Receipt of Warnings Regarding Potentially Impairing Prescription Medications and Associated Risk Perceptions in a National Sample of U.S. Drivers

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ABSTRACT. Objective: Reducing drug-involved driving is a national policy priority, but little is known about the extent to which drivers receive warnings about the impairment potential of their prescribed medications. We used data from the 2013–2014 National Roadside Survey (NRS) to quantify the proportion of drivers who received warnings regarding potentially impairing medications and the association with driving-related risk perceptions. **Method:** Drivers randomly selected at 60 sites completed the self-administered survey, which contained questions on their use of prescription medications. **Results:** Overall, 7,405 drivers completed the prescription drug portion of the NRS. Of these, 19.7% reported recent use (within the past 2 days) of a potentially impairing prescription drug, and 78.2% said the drug had been prescribed for their use. Users of prescribed sedatives (85.8%) and narcotics (85.1%) were most likely to report receiving information about potential impairment,

compared with only 57.7% and 62.6% of users of prescribed stimulant and antidepressant medications, respectively. Receipt of warnings varied by sex, race/ethnicity, income, geographic region, and time of day. For a majority of drug categories, drivers who reported receiving warnings had significantly higher odds of perceived risk of impaired driving/crash and criminal justice involvement. **Conclusions:** Most users of prescription medications reported that the drug was prescribed for their use, but not all reported receiving warnings about driving impairment. Our study provides evidence of missed opportunities for information provision on impaired driving, identifies subgroups that may warrant enhanced interventions, and provides preliminary evidence that receipt of impairment warnings is associated with increased perceptions of driving-related risk. (*J. Stud. Alcohol Drugs*, 78, 805–813, 2017)

REDUCING DRUG-INVOLVED DRIVING has been a national policy priority in the United States since 2011, when the Office of National Drug Control Policy set a goal to reduce “drugged driving” prevalence by 10% by 2015 (Executive Office of the President of the United States, 2011). This action was motivated by data showing a high prevalence of illicit and/or potentially impairing licit drug use among weekend nighttime drivers (Lacey et al., 2009) and drivers killed in motor vehicle crashes (National Highway Traffic Safety Administration, 2010), as well as high rates of driving after marijuana use among high school seniors (O’Malley & Johnston, 2013). Efforts to reduce drug-involved driving have focused largely on illegal drugs; however, many prescription drugs have psychoactive effects that can impair driving (Couper & Logan, 2004; Dassanayake et al., 2011; Hetland & Carr, 2014; Leung, 2011; Rapoport & Baniña, 2007).

Prescription drugs of concern include antidepressants, which can cause sedation; stimulants, which can influence

attention, aggressiveness, and risk taking; sedatives such as barbiturates, benzodiazepines, muscle relaxants, and sleep aids (e.g., “Z-hypnotics”), which can cause drowsiness and impair cognitive and motor function; and opioids/narcotics, which can cause drowsiness and cognitive and motor impairment. The most comprehensive effort to assess the impact of these medications was undertaken by the European Driving Under the Influence of Drugs, Alcohol and Medicines (DRUID) Project. In its 2012 final report (Schulze et al., 2012), DRUID presented case-control studies demonstrating increased risks for benzodiazepines and Z-hypnotics (twofold to threefold and fivefold to sevenfold increase for serious injury and fatality, respectively) and medicinal opioids (fivefold to eightfold and fivefold increase for serious injury and fatality, respectively). Experimental studies have shown that certain benzodiazepines have a substantially higher risk of impairment than alcohol and Z-hypnotics, and opioids showed impairment comparable to alcohol. However, DRUID’s meta-analyses suggest that drug-related impairment strongly depends on a variety of factors including the drug prescribed, dosage, and treatment duration, with longer treatment regimens contributing to increasing tolerance for some drug classes.

Subsequent studies further clarified these findings and confirmed the complexity of assessing medication-related driving risks at the individual patient level. In aggregate, these studies provide consistent evidence that benzodiaz-

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epines and Z-hypnotics have impairing effects, but these effects are variable across patients (Dassanayake et al., 2011; Hetland & Carr, 2014; Leung, 2011; Rapoport & Baniña, 2007; Strand et al., 2016). Experimental studies of opioids have shown moderate effects on driving but no clear dose-response relationship (Strand et al., 2016), whereas a majority of epidemiological studies have shown significant associations with road traffic crashes (Gjerde et al., 2015). The greatest risk was associated with opioid-naïve patients, suggesting that drug tolerance is an important consideration (Dassanayake et al., 2011; Fishbain et al., 2003; Galski et al., 2000; Leung, 2011; Wilhelmi & Cohen, 2012).

