## ARTICLE IN PRE

Journal of Safety Research xxx (2016) xxx-xxx



Contents lists available at ScienceDirect

## Journal of Safety Research



journal homepage: www.elsevier.com/locate/jsr

### Marijuana-, alcohol-, and drug-impaired driving among emerging adults: Changes from high school to one-year post-high school

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#### 8 ARTICLE INFO

Article history: 9 10 Received 21 September 2015 Received in revised form 20 April 2016 11 Accepted 26 May 2016 1213 Available online xxxx 15 41 Kevwords: 42 Adolescents 43Impaired driving Alcohol drinking 44

- 45Marijuana use 46
- Illicit drug use

#### ABSTRACT

Introduction: Driving while impaired (DWI) increases the risk of a motor vehicle crash by impairing performance. 19 Few studies have examined the prevalence and predictors of marijuana, alcohol, and drug-specific DWI among 20 emerging adults. *Methods*: The data from wave 3 (W3, high school seniors, 2012, N = 2407) and wave 4 (W4, 21 one year after high school, N = 2178) of the NEXT Generation Health Study with a nationally representative co- 22 hort. W4 DWI (≥1 day of past 30 days) was specified for alcohol-specific, marijuana-specific, alcohol/marijuana-23 combined, illicit drug-related DWI. Multinomial logistic regression models estimated the association of W4 DWI 24 with W3 covariates (perceived peer/parent influence, drinking/binge drinking, marijuana/illicit drug use), and 25 W4 environmental status variables (work/school/residence) adjusting for W3 overall DWI, demographic, and 26 complex survey variables. Results: Overall DWI prevalence from W3 to W4 changed slightly (14% to 15%). W4 27 DWI consisted of 4.34% drinking-specific, 5.02% marijuana-specific, 2.41% drinking/marijuana combined, and 28 3.37% illicit drug-related DWI. W3 DWI was significantly associated with W4 alcohol-related and alcohol/ 29 marijuana-combined DWI, but not other DWI. W3 marijuana use, binge drinking, and illicit drug use were positive- 30 ly associated with W4 marijuana-specific, alcohol/marijuana-combined, and illicit drug-related DWI, respectively. 31 W3 friend drunkenness and marijuana use were positively associated with W4 alcohol-specific and marijuana- 32 related DWI, respectively. W3 peer marijuana use was negatively associated with W4 alcohol-specific DWI. 33 Conclusions: Driving under the influence of alcohol, marijuana, and illicit drugs is a persistent, threatening public 34 health concern among emerging U.S. adults. High school seniors' binge drinking as well as regular alcohol drinking 35 and marijuana/illicit drug use were independently associated with respective DWI one year after high school. 36 Peer drunkenness and marijuana use in high school may be related to subsequent DWI of emerging adults. 37 Practical applications: The results support the use of injunctive peer norms about getting drunk and smoking 38 marijuana in guiding the development of prevention programs to reduce youth DWI. 39

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#### 1. Introduction 51

52Motor vehicle crashes are the leading cause of death among U.S. teenagers (Centers for Disease Control and Prevention [CDC], 2009a). 53Driving while alcohol- or illicit drug-impaired (DWI) increases the risk 5455of a motor vehicle crash by impairing performance (Hingson, Heeren, Levenson, Jamanka, & Voas, 2002). This effect is particularly problematic 56 among adolescents; alcohol-impaired youth are five times more likely 5758to experience a motor vehicle crash compared to alcohol-impaired 59adults (Peck, Gebers, Voas, & Romano, 2008). Among high school (HS) 60 students, the national prevalence estimates of drinking and driving range from 9% (Centers for Disease Control and Prevention, 2009b; 61

http://dx.doi.org/10.1016/j.jsr.2016.05.003 0022-4375/© 2016 Published by Elsevier Ltd. O'Malley & Johnston, 2013) to 12.5% (Li, Simons-Morton, & Hingson, 62 2013) in the past 30 days. Less data, however, are available on the 63 prevalence of substance-specific DWI. One nationally representative 64 study reported the prevalence of driving after marijuana, illicit drug, 65 or alcohol use among HS seniors (O'Malley & Johnston, 2013). However, 66 prevalence studies drawing conclusions from nationally representative 67 samples are scarce with regard to substance-specific DWI among 68 emerging adults (Fromme, Wetherill, & Neal, 2010; Kohn, Saleheen, 69 Borrup, Rogers, & Lapidus, 2014; Whitehill, Rivara, & Moreno, 2014). 70

