for the effect of detrimental drinking pattern, the variation of the BAC across sites drops from 0.13 (Model 1) to 0.02 (Model 4), which is the largest reduction attributable to any one of the site-level variables examined.

**Self-report**

The effect of self-reported drinking within 6 h prior to the injury event was similar to that of BAC. Self-report was a significant predictor of injury with an OR of 1.79, which dropped to 1.58 when controlling for gender and age. In addition to the significant interaction of 5+ monthly and 5+ weekly drinking with self-reported alcohol use, as was seen for BAC, the interaction of weekly drinking (of any amount) with self-reported use was also a significant (and negative) predictor of the likelihood of injury.

Among contextual variables (Model 4), trauma center and detrimental drinking pattern were both significantly (and positively) predictive of the relationship between self-reported drinking and injury. When trauma center and detrimental pattern were entered simultaneously (bottom of Model 4), only detrimental pattern remained significant, however. The last column of Table 3 shows that when including both covariates, the unexplained variation across EDs dropped from 0.13 (from Model 1) to 0.05.

**DISCUSSION**

This analysis of alcohol and injury in 31 ED sites across seven countries found odds ratios of 1.7–1.8 for BAC and reporting drinking prior to the event, which dropped only slightly when gender and age were controlled. These findings support those from prior individual ED studies (Cherpitel, 1993a) as well as findings from a previously reported meta-analysis covering EDs in five of the seven countries reported here (Cherpitel et al., 2003). While prior analysis suggested some effect of site-specific contextual variables on the association of BAC and self-report with injury, the interaction of usual heavier drinking or of contextual variables with drinking in the event on injury could not be directly examined. This is the first report in the literature that has been able to examine the interaction of patient-level variables and site-specific variables with drinking in the event variables on injury occurrence. Additionally, these previous analyses were unable to assess the magnitude of the across-site variation in likelihood of injury that remained after accounting for site-level predictors. Analyses reported here were also able to assess the ability of contextual variables to explain across-site variation.

The likelihood of injury for patients with a positive BAC or for those reporting drinking prior to the event was less for those who reported consuming five or more drinks on an occasion at least monthly. It is possible that heavier drinkers may have developed some tolerance to drinking which puts them at less risk of injury at a given level of consumption. This is not to say, however, that heavier drinkers are at lower risk of injury in general compared to lighter drinkers—they are only at lower injury risk if drinking prior to the injury (as measured here by a positive BAC or self-report) compared to lighter drinkers who have been drinking prior to the injury. The likelihood of injury for those reporting drinking prior to the event was also less for those reporting weekly drinking of any amount. It is likely that those reporting more frequent drinking would also be more likely to report drinking during any 6 h period, regardless of whether or not the 6 h period terminated in an injury. It is also possible that more frequent drinkers also may have developed some tolerance to alcohol and consequently be at lower risk for injury than less frequent drinkers.

These findings of the association of drinking in the event with injury appear to vary across ED sites in relation to the integration of alcohol in society, specifically in relation to the level of detrimental drinking patterns exhibited by the society. The likelihood of injury given one has been drinking is greater in those societies in which alcohol is less integrated, i.e., those societies that exhibit more detrimental patterns of drinking. The pattern in which alcohol is consumed by an individual is affected by the context of consumption in the society in relation to the regularity of drinking, integration of alcohol with meal functions and the extent of drunkenness (Room and Mäkelä, 2000). Detrimental drinking pattern is a measure of three parameters of drinking patterns which are expected to affect the impact of a given volume of drinking, as noted earlier: (i) heavy drinking occasions, which is based on the quantity per occasion, proportion of daily drinking, getting drunk and festive drinking; (ii) drinking with meals; and (iii) drinking in public places (Rehm et al., 2001b, 2003a). Both consuming a given amount of alcohol on fewer occasions and drinking in public places which may require transportation presume a greater risk from alcohol, i.e., a more detrimental pattern of drinking. When detrimental drinking pattern was considered in these analyses, it was found to be the most significant predictor of differences in likelihood of injury across sites, effecting the largest reduction in unexplained variation in the estimated multi-level model. These findings appear to support prior research on the association of both individual-level volume and pattern of drinking with negative consequences including injury (Rehm et al., 2001a,b), although prior analyses of societal-level drinking patterns and likelihood of injury have not been reported.

Other socio-cultural variables that were thought to be related to the degree of exposure to alcohol and integration of alcohol in society (per capita consumption, legal drinking age, legal level of intoxication) were not found to have significant interactions with drinking in the event on the likelihood of injury. It should also be noted that while patient samples were representative of the EDs from which they were drawn, contextual variables represent aggregate level statistics, ranging from area-level to country-level data. Although they reflect the same time period during which the ED data were collected, they may not adequately represent contextual variables at the geographic level relevant to the specific ED site, and thus the explanatory value of the contextual variables may be reduced. Interestingly, neither of the ED site-level organizational/administrative variables (ED type and trauma center status) appeared to be important predictors of the association of acute consumption with injury. The likelihood of injury for those reporting drinking prior to the event was greater among those treated in trauma centers compared to those not, but when
detrimental drinking pattern in the society was controlled, trauma center was no longer a significant predictor.

