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2
3 **Knowledge about Crash Risk Factors and Self-Reported Driving**
4 **Behavior: Exploratory Analysis on Multi-State Teen Driver Survey**

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1 ABSTRACT

2 Traffic crashes have been the leading cause of unintentional death for teen (15- to 19-year-old)
3 drivers for many years. Many challenges exist to determine the key risk factors in teen driver's
4 driving behavior, including conventional data sources—both prospective and retrospective.
5 Retrospective data sources are conventional structured police reports, which are limited in
6 information to identify risk factors at high levels of analysis. Prospective data like from a survey
7 may add value in the current gap of identifying key risk factors associated with teen driver
8 crashes. A countermeasure developed in 2003 within the state of Texas is the grassroots peer-to-
9 peer safety program for young drivers, Teens in the Driver Seat® (TDS). The program utilizes
10 positive peer influence and peer-to-peer education, which has been shown to have significant
11 impacts on high-risk behaviors. This study used a total of 109,266 surveys (from 11 states)
12 distributed through the TDS program for this analysis. State-specific exploratory analysis shows
13 trends of teen driving behavior for different states. Text mining was performed on the manual
14 entries of the perceived top risk factors from the survey respondents. The top perceived risk
15 factors varied among male and female teen respondents. A cluster of male respondents more
16 frequently responded with drinking, texting, phone use, speeding, and (lack of) seatbelts as top
17 risks, while female respondents cited drinking, phone use, talking, music, and eating. The
18 findings of the current study should provide significant contributions and insights into the area of
19 teen driver research.

20

21 *Keywords: Risk factors, self-reported driving behavior, teen driver, text mining.*

22

23 INTRODUCTION

24 In 2015, a total of 2,333 teen drivers ages 16-19 died in motor vehicle crashes and an additional
25 221,313 were injured in 2014 (1). To put this into perspective, six teen drivers died every day due
26 to motor vehicle crashes. In 2013, teenagers ages 15-19 represented 7% of the U.S. populace but
27 accounted for over 11% of the total costs of motor vehicle injuries (\$10 billion) (1). Motor vehicle
28 crashes remain the leading cause of unintentional death for teen drivers across the United States
29 and compared to other high-income countries, the U.S. continues to lose more people to car
30 crashes than any other nation. Despite the continued reduction in motor vehicle death rate per
31 capita in recent years (31% reduction), the U.S. saw the lowest decrease compared to other
32 countries, costing an additional 18,000 lives lost (2).

33 Research into the causes of teen crashes has identified several factors that contribute to
34 higher overall crash rates including driver inexperience, young age and riskier driving habits (3).
35 Perceived risk has been proposed to influence driving behaviors as younger teen drivers, in
36 particular, are more likely to underestimate risk and thus, more likely to engage in riskier driving
37 behaviors compared to their older counterparts (4-7). Theoretically, older drivers have gained a
38 better understanding of risk as they have more experience on the roadways compared to novice
39 drivers.

40 Efforts to reduce teen crashes has resulted in the implementation of Graduated Driver's
41 Licensing (GDL), which grants teen drivers full driving restrictions in phases of restricted
42 licensing(8). Research has shown GDL restrictions have a positive effect on teen crash rates, but
43 the impact can be limited if restrictions are not properly enforced, teens do not comply or meet
44 only the minimum requirements of safety (i.e. shorter nighttime driving restrictions, shorter phases
45 of restricted driving, earlier ages for licensure, etc.) (9-10). GDL combined with other
46 interventions has been shown to have significant impacts on teen crashes compared to states that
47 do not have an additional intervention and one such intervention is the focus of this paper (11). A
48 countermeasure developed in 2003 within the state of Texas was the development of a grassroots
49 peer-to-peer safety program for young drivers, Teens in the Driver Seat® (TDS). The program
50 utilizes positive peer influence and peer-to-peer education, which has been shown to have
51 significant impacts on high-risk behaviors such as teen pregnancy, drug abuse, etc. (12). The
52 program's design both "augments" and "complements" GDL restriction laws and has been shown
53 to provide a significant improvement in teen crash frequencies (12).

54 The objective of this paper was to examine teen drivers' self-reported driving behaviors in
55 different states with regard to risk factors, and associated attributes from a large dataset that has yet
56 to be analyzed in prior research.

57

58 EARLIER WORK AND RESEARCH CONTEXT

59 Studies have identified linkages to perceived risk and self-reported risky driving patterns among
60 young drivers (7, 13-18), with some exceptions (19). Measures on perceived risk typically involve
61 teens measuring or estimating a certain level of risk for a particular driving behavior; for example,
62 "how risky would it be to drive 10 mph over the speed limit?" (20). Simons-Morton et al. also
63 noted that risk perception can be assessed as a personal risk; "for example, how risky would it be if
64 you drove 10 mph over the speed limit?" and that risk perception can be a target of traffic safety
65 interventions aimed at reducing risky driving (20-21). A systemic investigation by researchers at
66 the University of NSW looked into different predictors (i.e. gender, age, personality, attitudes, and
67 belief) for the risky driving behavior of young drivers and found that these predictors are in fact
68 relevant to individual risky driving behaviors (14).

69 Similar studies to this paper have been smaller in sample size and scope focusing on either
70 individual cities or states but have significantly contributed to our understanding of methods used
71 to identify perceived and self-reported risky teen driver behavior. A Pennsylvania study conducted
72 focus groups for teen drivers (n=30) to identify the attitudes, perceived behavioral control, and
73 norms about driver inattention providing insight on why teens continue to engage in distracted
74 driving despite acknowledging it's risks (22). Ehsani et al. conducted qualitative research on a
75 small group (n = 48) of newly licensed teen drivers under the age of 17 to examine perceptions of
76 their peer passengers' in-vehicle presence and their potential contribution to crash risk (23).
77 Findings showed that the presence of peer passengers increases the risk of fatal crashes among teen
78 drivers and while teens recognize passengers as having direct and indirect distracting effects, they
79 consider them minimal (23).