Findings from previous studies have identified several individual 71 and social factors associated with adolescent DWI, including male gen-72 der (Sabel, Bensley, & Van Eenwyk, 2004), risky driving (Li et al., 2013), 73 riding with an alcohol/drug-impaired driver (Sabel et al., 2004), poor 74 family relationships (Dols et al., 2010), and previous driving offenses 75 (Copeland, Shope, & Waller, 1996). Studies examining factors associated 76 with DWI are lacking among young adults. 77

Please cite this article as: Li, K., et al., Marijuana-, alcohol-, and drug-impaired driving among emerging adults: Changes from high school to oneyear post-high school, Journal of Safety Research (2016), http://dx.doi.org/10.1016/j.jsr.2016.05.003

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78 In addition, there is a large body of research investigating socio-79environmental predictors of substance abuse among young adults. It is well known that the transition from HS to post-HS is characterized by 80 81 increased levels of substance use (Bachman, Wadsworth, O'Malley, Johnston, & Schulenberg, 2013). Facilitating factors, such as leaving 82 home and going to college, are associated with increased levels of sub-83 stance use. Previous research has identified factors protective against 84 85 this detrimental trend, such as having fewer substance-using friends 86 and higher parental monitoring (White et al., 2006). It is possible that 87 risk and protective factors influencing substance use such as alcohol 88 use/heavy drinking (Schulenberg & Maggs, 2002), smoking (Anda et al., 1999), drug use (Kandel & Logan, 1984), may be in turn related 89 to DWI during the transition from HS to emerging adulthood. To our 90 91knowledge, no studies have examined the predictive association between socio-environmental variables and DWI one year after HS. 92

Accordingly, it is reasonable to hypothesize, that environmental changes occurring during the transition from HS to post-HS may influence levels of DWI. Previous research has indicated that both facilitating and protective factors associated with substance use may be modified by environmental changes (Bertrand et al., 2013; Sloboda, Glantz, & Tarter, 2012). However, the extent to which changes in post-HS environment may affect DWI is unclear.

Given the paucity of research examining DWI among young adults, the purpose of this study was to examine the prevalence and predictors of DWI in the 12th grade, the first year most study participants were fully licensed to drive (no restrictions), and one year after HS using a nationally representative sample of U.S. youth.

#### 105 2. Methods

#### 106 2.1. Sampling

107Data for this study were from waves 3 (W3) and 4 (W4) (12th grade and one year after HS) of the NEXT Generation Health Study, a national-108 ly representative longitudinal study with a probability cohort starting in 109the 2009-2010 school year in the United States (Li, Iannotti, Haynie, 110 Perlus, & Simons-Morton, 2014; Li, Simons-Morton, Brooks-Russell, 111 Ehsani, & Hingson, 2014). Primary sampling units were stratified by 112 the nine census divisions. Within each census division, the sample of 113 primary sampling units was first selected with probability proportional 114 to the total enrollment. Within each selected primary sampling unit, 115137 schools with 10th grade (W1) were randomly recruited, and 81 116 agreed to participate. We then randomly selected 10th grade classes 117 within each selected school and recruited 3796 students to participate. 118 From W1 to W4, a total of 2785 participants completed the survey. Out 119 of a total of 2785 participants, 86% (N = 2407) and 78% (N = 2178) 120121 completed the survey in W3 and W4. Parental consent or participant's assent was obtained; participant consent was obtained upon turning 12218. African American participants were oversampled to provide better 123population estimates and to provide an adequate sample to examine 124racial/ethnic differences. The study protocol was approved by the 125126Institutional Review Board of the Eunice Kennedy Shriver National Insti-127tute of Child Health and Human Development, and the questionnaires were administrated in the spring semester in each school year. 128