Similarly, some experimental studies of stimulants have shown improvements in driving skills whereas others show impairment or no effect, and no dose-response relationship has been established (Strand et al., 2016). Results also varied by indication, with conditions such as attention-deficit/hyperactivity disorder (ADHD) and narcolepsy consistently showing improvements in driving performance in the presence of stimulant medications (Barkley & Cox, 2007; Kotterba et al., 2004; Philip et al., 2014). Epidemiological studies of stimulants are more conclusive, with 8 of 10 showing a significant relationship between stimulants and crashes (Gjerde et al., 2015). Last, the most recent epidemiological review of antidepressants showed a statistically significant association between tricyclic antidepressants and selective serotonin reuptake inhibitors and crashes in 9 of 13 studies (Gjerde et al., 2015), but experimental reviews have documented inconsistencies with regard to the impact of these drugs (Hetland & Carr, 2014; Ravera et al., 2012).

These findings suggest an urgent need for health care providers to fully understand the driving-related risks of the medications they prescribe and effectively relay these risks to individual patients. These interventions are crucial from both a health and safety perspective and a criminal justice perspective. Increasingly, U.S. states are enacting legislation to address drug-involved driving; as of November 2016, 16 states had zero tolerance laws making it illegal to drive with any measurable amount of listed drugs in the body, and an additional 6 states had per se laws that establish above-zero limits for listed drugs (Governors Highway Safety Association, 2016). In some states, these drugs include medications scheduled as controlled substances. Other states enforce drug-involved driving under general impairment laws, which require the state to prove the driver was impaired as the result of a specific drug. Only a small number of states allow taking a substance as directed under a valid prescription as a full or partial defense against driving while impaired (NORML, 2016). Accordingly, the vast majority of drivers are responsible for understanding any impairing effects of their medications and making informed decisions about driving.

Unfortunately, there is little information on the extent to which U.S. drivers receive medication-related impairment

warnings from providers. Perhaps the only study to date, limited to adults 55 years and older, found that fewer than one in four of those taking potentially impairing medications received a provider warning and less than half had any awareness that their medications might impair driving (MacLennan et al., 2009). Further, we are unaware of any U.S.-based studies on the content and effectiveness of provider warnings. In contrast, there is a growing effort to estimate the prevalence of drug use among U.S. drivers. For example, the 2007 National Roadside Survey (NRS; Lacey et al., 2009) reported prevalence among daytime and nighttime drivers at 0.5% and 0.2% for antidepressants, 1.6% and 1.6% for narcotic analgesics, 1.6% and 0.6% for sedatives, and 1.6% and 3.2% for stimulants, respectively, based on oral fluid testing. The 2007–2010 Fatality Analysis and Reporting System documented prevalence of 8.9% for stimulants, 7.6% for narcotics, and 4.8% for depressants (excluding alcohol) among fatally injured drivers based on blood toxicology (Brady & Li, 2014). Of note, these data sources do not always distinguish between legal and illegal drugs and cannot discern between medical and nonmedical use of drugs, which is crucial information for designing interventions.

As concerns in the United States regarding drug-involved driving grow, it is crucial to understand (a) the extent to which patients receive warnings regarding the risks of driving while using medications, and (b) the impact of these warnings on driver risk perceptions. We leveraged an opportunity within the 2013–2014 NRS to conduct a brief assessment of these issues in a nationally representative sample of U.S. drivers.

Method

The National Roadside Survey of Alcohol and Drug Use provides a periodic assessment of substance use among U.S. drivers. Data from the 1973, 1986, and 1996 NRS (Voas et al., 2000; Wolfe, 1973, 1986) were limited to alcohol use; in 2007, self-reported and biological measures of drug use were added to the survey (Lacey et al., 2009). This study reports results from the 2013–2014 NRS, which further expanded data collection on drug use. The study protocol is described in detail in the 2013–2014 NRS methodology report (Kelley-Baker et al., 2016).