80 Many studies focused on retrospective approach by using state maintained crash databases.
81 One potential gap in these studies is the limitation of sufficient information on risk perceptions,
82 which are unavailable in police reported crashes. The current study, based on a prospective study
83 design, examined a very large dataset (over 100,000 survey entries, and perhaps the largest of its
84 kind in the nation) to identify key behavioral risk factors among teen drivers. What sets this study
85 apart is a large sample across multiple years and eleven different states. The participants are
86 unique because they attend schools where the particular traffic safety intervention of the Teens in
87 the Driver Seat® (TDS) program occurs.

88

89 **SURVEY DESIGN, ADMINISTRATION, AND ANALYSIS**

90 The survey instrument used in this study was developed by TDS staff to obtain traffic safety
91 knowledge and self-reported driving behaviors prior to intervention. The survey instrument has been
92 approved by the Texas A&M Institutional Review Board.

93

94 **Survey Content and Item Design**

95 Part One (questions 1-5) of the survey obtains demographic information including age, school,
96 gender and grade level. Part Two (question 6) of the survey focuses on obtaining teen's knowledge
97 of the five most common factors that contribute to teens being hurt or killed in car crashes through
98 an open ended question. Part Three (questions 7-12) of the survey focuses on traffic safety
99 background including:

- 100 • License status and driver education history
- 101 • Crash and citation history
- 102 • On-road driving test was taken before receiving license
- 103 • Car crash history for either participant or family member
- 104 • Receipt of a traffic citation.

105 Question 12 a-m, in the last section of the survey, focuses on self-reported risky driving
106 behaviors and the frequency (Never; Some - 1-5 times; and A Lot - more than 1-5 times) that teens
107 have engaged in them over the past month. Questions focus on pre-identified risk factors for teens
108 including:

- 109 • Cell phone use (talking and texting) while driving
- 110 • Falling asleep while driving
- 111 • Driving or riding without a seat belt or driving a passenger who was unbuckled
- 112 • Speeding or street racing
- 113 • Driving after alcohol use

- 114 • Driving or riding in a vehicle with other teen passengers unaccompanied by an adult over
 115 the age of 21
 116 • Driving after 10 pm unaccompanied by an adult over the age of 21
 117 A revision of the survey was done in 2015 that omitted questions 9-11 but due to the method of
 118 analysis did not impact overall comparisons and analysis of data.
 119

120 Survey Population and Sampling

121 Survey population was obtained from schools that participate in the TDS program who receive
 122 surveys along with program kits. Distribution of the survey is voluntary (information sheets
 123 regarding participant rights are provided to all students and parents) and schools that participate
 124 are asked to survey a minimum of 90% of the teen driver population or 300 students across all age
 125 groups for a representative sample.

126 The data was collected from 2007-2016 and includes high school students between the ages
 127 of 14 and 18 (from 11 states), which was estimated based on reported grade levels. Population
 128 sample included 281 schools and a total of 109,266 respondents. Table 1 summarizes the surveys
 129 received and total number of schools that participated by state.
 130

131 **TABLE 1 Total Number of Schools per State and Number of Completed Surveys per State**

State	Number of Schools	Completed Surveys			
		Min.	Max.	Average	Total
Texas (TX)	213	1	3,896	413	88,064
Georgia (GA)	33	1	1,919	327	10,791
North Carolina (NC)	9	11	682	350	3,153
Nebraska (NE)	8	109	352	183	1,460
Connecticut (CT)	6	32	1,646	556	3,336
California (CA)	4	49	1,004	447	1,789
Colorado (CO)	3	49	108	71	214
Oklahoma (OK)	2	41	106	74	147
New Mexico (NM)	1	88	88	88	88
New York (NY)	1	213	213	213	213
Pennsylvania (PA)	1	11	11	11	11

132 STATE SPECIFIC FINDINGS

133 This subsection describes the descriptive statistics of the responses from the key survey questions.
 134

135 Question 3-11 Item-by-Item Findings

136 This subsection describes the descriptive statistics of the responses from questions 3-4, 7, 9-11.
 137 Refer to Table 2 for a summary of teen driver responses from each participating state.
 138

139 *Demographics*

140 Over half of the overall sampling size were female (51.8%) for the 11 states included in the
 141 dataset. A majority of the states had near-even gender distribution with the exception of
 142 Pennsylvania of which the sample consisted of 72% females.
 143

144 The average sampling distribution for the four different grades (Grade 9, 10, 11, and 12)
145 show similar percentage distributions across all states ranging from 24% - 26.7%. Overall, 11th
146 grade students had the highest level of representation (26.7%) while freshmen and seniors had the
147 lowest (24%).

148
149 *Driver Education and License Status*

150 Nearly fifty-one percent of teen respondents reported they did not have a driver's license. Sixteen
151 percent of teen respondents reported having a learner's license, 14% reported having a provisional
152 license and around 15% of the respondents reported having an unrestricted license. Georgia had
153 the highest percentage of learner's licenses (30.3%) and New York the lowest (5.2%). Nebraska
154 reported the highest percentage of provisional driver's licenses (40.1%) and New York the lowest
155 (2.8%), Colorado had the highest level of unrestricted driver's licenses (20.8%) and New York the
156 lowest (6.6%). New York and Pennsylvania had the highest reported numbers for no driver's
157 license (81.7% and 81.8%) and New Mexico the lowest (20.5%).

158 A majority of respondents (55.6%) reported they did not have an on-road driving test
159 before receiving their driver's license vs. 17.6% that did. North Carolina had the highest
160 percentage of teens reporting having taking an on the road drivers test (49.3%).

161
162 *Traffic Safety Background*

163 Roughly forty-two percent of teens reported they had a friend or family member seriously
164 injured or killed in a car crash. Data only includes information for seven states, as four states did
165 not provide this information (Colorado, New York, New Mexico, and Pennsylvania). A majority of
166 teen drivers reported they had not received a traffic ticket (71.8% vs. 8.2%).

