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## CHANGES IN CLASSES OF INJURY-RELATED RISKS AND CONSEQUENCES OF ALCOHOL MISUSE: A LATENT TRANSITION ANALYSIS

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### Abstract

Risk-level drinking, drinking and driving, and alcohol-related violence are risk factors that result in injuries. The current study sought to identify which subgroups of patients experience the most behavioral change following a brief intervention. A secondary analysis of data from a brief alcohol intervention study was conducted. The sample (N=664) includes at-risk drinkers who experienced an injury and were admitted for care to a Level-1 trauma center. Injury-related items from the Short Inventory of Problems+6 were used to perform a latent transition analysis to describe class transitions participants experienced following discharge. Four classes emerged for the year before and after the current injury. Most individuals transitioned from higher risk classes into those with lower risk. Some participants maintained risky profiles, and others increased risks and consequences. Drinking and driving remained a persistent problem among study participants. Although a large portion of intervention recipients improved risks and consequences of alcohol use following discharge, more intensive intervention services may be needed for a subset of patients who showed little or no improvement.

### Keywords

Screening and brief intervention; alcohol; injury; latent transition analysis

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### Conflicts of Interests

None

## Introduction

### Alcohol and Injury

Drinking at or above risk levels defined by the National Institute on Alcohol Abuse and Alcoholism (NIAAA, i.e., men: 5 drinks/day or 15 drinks/week; women: 4 drinks/day or 8 drinks/week)<sup>1</sup> is the primary risk factor for injury in the US<sup>2</sup> and is a major predictor of emergency<sup>3</sup> and trauma care.<sup>4</sup> In addition to risky drinking and injury, drinking and driving is a major contributor to non-fatal injury and is a significant predictor of injury cases admitted to trauma centers.<sup>5, 6</sup> Nearly one-third of motor vehicle crashes involving alcohol result in injury.<sup>7</sup> Alcohol use and violence are also primary predictors of injury.<sup>8–13</sup> Violent offenses are often perpetrated by intoxicated individuals or are perpetrated on individuals who have been drinking.<sup>10, 14</sup> Injury related risk behaviors, commonly associated with drinking, significantly contribute to the impact of alcohol use on public health.

Most people with alcohol use disorders do not receive help.<sup>15</sup> In specific terms, roughly 90 percent of individuals in the US who needed treatment in 2008 for alcohol problems did not receive care.<sup>15</sup> Screening and brief intervention (SBI) has been developed and tested in an effort to reduce alcohol-related injury or prevent their reoccurrence. SBI for injured individuals has been shown to reduce drinking,<sup>16–20</sup> injury,<sup>21</sup> drinking and driving,<sup>22</sup> and drunk driving arrests.<sup>23</sup> SBI for injured patients has also been demonstrated to increase the numbers of individuals who seek treatment for alcohol problems.<sup>20, 24</sup> Research also indicates, however, that SBI does not clearly help all injured patients. Some studies have shown no significant changes in alcohol use reduction,<sup>25–28</sup> alcohol-related adverse driving events,<sup>29–31</sup> or future injury.<sup>32</sup> Meta-analyses and systematic reviews of SBI for injured patients have also reported mixed results for the efficacy of SBI among injured patients.<sup>33–35</sup>

### Analytical Advancement

In light of the mixed evidence for the effectiveness of SBI among injured patients, it may be helpful to extend the field's current understanding regarding which intervention recipients experience the greatest change following discharge. Some secondary analyses have demonstrated promise for identifying how SBI can help specific subgroups of individuals;<sup>36–40</sup> though, these analyses often do not capture the complex nature of alcohol-related injury and associated behaviors. It is evident from the literature that risk level alcohol use, drinking and driving, and alcohol-related violence have some interrelationship in often times lead to the need for injury care. What is not clear is how these behavioral factors for injury patients who receive SBI may combine to form patient profiles and if individuals with different profiles improve or worsen over time.

A potentially more complete approach for understanding changes among those receiving SBI is latent variable statistical modeling; that is to say, statistical models that work to identify unseen or unobserved constructs by combining a set of indicator variables.<sup>41–43</sup> A method of latent variable modeling that could be especially helpful in the analysis and interpretation of findings from SBI studies is mixture modeling. Mixtures are used to draw out latent (or unobserved) subgroups or "classes" of individuals that exist within the data

based on multiple indicators<sup>43, 44</sup> and then capture changes that transpire among those groups across time.<sup>45, 46</sup> The purpose of this secondary analysis was to develop longitudinal injury-related consequence and risk behavior profiles based on seven items from the Short Inventory of Problems (SIP)+6,<sup>47</sup> and then to assess the changes patients with the different profiles experienced following the receipt of a brief alcohol intervention and discharge from a trauma center. The findings herein provide a clearer picture of the combination of risks and consequences individuals experience and then depict what changes in those behaviors are manifest across time.