Study design and recruitment

Data collection sites for the 2013–2014 NRS were selected using a multistage sampling procedure based on the National Highway Traffic Safety Administration's National Analysis Sampling System/General Estimates System (NASS/GES). The NASS/GES provides a national probability sample of 60 primary sampling units (PSUs) consisting of cities, large counties, or groups of counties representing

four geographic regions of the continental United States and three levels of population density. Together these 60 sites provide a representative sample of drivers across the country (Berning et al., 2015). Because assistance from law enforcement agencies (LEAs) was necessary for NRS data collection, we sought collaboration from LEAs in all 60 PSUs; where collaboration could not be obtained, we substituted a PSU with similar characteristics and supportive LEA from among the more than 1,000 PSUs from which the NASS/GES probability sample was selected.

To select specific data collection locations, we separated each of the 60 PSUs into 1-mile-square grid areas and randomly selected 30 grid areas from which we identified five feasible survey locations per PSU. Feasible locations were considered safe for survey activities, were large enough to accommodate the survey operation, and had sufficient traffic flow to generate an adequate number of subjects (limited to counties with population of >20,000 residents and roadways within those counties with daily traffic counts of 2,000–4,000 vehicles), as well as support from the LEA with jurisdiction over each location.

Data collection within each PSU consisted of one daytime session (Friday between either 9:30 A.M. and noon or 1:30 P.M. and 3:30 P.M.) and four nighttime sessions (Friday and Saturday nights between 10:00 P.M. and midnight and between 1:00 A.M. and 3:00 A.M.). Vehicles were recruited by a traffic director stationed at the roadway to direct drivers from the traffic flow safely into the survey location. Once an interviewer completed a survey with this vehicle, the traffic director would signal the next car to approach. This procedure is typical of roadside surveys and results in a random selection of eligible vehicles that is not biased toward any particular class of driver.

We informed all drivers that participation was voluntary and anonymous and that they could cease participation at any time. Drivers age 16 years and older who spoke English or Spanish were eligible to participate. Commercial drivers, drivers who did not speak English or Spanish, and drivers deemed to be significantly impaired were not invited to participate. All study protocols and procedures were approved by the Pacific Institute for Research and Evaluation's Institutional Review Board.

Data collection

After providing informed consent, survey participants answered interviewer-administered questions regarding sociodemographics, driving behaviors, alcohol consumption, and drinking and driving experiences, and were asked to provide a breath sample to measure alcohol content (Mark V Alcovisor®, PAS Systems International, Fredericksburg, VA). Drivers were then asked to provide an oral fluid sample (Quantisal™, Immulysis Corporation, Pomona, CA) for drug testing and to complete a self-administered drug use

TABLE 1. Prescription drug categories and classes

Category	Analysis class
Antidepressants (e.g., Prozac, Zoloft, Wellbutrin, Lexapro, Effexor)	Antidepressants
Methadone or buprenorphine (e.g., Subutex, Suboxone)	Narcotics
Morphine or codeine (e.g., Tylenol with codeine)	Narcotics
Other prescription pain medications (e.g., OxyContin/oxycodone, Percocet, Opana/oxymorphone, Vicodin/hydrocodone)	Narcotics
Barbiturates (Phenobarbital)	Sedatives
Benzodiazepines (e.g., Xanax/alprazolam, Valium/diazepam, Ativan/lorazepam)	Sedatives
Muscle relaxants (e.g., Soma, Flexeril)	Sedatives
Sleep aids (e.g., Ambien, Lunesta)	Sedatives
ADHD medications (e.g., Ritalin, Aderall, Concerta)	Stimulants
Other amphetamines (e.g., Benzadrine, Dexedrine)	Stimulants
Prescription dietary/appetite suppressant (e.g., Tenuate, phentermine)	Stimulants

Note: ADHD = attention-deficit/hyperactivity disorder.

survey including questions on both illegal drugs and medications, and drug and alcohol use disorder screening tests (Conley, 2001; Cottler et al., 1997; Maisto et al., 2000). All survey data were collected using Qualtrics Online Survey Software (Provo, UT) on iPad electronic tablets.

Prescription drug use questions focused on a list of drugs chosen for their potential impaired-driving effects and their likelihood of being reported by drivers. Table 1 lists the drug categories verbatim as they appeared in the survey and their categorization for analysis purposes. Drivers were asked when they had last used drugs in each category (i.e., “past 24 hours,” “past 2 days,” “past month,” “over a month,” or “beyond a year/never”). Drivers who reported using the drug(s) in the past 24 hours or 2 days (prescription drug use “within the past 2 days”) were asked whether the drug was prescribed for their use; those who answered affirmatively were asked several follow-up questions regarding warnings and risk perceptions related to drug use and driving. These questions are provided verbatim in Table 2, along with driver response options. Drivers who reported using the drugs of interest more than 2 days ago were excluded from follow-up questioning because of concerns about their ability to accurately recall warnings relayed via providers and/or labels over a longer time period.