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190 **TABLE 2 Survey Summary Responses for Items Across All 11 States for Items: 3-4, 7, 9-11**

Questions	States Where Survey was Conducted											
	All States	TX	GA	CT	NC	NE	CO	NY	OK	CA	NM	PA
Number of Respondents	109,266	88,064	10,791	3,336	3,153	1,460	214	213	147	1789	88	11
Q3: Gender												
Male	47.1	47.1	47.6	49.5	43.2	49.2	51.9	42.7	49.0	46.0	44.3	27.3
Female	51.8	51.7	51.8	49.6	56.5	50.8	48.1	54.9	50.3	53.2	55.7	72.7
Blank	1.1	1.2	0.6	1.0	0.4	0.1	0.0	2.4	0.7	0.8	0.0	0.0
Q4: Grade												
9	24.0	24.0	30.5	15.3	18.8	20.1	16.9	0.5	31.0	20.0	1.1	54.6
10	25.2	25.1	28.4	17.6	26.9	20.9	33.3	83.7	30.3	17.9	39.8	27.3
11	26.7	26.1	23.0	43.3	31.4	27.3	26.3	2.4	23.5	43.2	3.4	18.2
12	24.0	24.8	18.2	23.8	22.9	31.7	23.5	13.4	15.2	18.9	55.7	
Q7: License Status												
Learner	16.3	14.2	30.3	21.2	25.8	9.2	27.6	5.2	17.0	13.6	17.1	0.0
Provisional	13.9	13.3	16.6	12.1	14.2	40.1	15.4	2.8	10.2	8.7	37.5	9.1
Unrestricted	14.4	14.8	9.0	10.3	27.5	20.8	29.4	6.6	20.4	4.6	18.2	0.0
None	50.5	52.8	40.3	46.7	28.4	23.8	24.8	81.7	50.3	67.5	20.5	81.8
Blank	4.9	4.9	3.8	9.7	4.2	6.0	2.8	3.8	2.0	5.5	6.8	9.1
Q9: On-road Driving Test before Receiving Driver license												
Yes	17.6	16.3	17.9	14.3	49.3	47.3	0.0	0.0	11.6	16.2	0.0	0.0
No	55.9	60.6	34.2	26.5	38.1	45.6	0.0	0.0	14.3	71.1	0.0	0.0
Blank	26.5	23.2	47.9	59.2	12.6	7.1	100.0	100.0	74.2	12.8	100.0	100.0
Q10: Acquaintance Injured or Killed												
Yes	42.1	43.5	30.8	22.9	64.4	49.0	0.0	0.0	17.7	49.6	0.0	0.0
No	36.0	37.9	24.9	23.5	32.6	47.3	0.0	0.0	9.5	41.8	0.0	0.0
Blank	21.9	18.7	44.4	53.6	3.0	3.6	100.0	100.0	72.8	8.6	100.0	100.0
Q11: Traffic Ticket												
Yes	8.2	8.8	4.5	3.0	12.4	11.7	0.0	0.0	0.7	4.0	0.0	0.0
No	71.8	74.4	51.3	57.0	84.2	84.7	5.6	0.0	27.2	87.5	0.0	0.0
Blank	20.0	16.8	44.2	40.1	3.4	3.6	94.4	100.0	72.1	8.5	100.0	100.0

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Item 12a-m Self-Reported Driving Behavior across All States

This subsection describes the descriptive statistics of the responses from questions 12 a-m. Refer to Table 3 for a summary of teen driver responses from each participating state.

Cell Phone Talking and Text Messaging

Overall, 12.9% of students across entire sample reported talking on a cell phone while driving “A lot.” Respondents in New Mexico had the highest level of students’ report talking “A Lot” on cell phones at 20.5% compared to New York at 1.4%. More students reported doing so “some” of the time with the overall percentage increase to 22.6%. New Mexico (42.1%) and Nebraska (38.2%) reported the highest percentages compared to 6.6% of New York teens.

Almost fallen asleep

Across the entire sample, very few teens reported almost falling asleep “a lot” or “some” (2.3% and 8.3%) with a majority reporting they “never” had, 74.9%. New Mexico had the highest reported number of teens reporting almost falling asleep between one and five times in the past month at 19% followed by Colorado (15%), Oklahoma (15%) and Nebraska (11.1%).

Seatbelt use

Over seven percent of teens within the sample reported driving without a seatbelt “a lot” in the past month. Within the states, Nebraska teens had the highest percentage of teens reporting driving without a seatbelt “a lot” or “some” (21% and 25.2%) over the past month compared to New York (.5% and 6.6%).

Teens reported higher frequencies of non-seatbelt use when riding as passengers in the vehicle wherein 16.5% of the entire sample did “a lot” in the prior month. Three states showed significantly high frequencies for not using a seatbelt as a passenger “a lot” which were Nebraska (22.7%), Oklahoma (29.3%) and New Mexico (22.7%). Non-seatbelt compliance went up for “some” across the sample from 16.5% to 29.5%, and Georgia and New Mexico eight states reported the highest percentages of 31.1% and 40.9%.

Nearly 13% of teen drivers reported driving “a lot” in the past month with unbuckled teen passengers across the sample. Nebraska reported the highest percentages of 29.6%. More teens reported doing so “some” of the time, 27.5%, and eight states had in-state percentages that exceeded 27% including New Mexico (43.2%), Pennsylvania (36.4%) and Nebraska (35.6%).

Speeding, Street Racing and Running a red light

Driving 10 mph or more over the speed limit had unique results as higher levels of teens reported doing so “a lot” per month vs. “some” (14% vs. 7.7%). Colorado and Nebraska had the highest percentages of teen drivers reporting “a lot” at 22% and Nebraska following with 20.5% respectively.

Overall, a large percentage of teens reported never having street raced in the past month at 76.7%. New Mexico (18.2%), Colorado (15%) and Nebraska (14%) had the highest reported levels of street racing for “some”.