#### 129 2.2. Measures

2.2.1. Driving while alcohol- or illicit drug-impaired (DWI, W3, and W4) 130In W3, DWI was assessed with a single overall DWI item which 131 asked participants how many days they drove after drinking alcohol 132or using illicit drugs in the past 30 days (recoded as a dichotomous 133 variable due to the high skewness of the distribution:  $DWI \ge 1$  day vs. 134no DWI in the past 30 days). In W4, three substance-specific DWI items 135were collected to individually capture driving after alcohol, marijuana, 136 or illicit drug use in the past 30 days. We created a 5-group categorical 137 138 variable (alcohol-specific [did not include any other drugs], marijuanaspecific [did not include any other drugs], alcohol/marijuana-combined, 139 illicit drug-related [illicit drug only or illicit drug + alcohol or/and 140 marijuana] DWI  $\geq$  1 day vs. no DWI in the past 30 days) as the outcome 141 variable. W4 DWI was used as the outcome variable and W3 DWI was 142 used as a covariate. 143

2.2 Parental monitor	ring knowledge (W3)	144
.2.2. 1 นายาแนเ ทเงาแเง	The Knowledge (WJ)	144

Adolescents reported perceptions of their mother's and father's 145 monitoring knowledge (separate items) from a 5-item scale (Brown, 146 Mounts, Lamborn, & Steinberg, 1993) including who their friends 147 were, how they spent their money, what they did with their free time, 148 where they were after school, and where they went at night, with four 149 response options (1 = don't have/see father or mother/guardian; 2 = 150 he/she doesn't know anything; 3 = he/she knows a little; and 4 = 151 he/she knows a lot). 152

#### 2.2.3. Parental support of not using alcohol (W3) 153

One item was used to measure student-perceived parental support 154 of not using alcohol. The question was derived from the National Survey 155 on Drug Use and Health (United States Department of Health and 156 Human Services. Substance Abuse and Mental Health Services Administration. Center for Behavioral Health Statistics and Quality, 2013) and 158 asked participants how important it was to their parents/guardians 159 that he or she does not use alcohol (response options from 1 = not at 160 all to 7 extremely). 161

#### 2.2.4. Alcohol drinking (W3)

Drinking alcohol was measured using one question, "On how many 163 occasions (if any) have you drunk alcohol in last 30 days?" with re- 164 sponse options 1 = never to 7 = 40 times or more. Due to a severe 165 floor effect and non-normal distribution of the data (the same reason 166 for substance use and heavy episodic drinking below), the scores were 167 then dichotomized to at least once vs. none. This question was derived 168 from the Health Behavior in School-aged Children questionnaire 169 (Currie et al., 2004) and measured all four waves. 170

#### 2.2.5. Binge drinking (W3)

Teens were asked, "Over the last 30 days, how many times (if any) 172 have you had four (for females)/five (for males) or more drinks in a 173 row within two hours?" with response options from 1 = none to 6 = 174 10 or more times. The scores were dichotomized: at least once vs. 175 none. This question was adapted from the Monitoring the Future 176 National Survey (Johnston, O'Malley, Bachman, & Schulenberg, 2010) 177 and measured all four waves. 178

#### 2.2.6. Substance use (W3)

Substance use was measured by asking participants 10 questions derived from the Monitoring the Future National Survey (Johnston et al., 181 2010) on how often they have ever used drugs (e.g., marijuana, ecstasy, 182 medication to get high) in the last 12 months for all four waves with 183 seven options from 1 = never to 7 = 40 times or more. Two dichoto-184 mous variables were then generated to indicate: (a) have used marijuana as least once vs. none in the last 12 months; and (b) have used illicit 186 drug rather than marijuana as least once vs. none in the last 12 months. 187

#### 2.2.7. Drunk and marijuana-smoking peer (W3)

The extent to which peers of the participant got drunk and smoked 189 marijuana were measured by separate questions derived from the 190 National Longitudinal Study of Adolescent Health (Harris et al., 2009) 191 on how often they thought their five closest friends got drunk and 192 smoked/used marijuana with options from 1 = never to 5 = almost 193 always. 194

#### 2.2.8. Driving licensure (W4)

Driving licensure was generated based on students' reporting if they 196 had a license allowing independent, unsupervised driving. The analysis 197

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## was limited to those who reported having independent drivers' licensein W4.

