FOUNDATION FOR TRAFFIC SAFETY

Drowsy Driving in Fatal Crashes, United States, 2017–2021

The contribution of drowsy driving in motor vehicle crashes is difficult to measure. Although reports by police officers who investigate crashes sometimes indicate that a driver was drowsy, data derived from these reports are widely regarded as substantial underestimates of the true scope of the problem. The current study used data derived from in-depth crash investigations conducted for the National Highway Traffic Safety Administration to develop and validate a model to impute driver drowsiness in cases when the driver's pre-crash alertness or drowsiness could not be ascertained. The model was then used to impute the involvement of drowsiness in all fatal crashes nationwide that involved at least one car, pickup truck, van, minivan, or sport utility vehicle. Results show that an estimated 17.6% of all fatal crashes in years 2017–2021 involved a drowsy driver. These drowsy driving crashes resulted in 29,834 fatalities. The percentage of fatal crashes involving drowsy driving remained approximately constant over the study period; however, the annual number of fatal drowsy driving crashes increased significantly over the study period due to a large increase in total annual fatal crashes.

The National Highway Traffic Safety Administration (NHTSA) states that 91,000 police-reported crashes resulting in 50,000 injuries and 800 fatalities annually—amounting to approximately 1%–2% of all crashes, injuries, and deaths—involve drowsy driving; however, it also states that, "there is broad agreement across the traffic safety, sleep science, and public health communities that this is an underestimate of the impact of drowsy driving." (NHTSA, n.d.) A panel of experts convened by the NHTSA noted that many police officers who investigate crashes are not trained to recognize signs of driver drowsiness, and also that the forms on which they document information about crashes often are not designed to capture information about drowsiness (Higgins et al., 2017).

In acknowledgment of the fact that drowsy driving is underreported in data derived from police reports, the AAA Foundation for Traffic Safety (AAAFTS) has examined other sources of data including in-depth crash investigations and crashes captured on in-vehicle cameras, finding that as many as 6%–10% of all crashes and 16%–21% of fatal crashes involve driver drowsiness (Owens et al., 2018; Tefft, 2012, 2014). However, the most recent data included in either of these studies is from a full decade ago in 2013. Analyses of in-depth crash investigations require aggregation of multiple years of national data to produce statistically reliable estimates, thus making them poorly suited to investigating yearly changes or trends. Similarly, studies using in-vehicle cameras are too resource-intensive to update frequently. In addition, although data examined in the previous studies were designed to be broadly representative of crashes in the United States, neither provides full national coverage, precluding their use for examining regional, state, or local-level changes in drowsy driving in relation to policies or other countermeasures. The current study sought to (1) provide updated estimates of the number of fatal crashes that involve driver drowsiness and (2) develop a method that could provide greater temporal and spatial resolution than those used in previous studies to enable examination of trends and evaluation of countermeasures in the future.

METHOD

The current study used data from in-depth crash investigations to develop a model to impute driver drowsiness when a driver's pre-crash alertness or drowsiness could not be determined. The model was validated by treating drivers' drowsiness as "unknown" in a subset of the cases in which it was actually known, using the model to impute drowsiness in those cases, and comparing the percentages actually drowsy versus imputed as drowsy. The model was then used to impute drowsiness for all drivers involved in fatal crashes in the United States in years 2017–2021. The resulting dataset, containing imputed values of drowsiness for all drivers in fatal crashes, was then analyzed to estimate the percentage of fatal crashes that involved driver drowsiness overall and in relation to selected factors.

Data

The current study included data from a representative sample of drivers of cars, pickup trucks, vans, minivans, and sport utility vehicles (hereafter collectively referred to as passenger vehicles) that were towed from the scenes of crashes as well as all drivers of passenger vehicles involved in fatal crashes in the United States in years 2017–2021.