Similarly, over 68.9% reported never having run a red light in the past month. Thirteen percent of teens reported doing so between “some” in the past month. Among these responses, New Mexico had the highest percent of teen drivers doing so at 26.1%.

240 *Driven after drinking alcohol*

241 Eighty-one percent of teens reported never driving after drinking alcohol in the past month across
242 all states. Among those, that reported doing so “some”, Connecticut and New York had the highest
243 percentages of 12.7% compared to the total states percentage of 7.4%.

244 *Teen passengers unaccompanied by adult*

245 Driving with passengers or riding with a teen driver unaccompanied by an adult over the age 21
246 had higher levels of frequency. Twenty-two percent of teens reported doing so “a lot” in the past
247 month compared to 21.5% who reported doing so “some” across all states. New Mexico (48.9%)
248 and Nebraska (31.9%) had the highest percentages of teen drivers doing so “a lot” in the past
249 month.

250 A high percentage of teens reported having ridden with a teen driver without an adult “a
251 lot” in the past month at 26.5% across all states. New Mexico had the highest percentage at 54.6%
252 followed by Nebraska at 33.7%. Twenty-seven percent of teens reported doing so “some”.
253 California (30.5%), Nebraska (30.3%) and New Mexico (29.6%) had the highest reported
254 percentage of teens across all 11 states.

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256 *Driven after 10 pm unaccompanied by adult*

257 Driving after 10 pm unaccompanied by an adult had the largest difference between frequencies
258 with more teens reporting doing so “a lot” over “some” in the past month (23.8% vs. 6.9%).
259 Among the highest reported levels, 46.6% of California teens and 36.7% of Nebraska teens
260 reported driving after 10 pm “a lot” in the past month. Pennsylvania (18.2%), Connecticut
261 (12.5%) and New York (11.7%) had the highest percentage of teens who reported doing so
262 “some”.

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TABLE 3 Survey Summary Responses for Items Across All 11 States for Items 12 a-m

Questions	States Where Survey was Conducted											
	All States	TX	GA	CT	NC	NE	CO	NY	OK	CA	NM	PA
Q12a: Cell-Phone Talking												
A Lot	12.9	13.5	9.9	7.8	13.4	17.9	10.8	1.4	15.7	5.0	20.5	0.0
Some	22.6	23.2	19.0	12.8	26.9	38.2	31.3	6.6	27.2	12.4	42.1	0.0
Never	57.9	56.5	66.6	66.9	53.5	41.0	55.6	80.3	55.8	76.4	35.2	90.9
Blank	6.6	6.8	4.4	12.5	6.2	3.0	2.3	11.7	1.4	6.2	2.3	9.1
Q12b: Text Messaging												
A Lot	13.8	14.8	8.8	8.5	11.7	20.7	10.3	1.4	15.0	6.9	23.9	0.0
Some	20.3	21.0	16.5	12.2	22.4	31.9	23.4	8.5	22.5	14.3	37.5	0.0
Never	59.2	57.5	70.2	66.9	59.4	44.7	62.6	78.4	61.2	72.5	36.4	90.9
Blank	6.7	6.8	4.5	12.5	6.4	2.7	3.7	11.7	1.4	6.3	2.3	9.1
Q12c: Almost Fallen Asleep												
A Lot	2.3	2.4	2.0	1.1	1.6	2.3	2.8	0.5	2.0	2.0	2.3	0.0
Some	8.3	8.3	8.3	4.6	10.5	11.1	15.0	4.2	15.0	4.4	19.3	0.0
Never	74.9	73.3	85.0	67.5	81.4	83.8	79.4	83.6	81.6	87.5	76.1	90.9
Blank	14.6	16.0	4.7	26.9	6.6	2.8	2.8	11.7	1.4	6.2	2.3	9.1
Q12d: Driven without Seatbelt												
A Lot	7.6	7.8	6.1	5.3	5.0	21.0	5.1	0.5	16.3	4.7	8.0	0.0
Some	15.4	15.8	13.6	9.0	14.2	25.2	17.3	6.6	15.0	13.5	21.6	9.1
Never	70.3	69.5	75.8	73.3	74.4	51.0	75.2	80.8	67.4	75.9	68.2	81.8
Blank	6.7	6.9	4.6	12.5	6.4	2.7	2.3	12.2	1.4	5.9	2.3	9.1
Q12e: Ridden without a Seatbelt												
A Lot	16.5	16.2	17.4	14.7	16.9	30.0	13.1	12.2	29.3	15.8	22.7	0.0
Some	29.5	29.0	31.1	25.6	35.4	35.6	39.7	34.3	30.6	34.1	40.9	18.2
Never	40.1	39.4	47.2	34.3	42.1	31.6	44.4	41.3	38.1	44.9	34.1	72.7
Blank	13.9	15.4	4.4	25.4	5.6	2.7	2.8	12.2	2.0	5.3	2.3	9.1
Q12f: Passengers without Seatbelt												
A Lot	12.9	13.1	11.9	10.3	10.1	29.6	12.2	10.3	17.0	9.6	18.2	18.2
Some	27.9	28.1	26.4	23.4	28.4	35.6	34.1	29.1	28.6	23.2	43.2	36.4
Never	52.3	51.8	56.9	54.0	55.0	32.1	51.9	47.9	53.7	60.9	36.4	36.4
Blank	6.9	7.0	4.8	12.3	6.6	2.7	1.9	12.7	0.7	6.4	2.3	9.1
Q12g: 10mph or more over Speed limit												
A Lot	14.0	13.9	14.2	17.7	13.1	16.4	22.0	9.4	15.7	8.9	20.5	9.1
Some	7.7	8.1	4.6	12.3	6.5	3.0	1.9	12.2	1.4	6.4	2.3	9.1
Never	52.4	52.2	56.0	48.3	46.1	46.4	46.7	62.9	59.9	62.3	28.4	72.7
Blank	26.0	25.9	25.2	21.8	34.3	34.2	29.4	15.5	23.1	22.4	48.9	9.1