## Materials and Methods

### Data Source

Data from a SBI randomized clinical trial conducted in a Level-1 trauma department were used in this project (NIAAA, R01 013824). The consort chart, specific methods of participant recruitment, and detailed descriptions of experimental and control conditions for this trial have been reported elsewhere.<sup>32, 48</sup> All study participants were adults (≥ 18 years) who suffered a traumatic injury, were admitted to a Level-1 trauma center, and screened positive for risk-level drinking. Specifically, patients recruited for participation in the study had a clinical indication of intoxication upon admission to the trauma center (but not intoxicated at the time of recruitment), reported drinking six hours before the injury event, reported drinking at NIAAA risk levels,<sup>1</sup> or responded positively to one or more items of the CAGE.<sup>49, 50</sup> Informed consent was obtained from participants according to procedures approved by the university and medical center Institutional Review Boards. Following consent, participants were assigned to receive a brief motivational intervention or treatment as usual. The brief intervention consisted of a 15–30 minute brief motivational interviewing session between patients and study interventionists, and treatment as usual included patients receiving information only. This dataset contains 1,493 cases and includes self-reported information from baseline, six-, and 12-month assessments regarding alcohol use and alcohol risk information. The sample is comprised of 1,231 men and 262 women, of whom 668 are White, 288 are Black, and 537 are Hispanic. Follow up rates in this study have been reported elsewhere and are comparable to other brief intervention clinical trials.<sup>48</sup>

The main outcomes from the original trial found time effects for alcohol use<sup>48</sup> among both groups and significant interaction effects for reductions in drinking among Hispanics<sup>48</sup> and those dependent on alcohol.<sup>37</sup> Data from the experimental group only were used in the present study because the intent of the current project was to conduct a descriptive longitudinal analysis of transitions among individual behavioral profiles based on injury-related consequence and risks of risk-level drinking for those participants who received SBI. In other words—the purpose of this project was to describe if individual intervention recipients' profiles improved, stayed the same, or worsened following discharge from the trauma center.

### Model and Analytic Approach

The specific mixture modeling approach selected for this project was latent transition analysis (LTA).<sup>45, 46, 51</sup> LTA models are longitudinal applications of cross-sectional latent

class analyses (LCA). LCAs are statistical models that identify unique subgroups or profiles based on similar responses to variables from within a single population of individuals.<sup>44, 45, 52, 53</sup> LTA was selected as the analytical approach for this project in order to describe the transition patterns between latent classes of intervention recipients from the year before and after participants current injury admission and discharge. The LTA carried out in this project followed modeling building procedures outlined in the literature<sup>53,54,59</sup> by first establishing cross-sectional LCAs of injury-related risks and consequences at the two different time points and then incorporating those models into a single LTA model.

The first LCA model depicts subclasses of participant injury-related risks and consequences assessed at baseline of the SBI study. Specifically, this baseline model depicts participants' risks and consequences profiles in the year prior to admission to the trauma center. The second LCA model depicts participants' profiles based on the 12-month follow up assessment and includes the same risks and consequences captured in the first model, but for the year after discharge. These cross-sectional latent class models were established using the Akaike Information Criterion (AIC), Adjusted Bayesian Information Criterion (ABIC), and Bootstrapped Likelihood Ratio Test (BLRT).<sup>46, 51, 54</sup> Following the establishment of the cross-sectional LCAs, these models were combined into a single LTA longitudinal model to examine if transitions between behavioral profiles occurred (i.e., if individuals who were categorized within a class at time-one transitioned into another class at time-two).