Records of drivers of passenger vehicles towed from the scenes of crashes were obtained from the NHTSA's Crash Investigation Sampling System (CISS). CISS is a geographically stratified representative sample of police-reported crashes in which at least one passenger vehicle was towed from the scene. In addition to routine investigations by local law enforcement, crashes in CISS are investigated in depth by teams of investigators working for the NHTSA. The CISS database provides detailed data about passenger vehicles that were towed from the scene as well as their drivers; the involvement of other vehicles (e.g., passenger vehicles that were not towed, other types of vehicles such as large trucks) is recorded but few details are provided about those vehicles or their drivers. Records in CISS include statistical weights that account for each crash's probability of being selected for inclusion in CISS and thus enable inference about all crashes involving a towed passenger vehicle from analysis of the crashes included in the CISS sample (Radja et al., 2022). The current study included data from 20,292 drivers of passenger vehicles in transport that were towed from the scenes of 11,268 unique crashes included in CISS in years 2017–2021.

Data on drivers of passenger vehicles involved in fatal crashes were obtained from the NHTSA's Fatality Analysis Reporting System (FARS). FARS is a database comprising records of all crashes that occur each year on U.S. public roads, involve a motor vehicle in transport, and result in a death within 30 days of the crash. Data in FARS are drawn mainly from crash reports completed by law enforcement officers (NHTSA, 2023). The current study included data from 208,727 drivers of passenger vehicles involved in 152,174 unique fatal crashes in years 2017–2021; drivers of other types of vehicles (e.g., large trucks, buses, motorcycles, etc.) were not examined.

Assessment of Driver Drowsiness in Crashes

CISS investigators gather information about the driver's pre-crash attention to driving using data from multiple sources including interviews with drivers, medical records, and police reports. Investigators are instructed to record the driver's attention as "sleepy or fell asleep" (hereafter "drowsy") if it is determined that "the driver was sleeping or dozing prior to realization of impending danger or just prior to impact if realization did not occur" (NHTSA, 2022). Of particular importance for the current study, investigators are instructed to record the driver's attention as "Unknown" if they were unable to interview the driver and have no other source of information regarding the driver's attention prior to the crash. Drivers' pre-crash attentiveness or drowsiness is difficult to ascertain after the fact (Stutts et al., 2005), thus in many cases, crash investigators are unable to determine whether a given crash-involved driver was drowsy. Driver attention/drowsiness reported for drivers in CISS is shown in Table 1. While only 3.1% were coded as drowsy, investigators were unable to determine the attention or drowsiness of 41.4%. Also notably, CISS investigators recorded attention/drowsiness as unknown for 82.9% of drivers who died.

Table 1. Pre-Crash Attention/Drowsiness Among Drivers of Passenger Vehicles Towed from the Scenes of Crashes, as Reported in Crash Investigation Sampling System, United States, 2017–2021.

	Survived (N=19,637)	Died (N=655)	Total (N=20,292)
	Column % (Unweighted)		
Attentive	44.2%	10.4%	43.1%
Sleepy or Asleep	3.2%	1.7%	3.1%
Looked But Did Not See	3.7%	0.0%	3.6%
Inattentive or Distracted	8.9%	5.0%	8.8%
Unknown	40.1%	82.9%	41.4%

In the FARS database, in contrast, the only source of information regarding driver drowsiness is the police report. Drowsiness in FARS is recorded in a variable describing driver condition or impairment, which may be coded as "Apparently Normal / None," "Asleep or Fatigued," as well as a variety of other specific impairments (e.g., under the influence of alcohol or drugs) or conditions (e.g., paraplegia) (NHTSA, 2023). The reporting of driver condition in FARS for drivers of passenger vehicles involved in fatal crashes is shown in Table 2. Notably the proportion reported as "unknown" is much lower than in CISS. This does not necessarily reflect greater ascertainment of whether drivers were drowsy; the designs of many states' crash report forms fail to differentiate between cases in which the investigating officer effectively ruled out drowsiness versus cases in which the officer had no ability to infer whether or not the driver was drowsy (Tefft, 2012). Relatedly, the FARS code "not reported" indicates that the police crash report form lacked the data fields needed to code the driver's condition at all; it is not equivalent to the investigating officer reporting that the driver's condition was unknown (NHTSA, 2023).