#### 200 2.2.9. Environmental status variables (W4)

Three environmental status variables were assessed including 201current residence, school status, and work status. Residence included 202three categories: parent/guardian's home, own place (e.g., rented 203room, apartment), and on campus (school dormitory or residence hall, 204205fraternity or sorority house). School status consisted of three categories: 206 not in school, technical/community college, and university or college. Work status included three categories: not working, part time ( $\leq$ 30 h), 207and full time (30 h or more). 208

#### 209 2.2.10. Potential confounders (W4)

Because access to a vehicle might affect DWI, we controlled for this potential confounder in the analyses with two variables: miles driven each day (limited to 0–150 miles per day) and days driven in the last 30 days.

#### 214 2.2.11. Demographic variables

Participants reported age, gender, race/ethnicity, family socioeconomic status, and location (urban/rural). Family socioeconomic status was estimated using the Family Affluence Scale (Harris et al., 2009) and students were then categorized as low, moderate, and high affluence (Spriggs, Iannotti, Nansel, & Haynie, 2007). Parents reported the education level of both parents and were categorized based on the highest level of education of either parent.

#### 222 2.3. Statistical analyses

223 Among those who did not have an independent driver's license, only 224seven (two did not have license of any sort and five had permit for 225supervised practice driving) of them in total reported DWI in W4. Therefore, of the total sample of 2178 participants in W4, only 1330 226227participants who had obtained a driver's license were included for the analysis. In addition to those who reported no independent driver's 228 license in W4, 126 participants who were still in high school at W4 or 229230 self-reported other residences (e.g., living in barracks as part of the armed services, hospitalized for a sustained duration of time, living 231with family members other than their parents, and/or homeless) 232were excluded from this analysis because each group had too few to 233234analyze and these environments represented qualitatively different life circumstances. 235

Unadjusted and adjusted multinomial logistic regression was used
 to examine the association between DWI in W4 and potential predictors
 without and with controlling for covariates. Demographic variables and
 potential confounders that are associated with any type of DWI in W4 at

# p = 0.10 level were included in the adjusted model. Features of complexQ4survey design including clustering and sampling weights were taken241into account for all analyses. Domain analysis (referring to the computa-<br/>tion of statistics for subpopulations in addition to the computation of<br/>statistics for the entire study population) was applied for the analyses<br/>when using the subsample.243

#### 3. Results

#### 3.1. Descriptive analysis

In W4, weighted mean age was 19.16 years (SE = 0.02) and all included participants were younger than 21, the minimum legal drinking 249 age. Out of the 2178 included participants at W3, 54.1% (weighted hereafter) were female, 12.0% were Hispanic (versus 13.2% Blacks, 71.2% 251 Whites, and 3.63% other minorities), 15.1% were from low-affluence 252 families (versus 50.6% and 34.3% from moderate- and high-affluence 253 families, respectively), and 3.9% of students had 1 parent with less 254 than a high school diploma as the highest education level (versus 255 18.3% with high school diploma or GED, 41.8% with some college, 256 technical school, or associate degree, and 36.1% with bachelor's or 257 higher degree). Table 1 shows the weighted percentages of participants 258 who reported DWI among those having an independent driver's license 259 and substance use at W3 (14.3%) and W4 (15.2%). 260

3.2. Variable selection 261

To select the variables that would be included in the final models, 262 multinomial logistic regression was conducted to examine bivariate 263 associations of each type of DWI (compared to non-DWI) in W4 with 264 overall DWI, potential predictors, and covariates in W3 (data not 265 shown). The independent variables that are significantly (P<0.05) asso-266 ciated with any type of DWI in W4 were included in adjusted models. 267 The final model controlled for gender, race/ethnicity, family affluence, 268 parental education, urbanicity, miles driven each day, and days driven 269 in the last 30 days were included in the mode as they were associated 270 with DWI in W4 at P = 0.10 level. 271

3.3. Adjusted models 272

Table 2 shows the results of adjusted multinomial logistic regression 273 between DWI in W4 and all predictors controlling for selected covari-274 ates. Previous DWI was associated with alcohol-specific and alcohol/275 marijuana-combined DWI, but not marijuana-specific and illicit drug-276 related DWI, in W4. Binge drinking in W3 was significantly associated 277 with alcohol/marijuana-combined DWI, but not any other type DWI, 278 in W4. Binge drinkers in W3 compared to non-binge drinkers were 279

#### t1.1 Table 1

t1.2 Prevalence of DWI in high school seniors and post-high school graduates.