288 **TABLE 3 Survey Summary Responses for Items Across All 11 States for Items 12 a-m,**
 289 **Continued**

Questions	States Where Survey was Conducted											
	All States	TX	GA	CT	NC	NE	CO	NY	OK	CA	NM	PA
Q12h: Street-Racing												
A Lot	5.4	5.8	3.6	2.9	2.6	6.3	5.6	1.4	6.1	3.7	10.2	0.0
Some	10.2	10.9	6.9	6.9	5.6	14.0	15.0	4.7	13.6	7.1	18.2	9.1
Never	76.7	75.2	84.9	77.6	85.1	76.8	77.6	82.2	78.9	82.6	69.3	81.8
Blank	7.7	8.1	4.6	12.6	6.7	3.0	1.9	11.7	1.4	6.6	2.3	9.1
Q12i: Run a red light												
A Lot	3.1	3.3	2.5	2.2	1.5	3.3	4.2	0.5	2.7	2.9	3.4	0.0
Some	13.5	13.7	12.8	11.5	13.2	14.9	15.9	5.2	10.2	10.0	26.1	0.0
Never	68.9	67.1	80.0	59.3	78.9	78.8	77.6	82.6	84.4	80.4	68.2	90.9
Blank	14.6	16.0	4.7	27.0	6.5	3.0	2.3	11.7	2.7	6.8	2.3	9.1
Q12j: Driven after Drinking Alcohol												
A Lot	3.4	3.8	2.0	1.6	1.2	2.8	3.3	0.9	4.1	2.6	5.7	0.0
Some	7.4	7.6	4.8	12.7	7.1	3.0	2.8	12.7	2.7	6.7	2.3	9.1
Never	81.4	80.0	89.2	80.6	87.5	85.6	87.4	85.5	87.1	85.1	77.3	90.9
Blank	7.8	8.6	4.1	5.1	4.2	8.6	6.5	0.9	6.1	5.7	14.8	0.0
Q12k: Driven with Teenagers in Absence of Anyone over 21												
A Lot	22.3	23.6	14.5	17.6	20.2	31.9	22.9	8.5	17.7	13.2	48.9	0.0
Some	21.5	22.3	17.1	13.6	21.6	24.3	16.8	8.5	25.2	21.6	30.7	0.0
Never	49.3	47.1	63.7	56.3	51.5	40.6	57.5	71.4	55.1	58.6	18.2	90.9
Blank	6.9	7.1	4.8	12.4	6.7	3.2	2.8	11.7	2.0	6.5	2.3	9.1
Q12l: Ridden with Teen Driver without an Adult												
A Lot	26.5	27.7	17.8	24.8	26.0	33.7	27.1	15.0	24.5	18.6	54.6	9.1
Some	27.9	28.5	23.3	25.5	27.7	30.3	22.9	21.1	23.1	30.5	29.6	0.0
Never	39.0	37.1	54.2	37.7	40.2	33.2	48.1	53.1	49.7	44.8	12.5	81.8
Blank	6.6	6.7	4.7	12.0	6.1	2.8	1.9	10.8	2.7	6.2	3.4	9.1
Q12m: Driven after 10pm in Absence of Adult												
A Lot	23.8	24.9	16.2	20.2	22.5	36.7	21.5	9.9	27.9	12.7	46.6	0.0
Some	6.9	7.1	4.9	12.5	6.5	3.0	2.8	11.7	1.4	6.9	2.3	18.2
Never	49.5	47.4	63.8	51.8	54.0	35.6	55.6	69.0	52.4	61.9	20.5	81.8
Blank	19.8	20.6	15.1	15.6	17.1	24.7	20.1	9.4	18.4	18.5	30.7	0.0

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IDENTIFICATION OF RISK FACTORS

Data Preparation and Text Mining

The second level of analysis included in this research paper was conducting text mining on survey question number six, which is an open-ended question asking respondents to name five of the most common factors (Risk 1 to Risk 5) that contribute to teenagers being hurt (or killed) in a car crash. Mining on subjective texts containing risk perception may contribute to determining the key risk factors. **Error! Reference source not found.** shows the flowchart of the text mining procedure adopted in this analysis. Four corpora (Risk 1 to Risk 4) were selected for final analysis. In text mining, a large and structured document that merges information from several files (based on some clustering) is known as corpus (plural: corpora). Risk 5 was omitted from analysis due to the large volume of missing data. The risk factors written by the respondents contain irregularity of spelling mistakes. An algorithm was developed to contain both right spelling and possible spelling variations to extract the same word. For example, the word ‘texting’ contain these spelling variations: ‘txting’, ‘txt’, ‘txet’, ‘txeting’, ‘textting’, ‘texting’.