Table 2. Pre-Crash Condition/Impairment Among Drivers of Passenger Vehicles Involved in Fatal Crashes, as Reported in the Fatality Analysis Reporting System, United States, 2017–2021.

	Survived (N=118,955)	Died (N=89,772)	Total (N=208,727)
	Column %		
None/Apparently Normal	60.8%	26.3%	46.0%
Sleepy or Asleep	1.1%	1.3%	1.2%
Other Impairment	11.3%	19.2%	14.7%
Not Reported	19.5%	19.0%	19.3%
Unknown	7.4%	34.0%	18.8%

Multiple Imputation of Driver Drowsiness

Multiple imputation (Rubin, 1987) is a method used to infer—or impute—plausible values of a variable whose actual values are unknown, based on its relationships with other variables. Imputation can be performed multiple times so that statistical analysis of the imputed data reflects the uncertainty in the imputed values. The NHTSA has been using multiple imputation to produce its official statistics regarding the blood alcohol concentration (BAC) values of drivers in fatal crashes since 2001 (Rubin et al., 1998; Subramanian, 2002). The AAAFTS has used multiple imputation in previous studies to estimate the proportion of crashes that involve driver drowsiness (Tefft, 2012, 2014).

Model Development

The current study sought to update and extend the AAAFTS's previous work (Tefft, 2012) by developing a method to impute driver drowsiness for drivers in FARS based on information from drivers in CISS. The model used in the current study to impute driver drowsiness was first developed and validated using data from CISS and then applied to a combined dataset that included data from both CISS and FARS. Thus, the model used in the previous study was adapted to use only variables available in both CISS and FARS.

Driver attention/drowsiness was coded as a two-part variable consistent with its determination by CISS investigators: each driver was first coded as attentive, inattentive, or unknown; drivers coded as inattentive were further coded as drowsy, other inattention (not drowsy), or unknown. Attention was imputed using logistic regression; drowsiness was then

Table 3. Variables Used to Impute Driver Attention and Drowsiness.

Variable	Values
Driver age (years)	Age, age^2
Driver sex	Male, female
Driver injury severity	None, possible, minor, severe
Police-reported driver alcohol use	No, yes, not reported, reported as unknown
Police-reported driver drug use	No, yes, not reported, reported as unknown
Most severe injury of any person in crash	None, possible, minor, severe
Speed limit (mph)	<40, 40–50, 55+
Trafficway flow	Two-way undivided vs. divided or one-way
Speed limit × Trafficway flow	Interaction of speed limit and trafficway flow
Number of lanes	1–7 (>7 coded as 7)
Roadway alignment	Straight, curve
Road surface condition	Dry, wet or other, icy
Precipitation	Any precipitation, none
Time of day	First 2 sine-cosine pairs of Fourier series expansion of time in minutes (0-1339)
Day of week	First 2 sine-cosine pairs of Fourier expansion of day (1–7)
Month of year	First 2 sine-cosine pairs of Fourier expansion of month (1–12)
Crash type and driver role in crash	Head-on (striking), road departure (drive off road), road departure (loss of control), rear-end striking, forward impact (excl. rear-end), sideswipe, right angle (T-bone), struck by other vehicle, other
PSU Stratum	Categorical variable related to CISS sample design
Weight	Statistical weight indicating number of crashes represented by each case in sample

imputed using logistic regression for drivers imputed as inattentive. Predictor variables included in the models (shown in Table 3) were those that had statistically significant and practically non-trivial bivariate associations with drowsiness or with the probability of attention/drowsiness being unknown in CISS, variables related to the CISS sample design, as well as variables of substantive practical interest irrespective of statistical significance. Fatal crashes were coded as severe injury crashes for imputation purposes, effectively assuming that the role of drowsiness in fatal crashes is similar to its role in severe injury crashes after accounting for all other variables in the model (Tefft, 2012). Unknown values of predictor variables were imputed as needed to allow the imputation of attention/drowsiness but were not used in subsequent analyses. Imputation was performed using the method of chained equations in Stata version 18 (StataCorp LLC, College Station, TX). This method was used to produce 10 independent datasets in which each unknown value of driver attention/drowsiness was replaced with an imputed value.