Data analysis

Analyses were limited to drivers who self-reported using drugs within the past 2 days that were prescribed for their use. We calculated the proportion who reported a warning from a health care provider or pharmacy staff (referred to as “provider”) and/or package labeling for each drug category. For questions regarding risks of impaired driving and criminal justice involvement we created a binary variable, grouping “very likely” and “somewhat likely” responses to-

TABLE 2. Survey questions on warnings and perceptions regarding driving while taking prescribed medications

Survey questions	Response options
• “Did a health care provider or pharmacy staff warn you that the drug might affect your driving?”	Yes
• “Was there a label on the packaging warning you that this drug might affect your driving?”	No
	Don’t know
• “How likely do you think it is that taking this drug as prescribed could affect a person’s ability to drive safely?”	Very likely
• “How likely do you think it is that taking this drug as prescribed could cause a person to crash?”	Somewhat likely
• “How likely do you think it is that a person taking this drug as prescribed could be arrested for impaired driving?”	Somewhat unlikely
• “How likely do you think it is that a person taking this drug as prescribed could be convicted of impaired driving?”	Very unlikely

gether and “somewhat unlikely” and “very unlikely” together because of small cell sizes for some responses.

To identify driver characteristics associated with reporting impaired driving warnings from any source (provider and/or package label), we combined drug categories into four classes (antidepressants, sedatives, stimulants, narcotics) to further accommodate small cell sizes. We used multiple logistic regression modeling to analyze the relationship between each driver characteristic and reporting a warning, controlling for all other variables in the model. Finally, for each drug category we calculated univariate odds ratios to examine the association between reporting provider warnings and perceptions of the risk of impaired driving or criminal justice involvement as very/somewhat likely; we did not adjust for potential confounders in this final analysis because of small cell sizes. All analyses were weighted to account for the multistage sampling strategy to generate nationally representative survey estimates. We used Stata Version 11 software for all analyses (StataCorp LP, College Station, TX).

Results

Warnings and risk perceptions related to driving while using prescription drugs

Of 8,804 drivers who were NRS eligible and participated in the general roadside interview, 7,405 completed the prescription drug survey (83.9%). The majority were male (55.8%), non-Hispanic White (56.1%), and under 35 years of age (52.3%). Overall, 19.7% of drivers reported taking at least one potentially impairing medication within the past 2 days. The most common drug class was sedatives (8.0%), followed by antidepressants (7.7%), narcotics (7.5%), and stimulants (3.9%). Among drivers who reported using these medications within the past 2 days, 78.2% ($n = 1,127$) said the drug was prescribed for their use. More specific information on self-reported prescription drug use and prevalence across driver sociodemographic subgroups is described elsewhere (Kelley-Baker et al., 2017).

Table 3 shows the proportion of drivers using prescribed medications who said they received warnings about the potential of these drugs to affect driving and the source of those warnings. More than four out of five drivers who reported taking sedatives (85.8%) or narcotics (85.1%) reported a warning from their provider or medication label, whereas just over one of two reported receiving warnings about antidepressants (62.6%) or stimulants (57.7%).

Table 3 also quantifies drivers’ perceptions regarding the likelihood that taking these drugs as prescribed could affect safe driving and criminal justice involvement. These results are presented only by drug category because responses by drug class could not be aggregated across individual categories. Drugs most commonly perceived as affecting safe driving were sleep aids followed by morphine/codeine, other amphetamines, and muscle relaxants. Excluding barbiturates, which were reported by only five drivers, ADHD medications were least likely to be viewed as affecting safe driving. Similarly, sleep aids and ADHD medications were most and least likely, respectively, to be viewed as likely to cause a crash or result in criminal justice involvement.