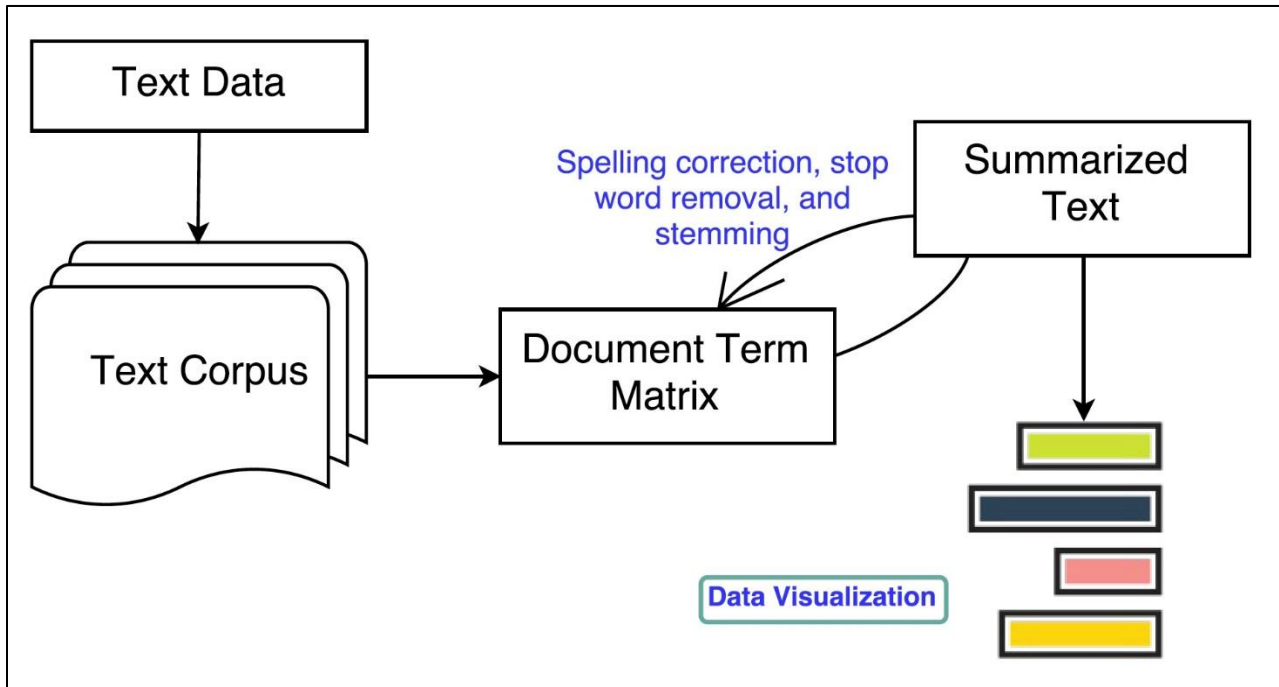


FIGURE 1 Text mining flowchart.

Teen Reported Teen Driver Risk Factors

Figure 2 shows the heat chart of the 20 most frequently cited terms in order of Risk 1 to Risk 4 (as listed in the questionnaire). The darker color indicates a higher percentage of usage, while the lighter color indicates a lower percentage. The six most frequently cited terms are “drinking,” “text,” “phone,” “seatbelt,” “drug,” and “speed.” Of the 20 most frequently cited risks, nine are distracted related risk factors. Similar to other studies, this shows that while teens may acknowledge various distraction related behaviors as risky to their driving still self-report engaging in them behind the wheel. Other important findings show that “sleep” or “tired” factors had a much lower frequency (0.49 - 4.56 and 0.22 - 0.89) compared to other listed risks like “music” (0.78 – 6.61). In addition, “friends” and “passengers” had lower frequencies (0.38 – 3.43 and 0.17 – 1.63) compared to “music,” reaffirming the need for continued education and outreach on the dangers of

322 peer passengers for teens. “Light” was also the third less frequently listed risk (0.12 – 1.57) despite
 323 nighttime driving posing a significant danger to teen drivers.
 324

Term	Risk 1	Risk 2	Risk 3	Risk 4
drinking	35.85	24.07	12.35	8.76
text	29.31	16.44	9.27	5.31
phone	12.07	14.59	13.75	10.87
seat/seatbelt	5.91	5.28	8.03	9.80
drug	4.55	7.40	5.55	4.74
speed	3.54	6.51	10.18	12.84
talking	2.59	6.78	7.26	6.91
distraction	1.57	3.09	5.61	6.33
inattention	0.88	2.34	4.76	5.65
music	0.78	3.44	5.52	6.61
careless	0.57	1.68	2.95	3.61
sleep	0.49	1.48	3.21	4.56
eating	0.44	2.10	3.39	3.87
friends	0.38	1.62	3.16	3.43
smoking	0.34	1.33	1.17	1.15
tired	0.22	0.32	0.65	0.89
passengers	0.17	0.71	1.38	1.63
light	0.12	0.33	0.76	1.57
road	0.11	0.25	0.47	0.00
weather	0.11	0.00	0.00	0.75

325 **FIGURE 2 Heat chart of most frequently cited risk factors.**

326
 327 Figure 3 represents a heat chart of the most frequently cited risk factors by the five states
 328 with the largest sampling size: Texas, Georgia, Connecticut, North Carolina and Nebraska. \The
 329 remaining six states were omitted due to limited available data or insignificant sample size.
 330 “Drinking” was the most frequently listed risk factor for four states (TX, GA, CT, and NC) and
 331 listed second for NE. Nebraska’s number one most frequently listed risk was “text” and when
 332 compared to results in Table 3, show that Nebraska had the highest reported number of teens
 333 engaging in texting messaging while driving with an average of 26.3% reporting doing so “a lot”
 334 or “some” in the past month. “Text” and “Phone” were the second and third most frequently listed
 335 risk factors followed by “speed” and “seatbelts” across all five states. “Sleep,” “light” and “tired”
 336 were listed at lower frequencies yet an average of 15% of teens across all five states reported
 337 driving “a lot” or “some” after 10 pm in the absence of an adult highlighting a significant gap in
 338 knowledge regarding nighttime driving. “Friends” and “passengers” were also listed at much lower
 339 frequencies across all five states falling below risks like “music” or “eating” but was self-reported
 340 at high levels across all five states (21% of teens reported doing so “a lot” or “some” in the past
 341 month).

342
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346

Term	TX	GA	CT	NC	NE
drinking	19.21	17.98	19.21	14.60	16.90
text	13.59	16.57	10.03	13.81	17.40
phone	12.51	9.19	15.31	11.78	8.20
speed	8.93	8.01	10.79	11.69	8.41
seat/seatbelt	7.29	8.41	7.42	12.34	10.99
talking	6.02	4.78	4.15	4.97	3.19
drug	5.55	5.02	7.26	3.63	3.93
distraction	4.21	4.93	6.34	5.33	5.37
music	4.11	5.59	4.36	5.15	5.10
inattention	3.82	4.39	2.37	3.44	3.29
sleep	2.99	2.60	1.45	2.27	2.38
eating	2.74	2.53	1.15	1.71	3.12
careless	2.47	2.88	1.66	2.84	3.23
friends	2.09	2.60	3.52	2.76	2.86
passengers	1.01	0.95	1.18	1.30	1.19
smoking	0.98	1.38	0.65	0.63	0.00
light	0.95	0.73	0.69	0.43	0.56
tired	0.61	0.44	1.03	0.51	1.41
makeup	0.47	0.00	0.00	0.00	0.53
road	0.47	0.41	0.47	0.25	0.53

347 **FIGURE 3 Heat chart of most frequently cited risk factors by state.**

348

349 **Analysis of Top Five Risk Factors**

350 The analysis compared responses based on gender (as shown in Figure 4) and will be discussed
 351 below. Researchers assume that risks are listed in the order of priority wherein the risks are listed
 352 in the order teens’ belief is most dangerous to least dangerous.