Validation

The following procedure was used to validate the performance of the imputation model. Using the 11,275 drivers in CISS with known values of attention/drowsiness and all predictor variables used in the imputation model, values of attention/drowsiness were deleted to simulate cases where drowsiness was unknown, and then imputed as described, above for a randomly selected 40% of drivers (to mirror the proportion of drivers with unknown attention/drowsiness among all drivers in CISS). This procedure was repeated 100 times. Across the 100 simulations, the mean difference between the percent imputed drowsy and the percent actually drowsy was −0.05 percentage points, the mean absolute difference was 0.7 percentage points, and the absolute difference was smaller than 2.2 percentage points in 95% of all simulations. The percent actually drowsy was within the 95% confidence interval of the percent imputed drowsy in 95% of the simulations, confirming that the confidence intervals appropriately captured the sampling variability and uncertainty due to imputation.

Imputing Driver Drowsiness in FARS

To impute driver drowsiness in FARS, data from CISS and FARS were merged into a single dataset. Drowsiness information in FARS was not used due to its failure to differentiate reliably between cases in which the investigating officer was able to rule out drowsiness versus those in which the officer was unable to make any determination about the driver's pre-crash alertness or drowsiness (Tefft, 2012). Thus, drowsiness was treated as unknown and imputed for all cases in FARS. Data from the FARS database were assigned a weight of 1 because every fatal crash is included in FARS. Fatal crashes in CISS were also present in FARS but were not identifiable as the same crashes due to measures taken by the NHTSA to protect confidentiality. Thus, fatal-crash-involved drivers in CISS (<0.5% of all drivers in the combined sample) were included in the imputation model but were excluded from analysis to avoid double-counting.

Statistical Analysis

The above-described multiple imputation method was used to produce 10 copies of the dataset in which drivers whose alertness or drowsiness status was unknown (i.e., drivers of unknown drowsiness in CISS and all drivers in FARS) were assigned imputed values of drowsiness. Summary statistics (e.g., means, percentages) were first computed in each copy of the dataset and then combined using the method of Rubin (1987) to produce estimates with confidence intervals that accounted for both the random variability in the data and the uncertainty in the imputed values.

RESULTS

The estimated proportion of drivers who were drowsy among all drivers of passenger vehicles towed from the scenes of crashes, based on investigators' assessments of drowsiness when known and imputed when unknown, is shown in Table 4. Table 4 also shows the corresponding estimates of the percentage of crashes that involved at least one drowsy driver.

While these estimates are informative in aggregate, the data on which they are based are too coarse to examine yearly changes or trends, especially for fatal crashes, as there was an average of only 150 fatal crashes per year in the CISS data. Table 5 shows the annual percentage of fatal crashes that involved at least one drowsy driver obtained from CISS alone, as well as the corresponding estimate derived from FARS with drowsiness imputed using information from CISS. While comparable in aggregate, annual estimates derived from FARS are much more precise (i.e., have narrower confidence intervals) due to the much larger number of fatal crashes each year in FARS. For example, when the proportion of fatal crashes that involved drowsy driving in 2018 was estimated from CISS alone, the 95% confidence interval of the estimate ranged from 0% to 47%. When estimated using FARS data with imputed drowsiness, the corresponding confidence interval ranged from 11% to 23%.

Table 6 shows the estimated total number of fatalities each year that occurred in crashes involving drowsy drivers estimated using FARS data with imputed driver drowsiness. Over the 5-year study period, an estimated 29,834 people were killed in crashes that involved drowsy drivers. Note that the actual number of fatalities in crashes involving drowsy driving is likely greater, as these estimates do not account for potential drowsiness among drivers of vehicles other than passenger vehicles involved in fatal crashes.