Factors associated with receiving warnings regarding impaired driving

Table 4 presents results from the multiple logistic regression modeling of factors associated with reporting a provider or label warning. We found statistically significant associations with sex, race/ethnicity, income, geographic region, and time of day. Specifically, males had significantly lower odds of reporting warnings for sedatives than did females. Black/African American drivers had higher odds than non-Hispanic White drivers of reporting warnings regarding stimulants, whereas Hispanic drivers had lower odds than non-Hispanic White drivers of reporting warnings for sedatives and narcotics. Drivers who used sedatives and had income of \$50,000–\$75,000 had higher odds of reporting warnings than did those with less than \$25,000 in annual income. Nighttime drivers had lower odds than daytime drivers of re-

TABLE 3. Reported warnings and risk perceptions related to driving while using prescription drugs ($n = 1,127$)^a

Variable	Used prescribed drug(s) within past 2 days <i>n</i>	Reported warnings			Very or somewhat likely that taking the drug as prescribed could . . .			
		Provider warning <i>n</i> (%)	Label warning <i>n</i> (%)	Any warning <i>n</i> (%)	Affect ability to drive safely <i>n</i> (%)	Cause a crash <i>n</i> (%)	Result in arrest for impaired driving <i>n</i> (%)	Result in conviction for impaired driving <i>n</i> (%)
Stimulants								
ADHD medications	139	67 (52.3)	63 (43.9)	78 (58.6)	33 (21.3)	16 (10.9)	21 (19.6)	19 (17.7)
Prescription dietary/appetite suppressants	56	23 (37.6)	21 (36.8)	26 (46.9)	12 (24.4)	10 (25.6)	14 (30.4)	11 (23.2)
Other amphetamines	27	19 (48.7)	21 (75.7)	22 (81.1)	17 (69.8)	16 (63.4)	17 (60.7)	16 (36.8)
Any stimulant	207	101 (47.6)	95 (44.5)	116 (57.7)				
Antidepressants	563	301 (53.8)	311 (54.0)	353 (62.6)	144 (27.0)	83 (13.9)	75 (13.7)	70 (11.8)
Sedatives								
Barbiturates	5	3 (53.8)	3 (36.4)	4 (59.2)	1 (3.3)	1 (3.3)	1 (3.3)	1 (3.3)
Benzodiazepines	177	135 (72.8)	145 (79.4)	149 (81.6)	104 (58.0)	87 (44.9)	85 (46.3)	79 (43.7)
Muscle relaxants	151	123 (83.7)	128 (85.7)	135 (89.0)	108 (69.6)	94 (59.0)	86 (52.7)	84 (46.8)
Sleep aids	206	170 (83.8)	173 (84.7)	185 (89.6)	158 (79.4)	142 (71.9)	137 (64.7)	128 (61.9)
Any sedative	436	344 (78.8)	360 (81.8)	381 (85.8)				
Narcotics								
Methadone or buprenorphine	47	29 (63.1)	32 (74.2)	37 (80.4)	28 (57.7)	21 (37.3)	22 (43.7)	20 (36.4)
Morphine or codeine	165	121 (78.2)	127 (78.2)	135 (83.8)	114 (72.6)	101 (66.3)	96 (61.3)	100 (61.7)
Other prescription pain medications	315	250 (80.4)	252 (80.8)	274 (88.2)	201 (63.3)	178 (57.5)	180 (58.7)	180 (60.4)
Any narcotic	412	305 (76.6)	312 (77.4)	341 (85.1)				

Notes: ADHD = attention-deficit hyperactivity disorder. ^aPercentages are weighted.

porting warnings for antidepressants and narcotics. Overall, the odds of reporting warnings for prescription drugs of any kind were significantly higher for Black/African American drivers compared with non-Hispanic White drivers and for Midwest drivers compared with those in the West and were significantly lower among nighttime than among daytime drivers.

Associations between drug warnings and perceived risk of impairment, criminal justice involvement

Table 5 shows the relationship between receipt of provider and/or label warnings and driver risk perceptions. Drivers who reported warnings had significantly higher odds of perceiving that impaired driving and/or crash was likely for dietary/appetite suppressants, other amphetamines, antidepressants, muscle relaxants, sleep aids, and pain medications other than methadone/buprenorphine and morphine/codeine. Reporting warnings was also associated with significantly higher odds of perceiving arrest and/or conviction as likely for ADHD medications, prescription dietary/appetite suppressants, antidepressants, sleep aids, morphine/codeine, and other pain medications.

Discussion

A majority of drivers who reported recent use of a potentially impairing medication said that the drug was

prescribed for their use, providing ample opportunities for warnings from health care providers and medication labels. The reasons for suboptimal receipt and recollection of warnings documented in our study, and the variation across drug classes, warrants further exploration. All of these medications should carry warning labels, but they appear not to be recognized and/or remembered by many drivers. Similarly, although providers may be viewed as having an ethical and professional responsibility to fully inform patients of the potential for driving impairment and related legal risks (Sigona & Williams, 2015), many drivers in our study either did not receive warnings or did not recall them.