+1 3		High scho (W3)	ool seniors		Post-high school graduates (W4)					
t1.4		Ν	Weighted %	SE	Ν	Weighted %	SE			
t1.5	DWI/30 days#	143	14.31	2.07	182	15.15	1.68			
t1.7	DWI/30 days by type <sup>#</sup>									
t1.8	Not any type DWI	-	-	-	1033	84.85	1.68			
t1.9	Alcohol-specific DWI	-	-	-	48	4.34	1.21			
t1.10	Marijuana-specific DWI	-	-	-	51	5.02	1.02			
t1.11	Alcohol/marijuana-combined DWI	-	-	-	29	2.41	0.68			
t1.12	Drug-related DWI	-	-	-	54	3.37	0.88			
t1.13	Alcohol drinking in last 30 days at W3 <sup>#</sup>	787	38.17	2.04	1044	53.15	2.38			
t1.14	Binge drinking within 2 h at W3 <sup>#</sup>	402	21.69	2.13	583	31.85	2.69			
t1.15	Marijuana use in last year at W3 <sup>#</sup>	583	25.11	1.69	654	29.83	2.50			
t1.16	Illicit drug (not including marijuana) use in last year at $W3^{\#}$	157	7.89	1.14	162	8.32	1.36			

t1.17 <sup>#</sup> Percentage of DWI was calculated within independent driving license holders (*N* = 1208 at W3 and *N* = 1215 at W4) and percentage of substance use was calculated in the whole t1.18 sample (*N* = 2407 at W3 and *N* = 2178 at W4).

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Table 2

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#### t2.1 t2.2

2 Adjusted multinomial logistic regression between W4 DWI and potential predictors.

2		Alcohol-specific DWI <sup>#</sup>				Marijuana-specific DWI <sup>#</sup>			Alcohol/marijuana-combined DWI <sup>#</sup>				Drug-related DWI <sup>#</sup>				
.4		AOR	95% C	I	Р	AOR	95% C	I	Р	AOR	95% C	I	Р	AOR	95% C	I	Р
.5	W3 DWI																
6	No	Ref				Ref				Ref							
.7	Yes	5.29	1.70	16.47	< 0.001	1.63	0.35	7.63	0.54	8.92	2.40	33.13	< 0.001	1.47	0.40	5.38	0.56
.8	School status at W4																
.9	Not attending school	Ref				Ref				Ref							
.10	College/graduate school	0.48	0.12	1.95	0.31	0.13	0.02	1.17	0.07	0.45	0.05	3.78	0.46	1.36	0.31	6.03	0.69
.11	Tech/Voca/Comm	0.77	0.19	3.09	0.71	0.18	0.04	0.92	0.04	1.22	0.11	13.53	0.87	1.91	0.45	8.09	0.38
.12	Residence at W4																
.13	At home																
.14	On campus	4.06	0.93	17.86	0.06	1.93	0.21	17.32	0.56	0.22	0.03	1.59	0.13	0.58	0.06	5.92	0.64
.15	In own place	2.52	0.72	8.81	0.15	1.10	0.14	8.52	0.92	0.14	0.02	1.34	.09	1.79	0.51	6.28	0.37
.16	Binge drinking within 2 h at W3																
.17	No	ref				ref				ref							
.18	Yes	1.11	0.38	3.27	0.85	1.88	0.46	7.63	0.38	4.88	1.39	17.15	0.01	2.20	0.84	5.80	0.11
.19	Marijuana use at W3																
.20	No	ref				ref				ref							
.21	Yes	0.90	0.27	2.93	0.85	5.53	1.49	20.51	0.01	4.36	0.21	89.71	0.34	0.86	0.29	2.55	0.79
.22	Illicit drug (not including marijuana) use at W3																
.23	No	ref				ref				ref							
.24	Yes	1.48	0.23	9.48	0.68	1.15	0.22	6.06	0.87	0.36	0.05	2.42	0.29	6.46	1.10	38.09	0.04
.25	Important to parent no alcohol at W3	1.08	0.85	1.37	0.55	1.29	0.89	1.88	0.18	1.11	0.80	1.54	0.53	1.15	0.86	1.55	0.35
.26	Mother's monitoring knowledge at W3	0.90	0.38	2.16	0.81	1.63	0.57	4.66	0.37	4.37	0.53	35.72	0.17	0.64	0.14	2.95	0.57
.27	Five best friend got drunk at W3	1.75	1.02	3.00	0.04	1.05	0.55	2.01	0.88	0.62	0.26	1.50	0.29	0.78	0.39	1.58	0.49
.28	Five best friend smoked marijuana at W3	0.45	0.23	0.88	0.02	2.20	1.10	4.39	0.03	3.08	1.48	6.39	< 0.001	1.24	0.68	2.25	0.49