Figure 1 shows the estimated percentage of fatal-crash-involved drivers who were drowsy in relation to selected factors. In percentage terms, the proportion of fatal-crash-involved drivers who were drowsy was greatest among drivers aged 16–20; however, the largest number of drowsy drivers in crashes were ages 21–34. Men were significantly more likely than women to be drowsy, and men accounted for the vast majority of drowsy drivers involved in fatal crashes. Approximately two-thirds of drowsy drivers in fatal crashes had not been drinking alcohol

Table 4. Estimated Prevalence of Drowsy Drivers in Crashes, by Crash Severity. Drivers of Passenger Vehicles Towed from Crash Scenes, United States, 2017–2021.

Most Severe Injury in Crash	Drivers		Crashes[a]	
	%	(95% CI)	%	(95% CI)
No Apparent Injury	3.5%	(2.1%–4.9%)	4.2%	(2.6%–5.8%)
Possible Injury	3.6%	(2.0%–5.1%)	5.2%	(3.0%–7.4%)
Suspected Minor Injury	5.9%	(4.0%–7.8%)	8.6%	(5.8%–11.4%)
Suspected Serious Injury	9.1%	(6.9%–11.3%)	13.4%	(10.3%–16.5%)
Fatal Injury	12.8%	(6.5%–19.1%)	17.6%	(9.0%–26.3%)
Total All Crashes	**4.5%**	**(3.5%–5.5%)**	**5.9%**	**(4.6%–7.1%)**

Data: Crash Investigation Sampling System (NHTSA).
Percentages are based on actual and multiple-imputed drowsiness and are weighted to reflect all crashes nationwide.
Confidence intervals reflect sampling variability and uncertainty due to imputation of drowsiness.
[a] Estimates in "crash" column represent percent of crashes in which at least one driver of a towed passenger vehicle was reported or imputed as drowsy.

(BAC = 0.00), however, one-third had non-zero BAC values. Drowsiness was significantly more prevalent among drivers who had been drinking than among those who had not. An estimated 17% of drivers with BAC of 0.01–0.07 and 20% of drivers with BAC ≥0.08 were drowsy, compared with 11% of those who had not been drinking.

Table 5. Estimated Annual Percent of Fatal Crashes that Involved a Drowsy Driver, Estimated from Crash Investigation Sampling System (CISS) versus Fatality Analysis Reporting System (FARS) Data, United States, 2017–2021.

	CISS[a]		FARS[b]	
	%	(95% CI)	%	(95% CI)
2017	15.7%	(5.0%–26.3%)	17.4%	(11.9%–22.9%)
2018	21.0%	(0.0%–47.4%)	17.3%	(11.4%–23.1%)
2019	17.6%	(3.9%–31.4%)	17.6%	(12.1%–23.1%)
2020	15.4%	(5.9%–24.8%)	17.9%	(12.0%–23.8%)
2021	18.7%	(6.7%–30.7%)	18.0%	(12.2%–23.7%)
Total	**17.6%**	**(9.0%–26.3%)**	**17.6%**	**(11.9%–23.4%)**

[a] Percentages are based on actual and multiple-imputed drowsiness and are weighted to reflect all crashes nationwide. Confidence intervals reflect sampling variability and uncertainty due to imputation of drowsiness.
[b] Drowsiness was multiply imputed for all passenger vehicle drivers in FARS using a model derived from CISS data. Percentages are based on crashes that involved at least one passenger vehicle. Confidence intervals reflect sampling variability and uncertainty due to imputation of drowsiness.

The percent of drivers who were drowsy was highest among those who crashed on rural collectors and local roads; however, the greatest number of fatal drowsy driving crashes occurred on urban arterials, as the largest proportion of all fatal crashes irrespective of drowsiness occurs on these roads. The greatest number of fatal drowsy driving crashes occurred between 11:00 PM and 2:59 AM; the percent of drivers who were drowsy was highest among those who crashed between the hours of 3:00 AM and 6:59 AM. When examining specific crash types and each driver's role in the crash, the percentage of drivers who were drowsy was highest among those who crossed over the centerline and struck a vehicle travelling in the opposite direction head-on; an estimated 45% of these drivers were drowsy. Road departure crashes represented the greatest number of drowsy driver fatal crash involvements and accounted for nearly half of all fatal drowsy driving crashes. Finally, while the study could not determine conclusively whether driver drowsiness was the necessarily the cause of a given crash, it is notable that only 0.4% of drivers struck by another vehicle were drowsy, compared with 14% for all other driver crash types together.