This situation is not unique to the United States. Studies in Australia and the Netherlands have similarly shown low recall of warning labels and provider information on impaired driving, respectively (Smyth et al., 2013; Veldhuijzen et al., 2006). As part of its systematic assessment, DRUID reviewed drug labeling across member countries and developed a harmonized, EU-wide labeling system designed to better inform drivers of their medications' potential driving impacts (Schulze et al., 2012). The system consists of four color-coded categories (i.e., no, minor, moderate, and major influence on driving) to which medications are assigned based on pharmacodynamics and pharmacokinetics, pharmacovigilance data, and experimental and epidemiological data. The new labels are colorful and easily interpreted, using color gradients across categories from green (no influence) to red (major influence; Ravera et al., 2012), and

TABLE 4. Factors independently associated with reporting a provider or label warning regarding impaired driving^a

Variable	Descriptive (prescribed) <i>n</i>	Provider and/or label warning (any drug) % [95% CI]	Reported warning from provider and/or label				
			Any Rx AOR [95% CI] (<i>n</i> = 1,072)	Antidepressants AOR [95% CI] (<i>n</i> = 541)	Sedative AOR [95% CI] (<i>n</i> = 420)	Stimulant AOR [95% CI] (<i>n</i> = 195)	Narcotic AOR [95% CI] (<i>n</i> = 384)
Sex							
Female	612	69 [64, 73]	1.00	1.00	1.00	1.00	1.00
Male	460	69 [64, 73]	1.02 [0.75, 1.40]	0.86 [0.52, 1.44]	0.46** [0.23, 0.94]	0.91 [0.44, 1.88]	1.85 [0.95, 3.62]
Age, in years							
<21	84	67 [51, 80]	1.00	1.00	1.00 ^b	1.00	1.00
21–34	317	69 [62, 76]	1.10 [0.50, 2.41]	0.74 [0.20, 2.73]	1.00 ^b	2.46 [0.66, 9.19]	3.30 [0.85, 12.74]
35–44	221	65 [55, 75]	0.82 [0.31, 2.20]	0.59 [0.15, 2.36]	1.20 [0.39, 3.74]	0.63 [0.11, 3.57]	1.99 [0.42, 9.31]
≥45	450	70 [63, 76]	1.03 [0.46, 2.32]	0.91 [0.23, 3.59]	0.93 [0.35, 2.51]	1.40 [0.34, 5.73]	1.60 [0.42, 6.05]
Race/ethnicity							
White, non-Hispanic	789	66 [42, 80]	1.00	1.00	1.00	1.00	1.00
Black/African American	153	78 [70, 84]	1.82* [1.13, 2.93]	1.76 [0.72, 4.29]	3.46 [0.68, 17.71]	3.32* [1.02, 10.86]	0.69 [0.28, 1.68]
Hispanic	55	63 [42, 80]	0.92 [0.38, 2.20]	4.20 [0.93, 19.02]	0.25* [0.08, 0.76]	0.19 [0.04, 1.00]	0.15* [0.04, 0.64]
Other	75	74 [59, 85]	1.60 [0.73, 3.52]	1.68 [0.50, 5.61]	0.82 [0.22, 3.01]	0.63 [0.10, 3.89]	0.30* [0.09, 0.98]
Education							
High school or less	303	73 [64, 80]	1.00	1.00	1.00	1.00	1.00
Some college	769	67 [63, 71]	0.77 [0.48, 1.23]	0.86 [0.46, 1.62]	1.00 [0.44, 2.30]	1.16 [0.43, 3.17]	0.47 [0.19, 1.17]
Employment							
Employed	560	68 [62, 73]	1.00	1.00	1.00	1.00	1.00
Unemployed	64	75 [59, 86]	1.28 [0.59, 2.78]	1.27 [0.50, 3.19]	1.76 [0.35, 8.97]	1.89 [0.41, 8.66]	0.51 [0.10, 2.57]
Disabled	84	68 [49, 83]	0.81 [0.36, 1.84]	0.43 [0.16, 1.14]	0.54 [0.15, 2.00]	11.46 [0.76, 173.04]	1.18 [0.33, 4.18]
Other	264	69 [62, 75]	0.97 [0.61, 1.55]	1.49 [0.84, 2.64]	0.69 [0.31, 1.54]	1.66 [0.61, 4.55]	0.48 [0.19, 1.22]
Income ^c							
<\$25	297	70 [63, 77]	1.00	1.00	1.00	1.00	1.00
\$25K–\$50K	309	72 [66, 77]	1.16 [0.74, 1.85]	0.74 [0.41, 1.33]	1.39 [0.45, 4.35]	2.17 [0.83, 5.67]	1.31 [0.51, 3.34]
\$50K–\$75K	224	63 [55, 71]	0.79 [0.47, 1.34]	0.86 [0.39, 1.90]	3.03* [0.85, 10.89]	1.04 [0.34, 3.13]	0.55 [0.18, 1.66]
>\$75K	242	67 [60, 74]	0.97 [0.60, 1.59]	0.85 [0.43, 1.70]	2.68 [0.72, 9.93]	2.39 [0.69, 8.36]	1.08 [0.33, 3.52]
Region							
West	309	63 [57, 69]	1.00	1.00	1.00	1.00	1.00
Northeast	188	65 [54, 74]	1.16 [0.70, 1.92]	1.26 [0.59, 2.71]	0.53 [0.17, 1.59]	0.88 [0.25, 3.03]	1.44 [0.49, 4.30]
Midwest	302	74 [68, 79]	1.67* [1.11, 2.50]	1.80 [0.91, 3.58]	0.71 [0.27, 1.88]	1.10 [0.44, 2.76]	1.83 [0.73, 4.60]
South	273	70 [64, 75]	1.40 [0.93, 2.11]	1.24 [0.58, 2.64]	1.08 [0.40, 2.95]	1.48 [0.60, 3.63]	1.35 [0.57, 3.18]
Time of day							
Daytime	338	66 [61, 70]	1.00	1.00	1.00	1.00	1.00
Nighttime	734	76 [71, 80]	0.58** [0.41, 0.82]	0.51* [0.31, 0.85]	0.63 [0.24, 1.68]	0.67 [0.30, 1.47]	0.20** [0.07, 0.62]