t2.29 *Note:* Tech/Voca/Comm = technological or vocational school or community college; AOR = adjusted odds ratio; CI = confidence interval. Models were controlling for gender, race/ t2.30 ethnicity, parental education, family affluence, urbanicity, days driven in last 30 days, and miles driven in each day at W4.

t2.31 <sup>#</sup> Compared to no DWI of any kind in the past 30 days.

280 more likely to report alcohol/marijuana-combined DWI (OR = 4.88, 95% confidence interval [CI] 1.39–17.15, P = 0.01); marijuana users 281282 compared to non-users in W3 were more likely to report marijuanarelated DWI (OR = 5.53, 95% CI 1.49–20.51, P = 0.01); illicit drug 283users in W3 compared to non-users were more likely to report illicit 284drug-related DWI (OR = 6.46, 95% CI 1.10–38.09, P = 0.04); partici-285 286 pants with higher perceptions of having friends drunk in W3 were more likely to report alcohol-related DWI (OR = 1.75, 95% CI 1.02– 287 3.00, P = 0.04); and participants with higher perception of having 288friends using marijuana in W3 were more likely to reported 289marijuana-specific (OR = 2.20, 95% CI 1.10–4.39, P = 0.03) and 290291 alcohol/marijuana-combined (OR = 3.08, 95% CI 1.48–6.39, P < 0.001) DWI. Those who had high scores of having five closest friends using 292293 marijuana in W3 were less likely to report alcohol-related (OR = 0.45, 29495% CI 0.23–0.88, P = 0.02). Those attending technical, vocational, or community colleges (OR = 0.18, 95% Cl 0.04–0.92, P = 0.04) were 295296less likely to report marijuana-specific DWI.

#### 297 3.4. Additional analysis

To examine if regular alcohol drinking is associated with DWI in the 298299same way as binge drinking, we re-ran the final model, replacing binge 300 drinking with the more inclusive drinking question (i.e., drinking alcohol of any kind in last 30 days in W3). All the results remained the 301 same except that those attending technical, vocational, or community 302colleges were modestly (OR = 0.22, 95% CI 0.04–1.17, P = 0.08) associ-303 ated with marijuana-specific DWI and those who reported drinking 304 alcohol in W3 were not significantly associated with any type of W4 305 DWI (data not shown). 306

#### 307 4. Discussion

In the current study, we reported the nationally representative prevalence of overall and substance-specific DWI (self-reported and hereafter) among emerging adults (high school graduates) and examined the prospective association between facilitating and protective factors in senior HS and substance-specific DWI during the transition 312 from HS to post-HS. The results of this study are noteworthy because 313 the identification of predictors of DWI at an earlier age can inform the 314 development of interventions that may prevent DWI when young 315 drivers become adults (21% for males and 11% for females; Caetano & 316 McGrath, 2005). 317