Table 6. Estimated Number of People Killed in Crashes that Involved a Drowsy Driver, United States, 2017–2021.

	No. Deaths	(95% CI)
2017	5,773	(3,985–7,561)
2018	5,611	(3,760–7,462)
2019	5,658	(3,901–7,415)
2020	6,066	(4,103–8,029)
2021	6,726	(4,578–8,873)
Total	**29,834**	**(20,323–39,344)**

Data: CISS and FARS (NHTSA). Drowsiness was multiply imputed for all passenger vehicle drivers in FARS using a model derived from CISS data. Percentages are based on crashes that involved at least one passenger vehicle. Confidence intervals reflect sampling variability and uncertainty due to imputation of drowsiness.

DISCUSSION

The contribution of drowsy driving to motor vehicle crashes is difficult to measure. NHTSA acknowledges that statistics derived solely from police crash reports underestimate how many crashes, injuries, and deaths involve drowsy driving (NHTSA, n.d.; Higgins et al., 2017). The current study used data from a different source, in-depth crash investigations, to develop

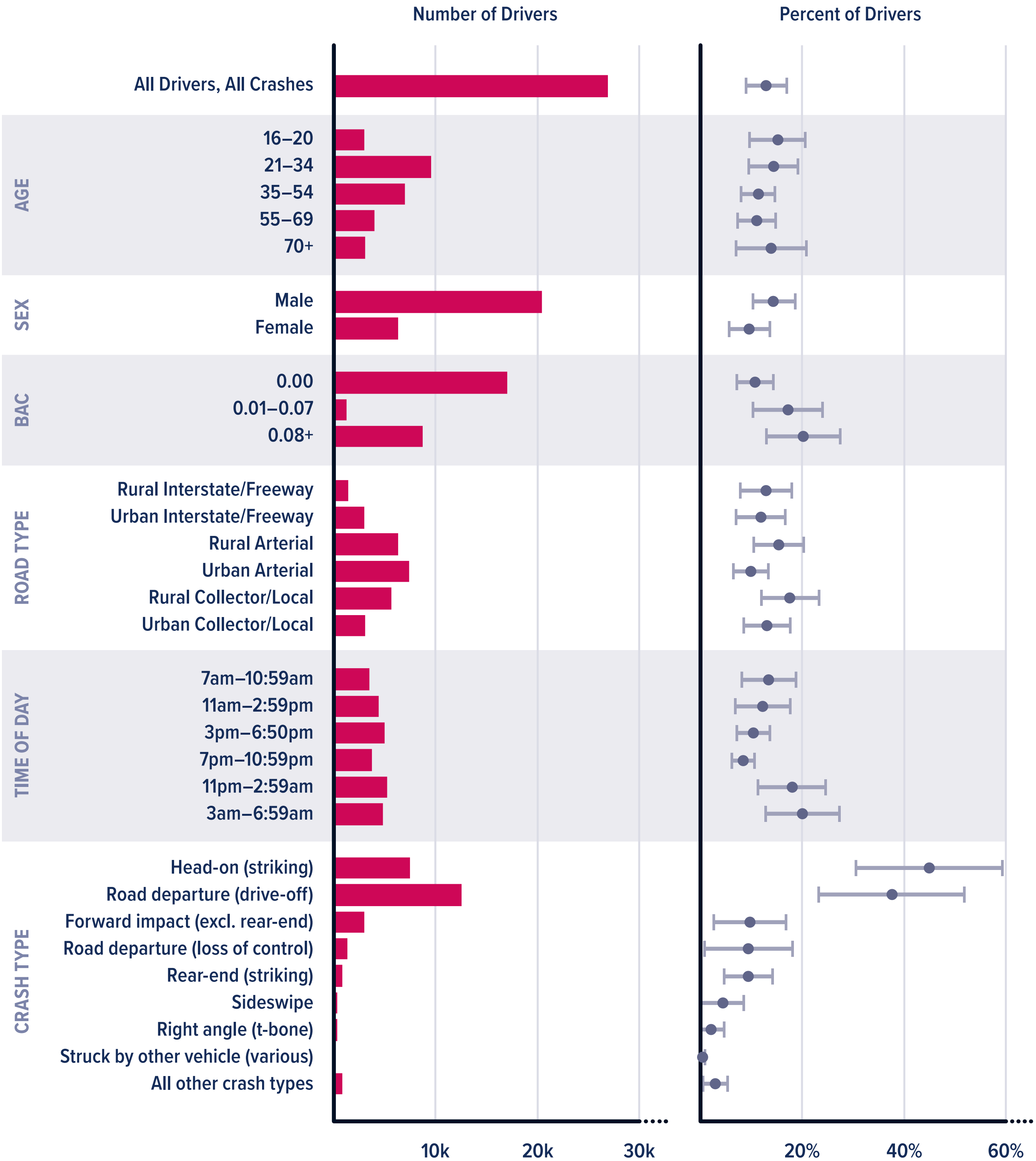

Figure 1. Estimated ■ Number and ■ Percent of Drivers in Fatal Crashes Who Were Drowsy, Overall and in Relation to Selected Factors, United States, 2017–2021.

Data: CISS and FARS (NHTSA). Drowsiness was multiply imputed for all passenger vehicle drivers in FARS using a model derived from CISS data. Unknown blood alcohol concentrations were imputed by NHTSA. Confidence intervals reflect sampling variability and uncertainty due to imputation of drowsiness.

and validate a model to impute—or infer—the involvement of driver drowsiness in cases where it was neither confirmed nor ruled out. The model was then used to impute drowsiness for all passenger-vehicle drivers involved in fatal crashes nationwide. Results suggest that nearly 30,000 traffic fatalities over years 2017–2021 occurred in crashes that involved drowsy driving. This represents more than 7 times as many as reflected in data derived from police reports.