353

354 *Highest rated risk factor*

355 Over twenty-seven percent of females and 19% of males listed “drinking and driving” as a risk
 356 factor for teen drivers. This factor was the highest ranked risk for both genders, but self-reported
 357 data across all states show that impaired driving has the lowest reported number of teens engaging
 358 in this behavior (81.4% of teen drivers reported never having done so in the past month). One
 359 possibility as to why this may be listed so high is due to the strong prevention culture that has
 360 arisen regarding impaired driving which continually warns against impaired driving and has high
 361 levels of visibility across multiple media platforms. Additionally, teens who have grown up seeing
 362 this message may therefore be more aware of the dangers, thus more likely to list it as a high risk
 363 factor for teens despite being less likely to engage in the behavior. Ginsburg et al., (2008) found
 364 teens ranked drinking while driving as the greatest roadway hazard for teens but only 12% reported
 365 witnessing it often (24).

366

367 *Second Risk Factor*

368 After ‘drinking’ 19% of females listed “phone” and 14% of males listed “text”. While both groups
 369 listed some form of electronic device use as a high-level risk, it is important to highlight the

370 following: while 14% of male respondents refer to texting as the second highest risk, less than 5%
371 of female respondents listed ‘text’ as a risk factor. According to the National Highway Traffic
372 Safety Administration (2017), younger drivers (ages 16-24) and female drivers have higher
373 observed rates of visibility manipulating hand-held devices while driving (25). It is possible that
374 female drivers may engage in this habit more frequently because they may not view it as hazardous
375 to their driving or be less reluctant to admit to doing so because they feel it is not a danger to them.
376

377 *Third Risk Factor*

378 Following very closely behind ‘phone’ is “talking” which was listed by 18% of females as the
379 third risk factor. Twelve percent of males listed “phone” as the third risk factor. For this analysis,
380 “talking” will refer to hand held device use. Due to the nature of open-ended questions, researchers
381 must interpret answers and their meanings with the limited information provided. An important
382 distinction to make is that while 18% of females listed “talking” as an important risk factor, only
383 6% of males listed it. Traffic data from 2015-2016 showed that male drivers had lower rates of
384 holding a phone to their ear while driving, but higher rates of talking on the phone with a visible
385 headset yet Barr et al., (2015) found a higher proportion of males’ self-report using their cell
386 phones more often while driving than females (26). It is possible that male drivers do not view
387 talking on their phones as a dangerous activity when compared to texting or other risk factors and
388 thus more likely to engage in the behavior. Regardless, drivers ages 16-24 had the highest rates of
389 talking while holding a phone or on visible headsets across all ages, highlighting the importance of
390 continued intervention (26).
391

392 *Fourth Risk Factor*

393 After the top three risk categories, a significant drop is seen for the remaining listed factors for
394 female respondents with all remaining factors ranking below 10%. The drop for male respondents
395 is not as large, but a drop is still seen after the third risk factor from 12% to all remaining risks
396 falling at or below 9%. Eight-percent of females listed “music” as the fourth risk factor while 9%
397 of males listed “speed” as the fourth risk. As stated previously, speeding is a significant risk factor
398 for teen crashes and one of the five main risks that are focused on through the TDS program.
399 Interestingly, only 3% of females listed speed as a risk factor compared to 9% of males who
400 overall, have a much higher rate of fatal crashes due to speed compared to female drivers (32% vs.
401 20%) (27). This information is important as it supports previous literature that has shown that
402 while teen drivers acknowledge risky driving behaviors, they still report engaging in them.
403