The change in DWI prevalence among HS seniors exhibited a 318 decreasing curvilinear trend from 2001 to 2011 (from 19.5% to 16.0%; 319 O'Malley & Johnston, 2013). The average DWI prevalence during the 320 last three years was 14.9%, which is consistent with the current preva- 321 lence (14.3%) data that were collected in 2012. Given that O'Malley 322 and Johnston's (2013) study did not have the data in the year 2012, 323 the current study contributed to the literature with the latest overall 324 DWI prevalence for HS seniors. In addition, this study provides novel 325 insight about the overall and substance-specific DWI for first-year HS 326 graduates, among whom 15.15% reported overall DWI and 4.34%, 327 5.02%, 2.41%, and 3.37% reported alcohol-specific, marijuana-specific, 328 alcohol/marijuana-combined, and illicit drug-related DWI, respectively, 329 in the last 30 days. In this cohort, overall DWI slightly increased from HS 330 seniors to one after HS by about 1%. Marijuana-specific DWI is more 331 common than alcohol-specific DWI, which is consistent with the finding 332 from a non-representative college sample (Whitehill et al., 2014). The 333 higher prevalence of marijuana-specific DWI may be due to the fact 334 that the majority of the participants in this study were still underage 335 for drinking. One cohort study reported an immediate increase of 336 alcohol-specific DWI when college students turned 21, the legal 337 drinking age (Fromme et al., 2010). 338

Despite the DWI prevalence remaining relatively stable from HS 339 seniors to one-year post-HS, transitional changes were observed from 340 DWI to non-DWI as well as from non-DWI to DWI. Better understanding 341 of the social-contextual determinants of these changes is needed to 342 guide the development of strategies focused on preventing DWI during 343 this transition from adolescence to adulthood. 344

Some evidence suggests that certain psychosocial and social- 345 contextual variables, such as peer support, family influence, and previous 346 substance use of an individual can influence DWI among youth 347

Please cite this article as: Li, K., et al., Marijuana-, alcohol-, and drug-impaired driving among emerging adults: Changes from high school to oneyear post-high school, *Journal of Safety Research* (2016), http://dx.doi.org/10.1016/j.jsr.2016.05.003

## (Leadbeater, Foran, & Grove-White, 2008; Maldonado-Molina, Reingle, Jennings, & Prado, 2011). This study extended the investigation to the association between the potential covariates in the last year of HS and DWI one year post-HS; however, the pattern of predictors of the four specific DWI in emerging adulthood varies.

Overall DWI in the last year of HS predicted post-HS alcohol-specific 353 DWI and alcohol/marijuana-combined DWI but not marijuana-specific 354and illicit drug-related DWI, although overall DWI is significantly 355356 associated with any of the four types of DWI in the unadjusted model. The non-insignificant association between overall high school DWI 357 358and post-high school marijuana-specific and illicit drug-related DWI 359suggests that high school DWI may be primarily alcohol-related. 360 O'Malley and Johnston's study showed that 15.1% of HS seniors reported 361 alcohol related DWI and 11.9% marijuana-related DWI (O'Malley & Johnston, 2013). Therefore, alcohol-related DWI in HS may be more 362 likely to be carried over post-HS. However, given the lack of longitudinal 363 364 data including both specific DWI in HS and post-HS, future study is needed to warrant the hypothesis. 365

As expected, marijuana and illicit drug use in HS were related to 366 marijuana-specific and illicit drug-related DWI, respectively. Binge 367 drinking in HS was not associated with alcohol-specific DWI in W4; 368 however, it was associated with alcohol/marijuana-combined DWI. 369 370 The findings suggest that substance use at early lifetime may particular-371 ly predetermine relevant risky driving under the influence. Association between binge drinking and alcohol-specific DWI was suppressed by 372 the association between binge drinking and alcohol/marijuana-373 combined DWI, indicating that most binge drinkers in W3 may smoke 374375 marijuana in W4 and the co-occurrence of binge drinking and using marijuana may lead to impaired driving under joint influence of alcohol 376 and marijuana. Additional analysis showed that 49.92% of participants 377 reported both binge drinking and smoking marijuana and 30.53% 378 379reported one of them.