In these analyses, odds ratios for injury were calculated compared to non-injured patients as quasi-controls. While non-injured patients may serve as reasonable control subjects in some respects related to both known and unknown demographic and associated characteristics of cliente seeking services at a given emergency room, previous research has found that non-injured patients tend to be heavier drinkers and to report more alcohol-related problems than those in the general population from which they come (Cherpitel, 1993b). While the use of non-injured patients as control subjects in this analysis would lead to conservative estimates of the predictive value of BAC and self-report on admission to the ER with an injury, it also could potentially affect the interactions of drinking in the event and usual drinking patterns on the likelihood of injury.

BAC and self-report do not necessarily cover the same time period, particularly for those arriving at the ED well after the injury event, and as two independent measures would not necessarily be expected to provide similar results across outcomes. Findings related to BAC and self-reported consumption were of similar magnitude, however, and the concordance of these two measures serves to reinforce the veracity of findings reported here. In analysis of neither BAC nor self-reported consumption were variables quantified. As mentioned earlier, estimated odds of injury did not appear to increase significantly for BAC levels >0.01. While the total amount of alcohol consumed during the 6 h period prior to injury would be potentially important to consider for a better understanding of the association of alcohol and injury, these data were not available and this awaits future analysis. Although data collection occurred across studies spanning a 19 year period (1984–2003), findings here shed light on patterns of drinking in general, and is important to consider in addition to drinking characteristics of the individual in planning and implementing prevention strategies to reduce alcohol-related injury.

Acknowledgements—We thank Alicia Rodriguez-Martos for assisting in collection of the contextual data for Barcelona, Spain. We acknowledge the statistician who reviewed the paper for his thoughtful comments regarding an appendix to describe the analytic models algebraically. This paper is based on data collected by the following collaborators participating in the Emergency Room Collaborative Alcohol Analysis Project (ERCAAP): Guillerme Borges, Mariana Cremente, Norman Giesbrecht, Scott Macdonald, Jacek Moskalewicz and Grazyna Swiatkiewicz. This study was supported by a National Alcohol Research Center grant AA 05595-21 from the National Institute on Alcohol Abuse and Alcoholism. The paper was presented at the American Public Health Association Annual Meeting, San Francisco, November 15–19, 2003.

REFERENCES


APPENDIX

Model I

Level 1: \( \logit(y_{ij}) = \beta_0 + \beta_1 x_{ij} \)

Level 2:

\[
\begin{pmatrix}
\beta_0 \\
\beta_1
\end{pmatrix} \\
\sim N\left( \begin{pmatrix}
0 \\
0
\end{pmatrix}, \begin{pmatrix}
\sigma_{\beta 0} & \sigma_{\beta 01} \\
\sigma_{\beta 01} & \sigma_{\beta 1}
\end{pmatrix} \right)
\]
where $y_{ij}$ is the patient probability of injury and $x_{1ij}$ is an indicator variable for positive BAC or self report. Estimates of $\beta_0$ (intercept), $\beta_1$ (BAC/self report), and $\sigma^2_{\alpha_1}$ (BAC/self report variance) are presented in Tables 2 and 3.

**Model 2**

Level 1: $\logit(y_{ij}) = \beta_0 + \beta_1 x_{1ij} + \beta_2 \text{sex}_{ij} + \beta_3 \text{age}_{ij}$

Level 2 for Model 2 is the same as that for Model 1, where $\beta_0$, $\beta_1$, $\beta_2$, $\beta_3$ and $\sigma^2_{\alpha_1}$ are presented in Tables 2 and 3.

**Model 3**

Level 1:

$$\logit(y_{ij}) = \beta_0 + \beta_1 x_{1ij} + \beta_2 \text{sex}_{ij} + \beta_3 \text{age}_{ij} + \beta_4 \text{usual\_frequency}_{ij} + \beta_5 x_{ij} \times \text{usual\_frequency}_{ij}$$

Level 2 for Model 3 is the same as that for Model 1. Estimates of $\beta_5$ (the interaction of BAC/self-report with usual frequency) are presented in Tables 2 and 3. Usual frequency refers to any weekly, 5+ weekly, 5+ monthly, 5+ last year.

**Model 4**

Level 1 for Model 4 is the same as that for Model 2

Level 2: $\begin{align*}
\beta_{0j} &= \beta_0 + \beta_6 \text{contextual}_{j} + \mu_{0j} \\
\beta_{1j} &= \beta_1 + \beta_6 \text{contextual}_{j} + \mu_{1j}
\end{align*}$

$$\begin{pmatrix}
\mu_{0j} \\
\mu_{1j}
\end{pmatrix} \sim \mathcal{N}\left(\begin{pmatrix}
0 \\
0
\end{pmatrix}, \begin{pmatrix}
\sigma^2_{\mu_0} & \sigma_{\mu_{01}} \\
\sigma_{\mu_{01}} & \sigma^2_{\mu_1}
\end{pmatrix}\right)$$

Estimates of $\beta_7$ and $\sigma^2_{\alpha_i}$ are presented in Tables 2 and 3. Contextual refers to level two contextual variables.