Notes: AOR = adjusted odds ratio; CI = confidence interval; K = 1,000. ^aPercentages are weighted. ^bZero cases of under-21 year olds failed to receive a warning for sedative use; therefore, <21 and 21–34 year age groups were combined as the reference category to facilitate identification of odds ratios for age categories. ^cAll income amounts are in U.S. dollars.

p* < .05; *p* < .01.

at least two studies have found them to be more accurately understood than existing warning labels (Emich et al., 2014; Monteiro et al., 2013). Our findings suggest that a similarly comprehensive U.S.-based assessment of warning labels and drivers' ability to recall and understand them, and development of an improved labeling system such as that developed by DRUID, is perhaps long overdue. This initiative would require leadership at the federal level by the U.S. Food and Drug Administration to achieve consensus on and codify a new national labeling scheme and categorize existing drugs within that scheme.

Beyond labeling, it is important that health care providers understand and consistently relay information to patients regarding their medications' driving-related risks. This is particularly true given that the potential for impaired driving varies depending on a wide range of drug- and patient-specific characteristics. Of note, an additional benefit of the

DRUID effort to improve labeling was that it served as a vehicle to better inform health care providers about driving-related risks and as a reminder to relay this information to patients (Ravera et al., 2012). To date, there has been little research to improve provider effectiveness in relaying information on medications and driving to patients. Perhaps the only relevant study, conducted in Belgium, found that an integrated software product could increase pharmacists' awareness of medicines' effects on driving skills and increase their engagement with patients around this issue (Legrand et al., 2012). More research is needed to assess the content and efficacy of provider warnings related to drug-impaired driving and develop appropriate interventions.

Among drivers who reported receiving warnings, a substantial proportion did not think it likely that taking the drug as prescribed could affect their ability to drive safely, cause a crash, or lead to criminal justice involvement. This is not

TABLE 5. Association between reporting prescription drug warnings and perceived risk of impairment, arrest, and/or conviction