Models parameters for the LTA were freely estimated, without imposing full or partial model constraints.<sup>45, 46</sup> Imposing parameter constraints forces profiles to take on specific attributes. In the current analysis, for instance, imposing full constraints on the time-two model based on information from the time-one model would cause the classes from the both models to exactly mirror one another. The decision to allow the classes to estimate freely in the current analysis was based on the assessment of differences in the classes<sup>46</sup> at time-one compared to time-two. The free estimation of parameter values was judged for this LTA to have the ability to represent the most accurate changes among study participants by not forcing profiles and transitions to fit specific requirements. All analyses were conducted using Mplus 6.<sup>55</sup> In addition to the latent models developed and tested, descriptive analyses of participant demographic characteristics were calculated using IBM SPSS 19<sup>56</sup> and are reported.

### Variables and Sample Size

Table 1 contains the variables utilized in the cross-sectional measurement models. Items from the SIP+6 were selected for analysis in this study.<sup>47,57</sup> The seven items selected from the SIP+6 are the injury-related risks consequences of risk-level drinking that are among those identified factors that lead to emergency and trauma care.<sup>28, 58, 59</sup> Each of the seven items were yes (coded as 1) and no (coded as 0) statements, indicating the participants had participated in the behavior or not. The time periods measured the 12-month period prior to patients' current trauma center admission and 12 months after discharge. For the 12 months previous to the injury admission, the Cronbach's alpha for the seven indicators was 0.84, and for the 12 months following discharge, the alpha was 0.70. Validity of these seven items

has not been specifically examined. However, previous research has established validity and reliability for the full measure containing all items from the SIP+6.<sup>60</sup>

In terms of number of cases required to adequately power the model estimated, a standard convention for latent variable modeling with multiple time points suggests approximately five to ten cases per parameter estimated.<sup>61</sup> The LTA in the current project contains 71 parameters. Therefore, the current sample (N=664) contains sufficient cases for model estimation.

## Results

### Study Sample and Characteristics

The total number of participants who were assigned to the intervention group at baseline was 737. However, due to attrition at follow up in the parent study, 73 participants were missing all data in the combined six- and 12-month follow up assessments. Therefore, 664 participants were included in the current LTA. These participants were mostly males (n=571, 86%), and their average age was 33 years (SD=11.5). Whites were the largest racial/ethnic group (n=303, 45.6%) followed by Hispanic (n=228, 34.3%) and Black (n=133, 20%, 20.1%) participants. Approximately one-third of participants were married (n=188, 28.3%), had a high school diploma/GED (n=241, 36.3%) or some high school education (n=245, 36.9%), and were not employed (n=211, 31.8%). Most injuries participants sustained were unintentional (n=522, 78.6%), and participants reported heavy drinking an average of 62 percent of days in the previous year (SD=0.4), with an average maximum amount consumed of 14 (SD=10.9) standard drinks (about 0.6 fluid ounces of pure alcohol, e.g. one 12 ounces of beer or 5 ounces of table wine).

Proportional and mean difference tests (results not shown) were conducted to examine whether demographic characteristics for participants assigned to receive the intervention at baseline (N=737) and those participants who were included in the present LTA (N=664) differed significantly. Similar to the significant follow up differences reported in the main outcomes paper of the parent study by Field et al.,<sup>48</sup> Hispanic (standardized residual=1.8) participants included in the LTA were more likely ( $\chi^2=6.9$ ,  $df=2$ ,  $p=0.04$ ) to have not completed the follow ups compared to White (standardized residual = -1.6) and Black (standardized residual =0.1) participants. No other significant differences emerged between participants who received the intervention at baseline and those included in the current study.

### Classes and Conditional Item Probabilities

Four classes of participants were identified in the year before the current injury and in the year after the current injury (see Table 2). Figures 1 and 2 plot the conditional item probabilities for each time point for the four class solutions. The four classes for time-one were labeled: time-1 high-risk, time-1 injury and accident history, time-1 drinking and driving foolish risk, and time-1 low-risk class. The classes for time-two were labeled: time-2 high-risk class, time-2 fighting and injury, time-2 drinking and driving foolish risk, and

time-2 low-risk (Class labels are the authors' attempts at describing the class characteristics using the minimum amount of words; as a result, these labels may be somewhat subjective).