380 The findings show peer drinking and marijuana use in HS were inde-381 pendently associated with DWI after HS. Specifically, peer drunkenness was associated with alcohol-specific DWI and peer marijuana use was 382 associated with marijuana-specific and alcohol/marijuana-combined 383 DWI. It is not clear the extent to which peer marijuana use reflects ado-384 385 lescent marijuana use or peer norms consistent with risk taking. A series of studies has shown that adolescents' perception of peer norms is relat-386 ed to their engagement in alcohol-related behavior (Song, Smiler, 387 Wagoner, & Wolfson, 2012), risky driving (Møller & Haustein, 2014), 388 and driving after drinking (Kenney, LaBrie, & Lac, 2013). Curiously, per-389 ceived peer marijuana use appears to be a likely pathway leading to 390 marijuana-related DWI, but not alcohol-specific and illicit drug-related 391 DWI. It is puzzling why perceived peer marijuana use was related to 392 393 low likelihood of alcohol-specific DWI, suggesting that the mechanistic 394linkages leading to DWI may be substance-specific. Adolescents might reveal injunctive peer misperceptions (Litt, Lewis, Linkenbach, Lande, 395 & Neighbors, 2014), which may lead to incorrect estimation of their 396 peers' approval toward risk behaviors such as DWI (Kenney et al., 397 2013). Also, the association between perceived peer marijuana use 398 399 and alcohol-specific DWI may be influenced by more complicated 400 pathways, through which some factors may mediate the association indirectly. The non-significant association between binge drinking and 401alcohol-specific DWI in this study indicates the complexity of the 402 403 issue. Although additional evidence is needed demonstrating the associ-404 ation between peer influence and DWI, perceived peer marijuana use and peer drunkenness may be considered targeting components in HS 405prevention programs. Accurate peer norms about substance use may 406 407help lead to more effective interventions reducing self-approval and incidence of DWI in youth. 408

While previous research has reported on changing patterns in substance use from HS students to post-HS graduates (Patrick & Schulenberg, 2011), little is known about the extent to which environmental changes during this transition influences driving after drinking alcohol or using marijuana and illicit drugs among post-HS youth. Findings from the current study did not confirm the hypothesis that 414 environmental circumstances (school status, living status, and work 415 status) are related to DWI risk during the transition from HS to post-HS. Only post-HS attendance of technical and community college was 417 negatively associated with the likelihood of marijuana-specific DWI. 418

The strengths of the study include data drawn from a nationally rep- 419 resentative, longitudinal sample and the measurement of substance- 420 specific DWI, and environmental variables one year after HS. Whereas 421 most studies examining post-HS DWI are exclusive to college partici- 422 pants, the current study included emerging adults who were attending 423 and not attending colleges. Study limitations were present. First, the rel- 424 atively small sample size when breaking down DWI into different types 425 may limit the power of the analysis. Second, DWI was not specified with 426 alcohol, marijuana, and illicit drug use in W3, which limits the direct test 427 of association of specific DWI types between W3 and W4. Third, self- 428 reported measures (DWI and substance use) may introduce the poten- 429 tial for recall and social desirability bias. Fourth, not all possible risk fac- 430 tors were collected. For example, the study did not capture perceived 431 importance of social events where illicit substances may be present 432 (e.g. fraternity parties), community service, religion (Kohn et al., 433 2014), or history of alcohol/marijuana possession. 434

#### 5. Conclusions

Substantial numbers of emerging adults in the United States contin-436 ue to put themselves and others at risk by driving under the influence of alcohol, marijuana, and illicit drugs. Previous DWI was the main predic-438 tor of DWI under alcohol-related influence. Binge drinking, as well as regular alcohol consumption, marijuana use, and illicit drug use led to the respective substance-specific DWI one year after HS. Injunctive the respective substance at reducing DWI among youth and emerging adults. 444

#### Acknowledgments

*Funding/support*: This research was supported by the Intramural Research Program of the Eunice Kennedy Shriver National Institute of Child 447 Health and Human Development (contract #HHSN2752012000011), 448 and the National Heart, Lung and Blood Institute (NHLBI), the National 449 Institute on Alcohol Abuse and Alcoholism (NIAAA), and the Maternal 450 and Child Health Bureau (MCHB) of the Health Resources and Services 451 Administration (HRSA), with supplemental support from the National 452 Institute on Drug Abuse (NIDA).

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Please cite this article as: Li, K., et al., Marijuana-, alcohol-, and drug-impaired driving among emerging adults: Changes from high school to oneyear post-high school, *Journal of Safety Research* (2016), http://dx.doi.org/10.1016/j.jsr.2016.05.003

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