Reported provider and/or label warning for:	Very or somewhat likely that taking the drug as prescribed could . . .	
	Affect ability to drive safely and/or cause a crash Odds ratio [95% CI]	Result in arrest and/or conviction for impaired driving Odds ratio [95% CI]
Stimulants		
ADHD medications	1.97 [0.65, 5.91]	3.91* [1.09, 13.96]
Prescription dietary/appetite suppressants	30.26** [4.44, 206.33]	12.17** [2.38, 62.26]
Other amphetamines	17.09* [1.21, 240.71]	6.29 [0.39, 100.98]
Antidepressants	4.22** [2.02, 8.80]	2.79* [1.03, 7.59]
Sedatives		
Barbiturates	—	—
Benzodiazepines	1.80 [0.54, 5.94]	3.04 [0.90, 10.23]
Muscle relaxants	4.65* [1.23, 17.57]	2.43 [0.61, 9.72]
Sleep aids	5.65** [1.76, 18.13]	5.39** [1.64, 17.74]
Narcotics		
Methadone or buprenorphine	1.21 [0.18, 8.23]	1.84 [0.32, 10.76]
Morphine or codeine	2.93 [0.93, 9.20]	4.43* [1.33, 14.73]
Other prescription pain medications	2.91* [1.20, 7.01]	2.67* [1.17, 6.06]

Notes: CI = confidence interval; ADHD = attention-deficit/hyperactivity disorder.

* $p < .05$; ** $p < .01$.

surprising, as these drugs have the potential to impair driving but do not do so in all cases. Nonetheless, drivers should be aware that these drugs have the potential to impair driving and lead to legal consequences. At least one study demonstrated that patients using drugs affecting the central nervous system poorly predicted their level of driving impairment (Verster & Roth, 2012), suggesting that drivers may not be able to accurately assess the risks of driving while using these medications.

In terms of the effectiveness of drug-related warnings, a study from the Netherlands demonstrated no relationship between receiving information from a health care provider and perceived risk of having a road accident (Monteiro et al., 2012). Another study found that although a majority of patients taking potentially impairing medications received information from the patient information leaflet and/or their healthcare provider, knowledge of driving-related risks was low and there was no association between receipt of information and risk perceptions (Monteiro et al., 2012). In contrast, our study documented a significant association between receiving warnings and perceived risk of safe driving/crash and arrest/conviction for a majority of drug categories. We were not able to control for potential confounders, but our findings provide preliminary evidence that receiving warnings about impaired driving may influence the risk perceptions of U.S. drivers.

Last, our study provides targets for prioritized intervention. In addition to identifying drug categories with the lowest level of warning receipt (stimulants and antidepressants), we found that male sedative users, Hispanic sedative and narcotics users, and nighttime drivers who reported using antidepressants and/or narcotics had significantly lower odds

of reporting impairment warnings even after we controlled for other factors. Whether this represents a lower level of warning receipt or issues with comprehension and retention of information is not clear, but additional research on subgroup-specific differences in impairment-related information provision is warranted.

Our study has several limitations. First, our findings are based on self-report. It is possible that just asking whether drivers received medication warnings prompted a positive response from some, which would overestimate warning receipt. Other forms of socially desirable reporting (e.g., not reporting drug use because they were driving) may also have occurred, although we attempted to address this through driver self-administration of drug-related questions. Future studies could include in the drug list one or more drugs without impairment potential, which would help to quantify any overreporting. Second, drivers may not have known into which category their drugs should be reported. Although we provided examples for most drug categories, the nature of our survey (conducted at the roadside at night) precluded us from providing more lengthy descriptions or photos to assist drivers in identifying and categorizing their medications. This may have contributed to underreporting, overreporting, or miscategorization. Third, because of small cell sizes we were unable to examine specific drug classes in Table 4 or control for potential confounders in Table 5.

We were also unable to collect information on warning content and therefore cannot provide insights into whether just receiving a warning, or the specific warning content, drives the association with risk perceptions. In addition, because of high levels of overlap between warning receipt from providers and labeling, we could not assess the impact

of these sources individually, which would be a useful area for future study. Finally, different states have different laws governing drug-involved driving, and knowledge of these laws may have influenced risk perceptions in different states; however, small cell sizes precluded us from examining state-specific differences. Despite these limitations, we believe this study is the first to investigate the frequency with which drug-related driving warnings are relayed, and their associated impact, in a populations-based sample of U.S. drivers and provides valuable information for future research and intervention efforts.

Conclusions

This study suggests that a majority of drivers who report recent use of potentially impairing prescription medications have received warnings about impaired driving from providers and/or product labeling, but that warning receipt varies by drug category, class, and sociodemographic subgroups. The study provides preliminary evidence of a positive association between warning receipt and driver risk perceptions, which suggests that more research on effective and acceptable interventions to improve the frequency and content of these warnings is warranted.

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