### Year Prior to Injury

Figure 1 contains the class profiles for the year prior to the injury. The first class is labeled the time-1 high-risk class. This class contains 341 individuals (51.3%) and represents the group with the highest probabilities of endorsing each of the seven SIP+6 items. All time-1 high-risk class members endorsed four of the seven items at 100 percent; the item with the lowest probability of endorsement in the time-1 high-risk class was drunk driving arrests, with a 63 percent probability of endorsement. The second class is labeled the time-1 injury and accident history class. This class contains 143 (21.5%) individuals. All 143 members had injured themselves while drinking in the year before their current injury admission, and they were the second most likely of any class to have experienced an accident (76.3%) and to have injured others (72.3%). The third class is labeled the time-1 drinking and driving foolish risk class. This class contains 25 individuals (4%). Nearly all class members had driven after drinking (95.3%); all had done foolish things while drinking, and over three-quarters had been in fights (77.9%). The last class was labeled the time-1 low-risk class. This class included 155 (23.3%) individuals. These study participants had the lowest probabilities of endorsements of each of the seven SIP+6 items compared to the other classes, with having an accident (39.6%) being the highest item probability in the class.

### Year after Injury

Figure 2 contains the class profiles for the year following the injury and discharge from the trauma center (although the following class labels possess some overlap between the year prior to and after the injury, the labels are not intended to imply that the classes are exactly similar in constitution). The first class is labeled the time-2 high-risk class. This class contains 22 individuals (3.3%). The time-2 high-risk class of individuals contained the highest probabilities of item endorsement, with all class members endorsing three items at 100 percent; the lowest probability of item endorsement in class time-2 high-risk class was injuring others, at 25 percent. The second class was labeled the time-2 fighting and injury class. This class contains 23 study participants (3.4%). All members of this class had been in fights while drinking, and this class had the highest probability of injuring others (80.8%) and the second highest probability of injuring self (73%). The third class was labeled the time-2 drinking and driving foolish risk class. This class contains 359 individuals (54.1%). This class was primarily characterized by drinking and driving (79.9%) and doing foolish things while drinking (64%). The fourth class was labeled the time-2 low-risk class. This class contains 260 individuals (39.2%), with most individuals endorsing none of the risk consequences except for drinking and driving, which had a 21.3 percent probability of endorsement.

### Transitions

As is shown in Table 3, the largest number of participants who transitioned from one profile to another were those 310 individuals who moved from the time-1 high-risk class into the time-2 drinking and driving foolish risk class (a class with some of the lowest risk at time-two with the exception of drinking and driving and foolish risks while drinking). Another



transition for the time-1 high-risk class included members transitioning into the time-2 high-risk class (4.4% n=15) and the time-2 fighting and injury class (4.4% n=15). Nearly all individuals in the time-1 injury and accident history class moved to the time-2 low-risk class (94.4%; n=135). Individuals in the time-1 injury and accident history class also transitioned into the time-2 high-risk class (4.2%, n=6) and time-2 fighting and injury class (1.4%, n=2). The only transition that occurred for the time-1 drinking and driving foolish risk class was that each of these participants moved into the time-2 drinking and driving foolish risk class. Members of the time-1 low-risk class transitioned into the time-2 low-risk class (80%, n=124), the time-2 fighting and injury class (3.9%, n=6), and the time-2 drinking and driving foolish risk (15.5%, n=24).

## Discussion

The results of this latent transition analysis demonstrated that four groups of individuals experienced injury-related risks and consequences of risk-level drinking in the year before and the year following their current injury and intervention. This study also demonstrated many individuals transition from baseline classifications into other groups across time—with most transitions appearing to be in many respects positive. Such transitions represent positive patient improvement that could be the base of reinforcement within intervention sessions aimed at encouraging additional change and improvement. Nevertheless, other transitions demonstrated marginal improvement and indicate possibly needed future research examine methods to enhance more positive transitions.

The results of this study possibly illuminate previously reported mixed findings of SBI studies. For instance, time-1 low risk participants either stayed low risk or became worse at time-two. While remaining low risk is desirable, such transitions raise potential questions regarding whether low risk groups who remain low risk possibly washout treatment effects in clinical studies. Future research should compare the influence of these latent classes and transitions in relation to participants in control conditions.

The findings herein also appear to be consistent with those previously reported that have demonstrated individuals with higher levels of alcohol use severity make substantial changes following the receipt of a brief intervention.<sup>37</sup> Indeed, while some studies have struggled to identify clear improvements for alcohol use among injured populations,<sup>28</sup> the combination of alcohol-related risks and consequences may better describe the constellation of changes individuals experience following an injury and SBI. However, the current application of latent transition analysis is new to the SBI field, and therefore, the results of this secondary analysis are provisional and require further replication in order to substantiate its findings. Such replications would provide important evidence to support the reliability of the results of this study.