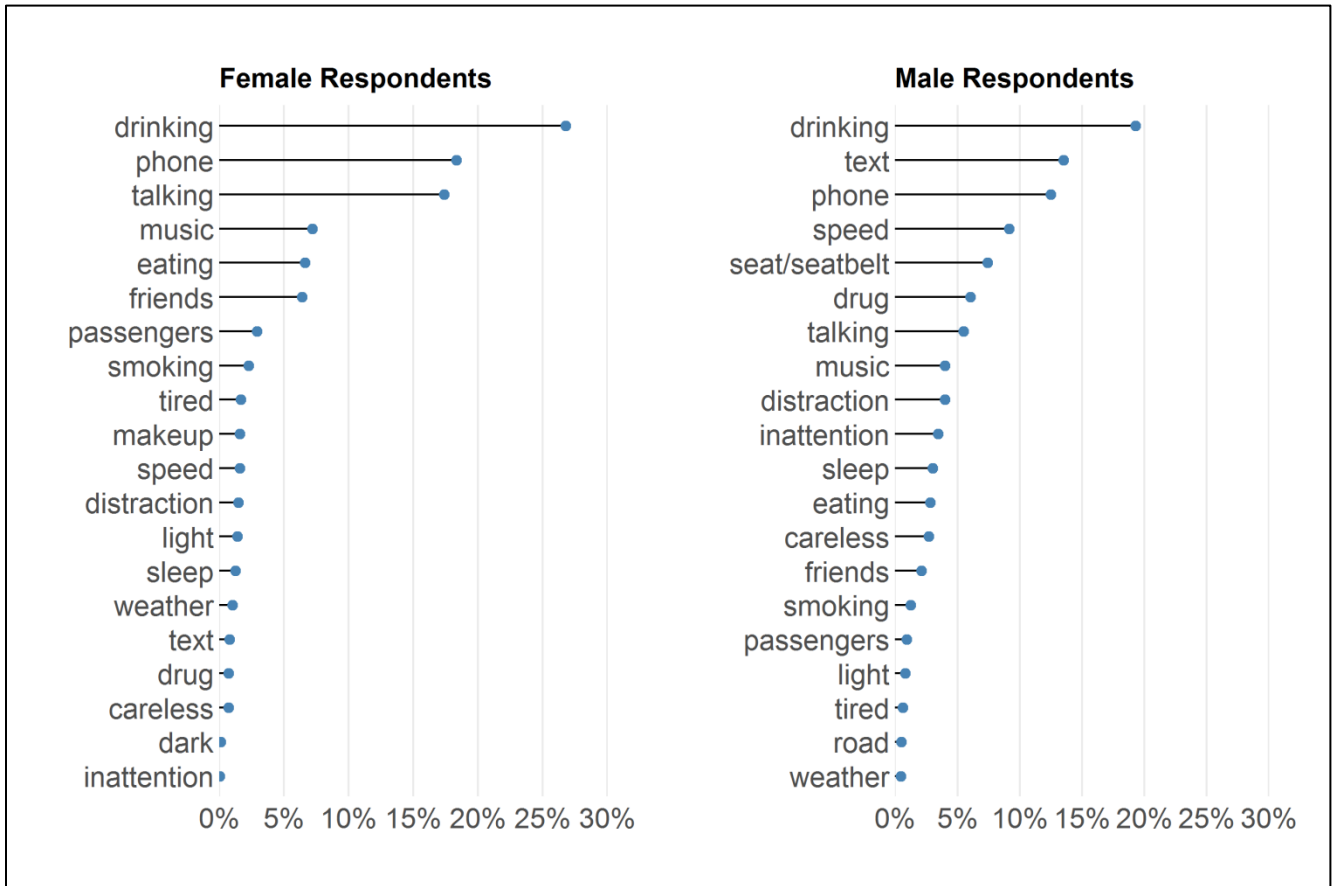
404 *Fifth Risk Factor*

405 Seven-percent of females listed “eating” as the fifth risk factor while 8% of males listed
406 “seatbelts.” An important result to note is that “seatbelt” does not appear on the top 20 risk factors
407 listed by females. Self-reported seatbelt use across the states still shows a significant number of
408 teens driving or riding without a seatbelt “a lot” and “some” in the past month (11.5% and 23%).
409 It is possible that female drivers may be less likely to ride without a seatbelt and so do not view it
410 as a risk, but findings from self-reported driving behavior did not identify significant differences
411 between male and female drivers (28).
412

413 *Significant gender differences for remaining factors*

414 Other interesting findings between males and females showed that females listed “friends” and
415 “passengers” at significantly higher frequencies compared to male drivers ranking sixth and

416 seventh for females compared to the fourteenth and sixteenth most frequently listed risk factor for
 417 males. This is an important area to address because not only are teen passenger combinations
 418 dangerous but also research has identified increased crash risks of male-to-male passenger
 419 combinations (29). Males also ranked “drugs” higher than females (6th vs. 17th) and while the
 420 literature on gender differences on drugged driving is sparse, research has shown that men are
 421 more likely than women to drive under the influence of drugs or alcohol (30).
 422



423
 424 **FIGURE 4 Survey item 6: top cited driving risks for males and females.**
 425

426 **CONCLUSION**

427 Risks such as “drugs,” “music,” “smoking” and “makeup” while not captured within the spectrum
 428 of specific questions addressing self-reported driving behavior are important factors to consider as
 429 further opportunities for research given the frequency with which they were noted by teens as top
 430 driving risks. “Drugged driving” in particular had a high frequency, which may possibly mean that
 431 teen drivers are seeing this behavior more frequently behind the wheel (or inside the vehicle). The
 432 impact of drugged driving on crashes is difficult to measure, but literature has shown an increasing
 433 trend in drugged driving related crashes and increased crash risk (31).

434 Findings also include:

- 435 • The most frequently self-reported risky driving behaviors for teens across all 11 states
 436 included talking on a cell phone, text messaging, driving 10 mph or more over the speed
 437 limit, driving or riding with teen passengers unaccompanied by an adult and driving after
 438 10 pm unaccompanied by an adult. With regard to these behaviors, teen drivers reported

439 doing so with higher frequencies across several states, highlighting the need for continued
440 education and more focused outreach for these high priority risk factors.

- 441 • Drinking was listed as the number one risk factor by males and females yet has the lowest
442 reported number of teens engaging in this behavior. This was also true when analyzed
443 state-by-state in a heat. Distracted driving related to cell phones was the second and third
444 most frequently listed risk factor across genders and states. Findings also show significant
445 gender differences for *texting*, *passengers*, *speed* and *seatbelts*.

446 Other important findings show that “sleep,” “tired,” and “light” factors had a much lower
447 frequency of being listed by teens highlighting the need for continued emphasis on the risks of
448 nighttime driving for teens. “Friends,” and “passengers” were also listed at much lower
449 frequencies but had some of the highest levels of teens self-reporting that they frequently engaged
450 in these driving behaviors. It is important to note that the current study is unique as it brings to
451 light the complexity in identifying key risk factors associated with teen driving. The implications
452 of these findings highlight important areas for practitioners to increase focus on particularly,
453 education pertaining to passengers, speeding and seat belts in order to improve messaging
454 targeting teen drivers. However, it has some limitations. Results from states outside of Texas
455 were included in analysis but should not be interpreted as representative of entire state due to small
456 sampling size. In addition, research data was distributed through programs utilizing TDS, which
457 can effect random distribution for areas outside of Texas due to small sampling sizes. Crash data
458 was not used in validating the current findings. Future studies can incorporate multistate teen
459 driving related crash data to examine the current findings and help collect and/or consolidate
460 additional knowledge on key teen driving risk factors.

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