## Translation into Practice via EHR

This study provides a first glimpse into the classes that exist among a sample of injured patients who drink at risk levels. If future research can replicate the findings herein with extensions to models that better examine and explain potential causal relationships, clinical applications of how to actually determine classes at the bedside would be important. Both

the Affordable Care Act and the HITECH legislation include important mandates that direct the establishment and integration of electronic health records (EHR) into practice in order to coordinate, facilitate, and improve patient care.<sup>62-64</sup> It is in such a record keeping environment that mixture model algorithms (such as those used in the current LTA) could be imbedded so as to provide class assignment output to clinicians following the entry into an EHR system of patient responses to the seven items used in this analysis. Further, information systems like the National Trauma Data Bank<sup>65</sup> could also be adapted to interface with EHRs and provide a nationally representative sample of profiles to providers within clinical settings. In addition to class assignment, personalized feedback could also be provided as part of output delivered to clinicians for patients. Personalized feedback based on transition probabilities could guide providers to tailor interventions to include topics such as drinking and driving and/or warning of possible continued or increased risk.

### Drinking and Driving

A majority of patients nearly eliminated DUI arrests in the year after discharge. This result appears to be consistent with findings from previous studies that have also documented improvements in drinking and driving-related arrests following SBI.<sup>23, 66</sup> Furthermore, both Monti et al.<sup>22</sup> and Runge et al.<sup>24</sup> have previously reported that individuals who experienced car crashes and subsequently received care in an emergency or trauma settings experience significant improvements following SBI. While the current study does not include car crashes as an indicator, the findings herein possibly support these previous studies and suggest that future research should include alcohol-related car crashes as a profile indicator that is likely influential in class membership and class transitions across time.

However, despite the improvement noted in the current study for drinking and driving arrests and possible future directions for research for motor vehicle crashes, a large portion of the current study participants reported driving after consuming three or more drinks in the year following their discharge from the trauma center. Given the lethal potential for drinking and driving, further research is needed to elucidate why DUI arrests appear to improve but drinking and driving remains problematic. However, regardless of why differences between DUI arrests and drinking and driving episodes may exist, clinicians delivering SBI may nevertheless consider a universal inclusion of drinking and driving as a part of intervention sessions with patients. Some limited drinking and driving messaging already exists within SBI guides produced by the American College of Surgeons as well as the American Public Health Association.<sup>67, 68</sup> If drinking and driving messaging becomes standard in SBI guides and practice, future episodes possibly may be prevented.

### Limitations

Strengths of this study include the new application of LTA modeling to brief intervention analysis and the identification of previously unknown subgroups of patients and their improvements following the receipt of SBI. In spite of these strengths, the parent trial upon which the current project was based was not designed to answer the specific questions addressed in this secondary analysis. Given this novel application of LTA in a secondary analysis, classes and transition probabilities were allowed to estimate freely. Though this approach provides the clearest statistical picture of changes among injury-related risks and



consequences classes, class transitions and conditional item probabilities are more difficult to interpret as they are not uniform across time. Future analyses may benefit from using information from the present or similar studies in examining models for which some level of invariance is imposed to increase uniformity and facilitate interpretation of results. Aside from possible challenges in analysis and interpretation, three of the classes that emerged from the data were relatively small in size, ranging from 3.3 to 4 percent of the sample. These smaller classes raise the question of whether these groups are artifacts of the analysis or true subgroupings. Replication of the current study would alleviate this uncertainty. However, given the fact that two of these smaller classes were groups at time two with higher levels of risk, these small class sizes may represent positive findings of desired behavior changes among patients.

## Conclusion

Exceeding NIAAA risk drinking guidelines, driving under the influence of alcohol, and alcohol-related violence are among the primary risk factors that result in injuries that require medical care in the nation's emergency and trauma centers. It is not clear from the extant research literature which individuals make positive changes following the receipt of brief interventions. The current study sought to identify which groups of individuals experience the most behavioral change following a brief intervention. The LTA conducted in this study demonstrated that four subclasses of participants could be identified in the year before and the year after the intervention based on injury-related risks and consequences classes.

Most individuals transitioned from classes with higher endorsements of injury-related risk and consequences into classes with lower endorsements. Nevertheless, drinking and driving remains a persistent issue in the year following the SBI service delivery. Replications of these findings could provide the necessary support for accreditation or practice level enhancements to deliver specific drinking and driving information to patients. Additionally, some transition classes experienced little or no positive change from time-one to time-two. Future research should focus on how to better service those whose behavioral profiles do not improve following SBI services and discharge. Such evidence can be used to likewise improve accreditation standards and service delivery for injured patients who drink at risk levels.

## Implications for Behavioral Health

Trauma centers are among the key locations for the delivery of SBI for injured individuals who exceed risk-drinking thresholds. However, these locations are often among those that struggle with financial viability.<sup>69-71</sup> Furthermore, the research evidence is not clear regarding which injured patients benefit the most from SBI services. Therefore, limited behavioral health resources are being delivered without a clear understanding patient benefit. The findings of this paper suggest that specific subgroups of patients exist who receive SBI, and some of those subgroups improve more than others. Possessing a clearer understanding of which patients improve to the greatest extent following discharge stands to improve patient care and costs for health systems.

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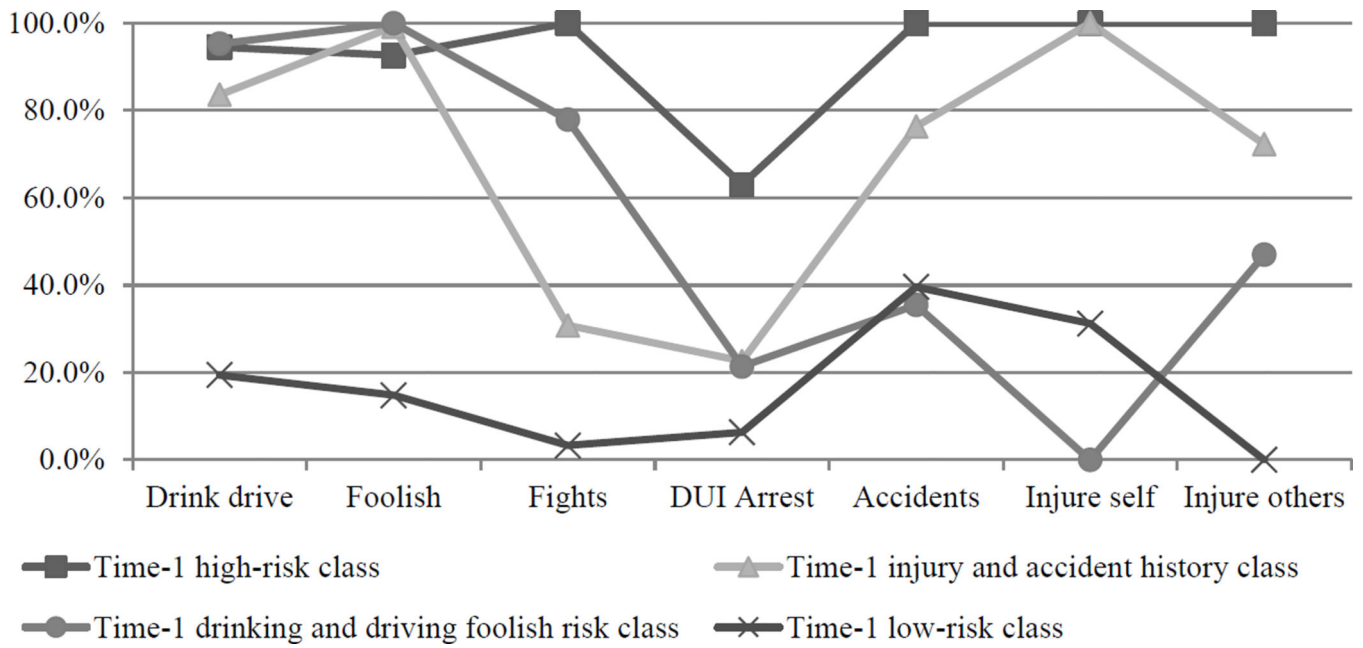
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**Figure 1.**  
 Conditional item probabilities for four class solution one year before SBI

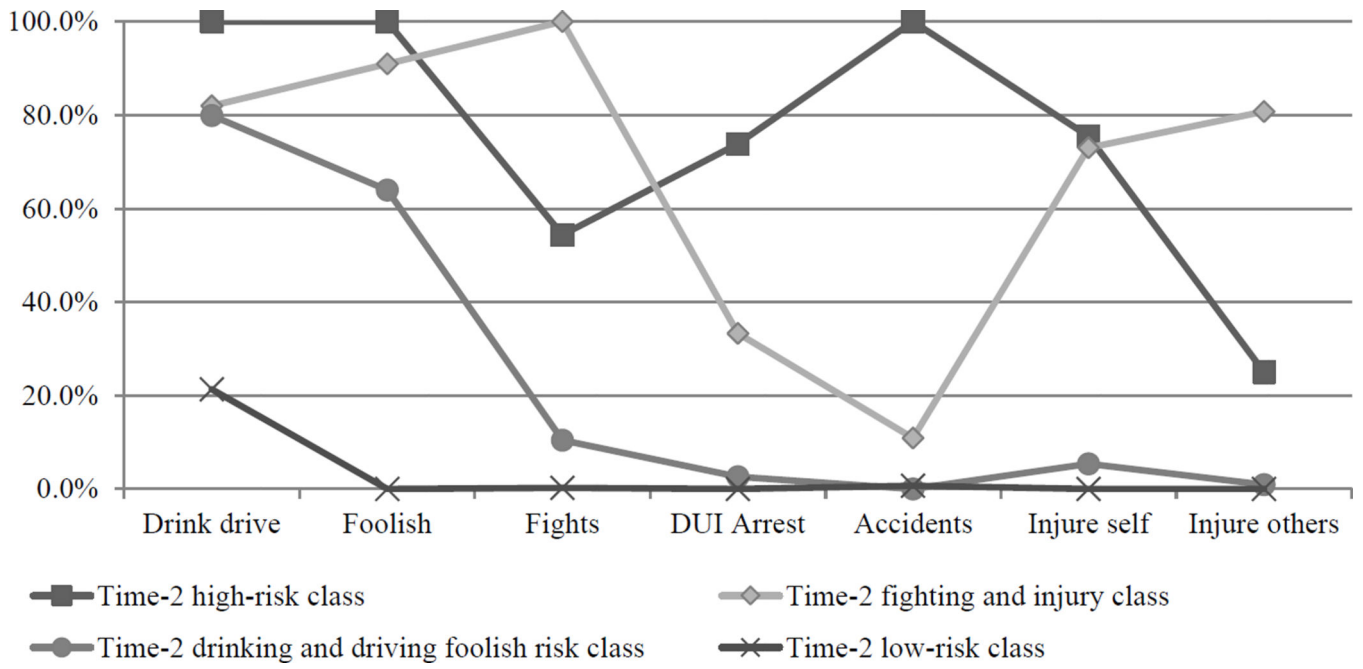
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**Figure 2.** Conditional item probabilities for four class solution one year after SBI

**Table 1**

Observed indicators from 12 months before and after SBI

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<b>Observed Indicator</b>
I have driven a motor vehicle after having three or more drinks (SIP+6)
I have taken foolish risks when I have been drinking (SIP)
I have gotten into a physical fight while drinking (SIP+6)
I have been arrested for driving under the influence of alcohol (SIP+6)
I have had an accident while drinking or intoxicated (SIP)
While drinking or intoxicated, I have been physically hurt, injured or burned (SIP+6)
While drinking or intoxicated, I have injured someone else (SIP+6)

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**Table 2**

Numbers of classes identified from data

12 months before SBI				
Classes	AIC	ABIC	BLRT	
2	1749.87	1768.11	0.00	
3	1736.90	1764.86	0.00	
<b>4</b>	<b>1735.18</b>	1772.86	<b>0.02</b>	
5	1742.55	1789.95	0.37	
12 months after SBI				
2	1472.35	1483.82	0.00	
3	1433.99	1451.58	0.00	
<b>4</b>	<b>1423.86</b>	<b>1447.56</b>	<b>0.00</b>	
5	1429.73	1459.56	0.50	

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**Table 3**

Percent of classes transitioning (total individuals in transition class)

Baseline classes	Year following injury and intervention classes			
	Time-2 high risk	Time-2 fighting and injury class	Time-2 drinking and driving foolish risk	Time-2 low risk
Time-1 high risk	4.4% (15)	4.4% (15)	90.9% (310)	0.3% (1)
Time-1 injury and accident history	4.2% (6)	1.4% (2)	0% (0)	94.4% (135)
Time-1 drinking and driving foolish risk	0.0% (0)	0.0% (0)	100% (25)	0.0% (0)
Time-1 low risk	0.6% (1)	3.9% (6)	15.5% (24)	80.0% (124)

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