Previous research by the AAAFTS and others had attempted to estimate the role of drowsy driving in crashes using a variety of methods, producing results generally consistent with those reported here. In a study similar in concept to the current study, Masten et al. (2006) first developed a model to predict driver drowsiness in a sample of North Carolina crashes in which the role of drowsiness had been confirmed, applied this model to all drivers in fatal crashes nationwide, and estimated that 15%–16% of drivers in fatal crashes in 2001–2003 were drowsy. The AAAFTS used the method of multiple imputation to estimate the prevalence of driver drowsiness in a sample of crashes subject to in-depth investigations, and estimated that 7% of all crashes resulting a passenger vehicle being towed, 13.1% of those resulting in injuries requiring hospitalization, and 16.5% of fatal crashes involved drowsy driving in years 1999–2008 (Tefft, 2012). A subsequent update to that study estimated that 6% of all crashes in which a vehicle was towed, 13% of those resulting in hospitalization, and 21% of fatal crashes involved drowsiness (Tefft, 2014). An AAAFTS-sponsored investigation of predominantly lower-severity crashes captured on in-vehicle video estimated that 8.8% of all crashes including minor non-reportable crashes and 10.5% of police-reportable crashes involved drowsy driving (Owens et al., 2018).

While these previous studies were informative in providing baseline estimates of the overall scope of drowsy driving crashes, their methodology precluded their use to examine changes or trends over time or to evaluate the impacts of countermeasures, the need for which has been noted previously (Bayne et al., 2022). As the current study illustrates, studies of data compiled from in-depth crash investigations alone include too few fatal crashes to provide the spatial or temporal resolution needed to track changes or trends over time or to evaluate countermeasures. Studies of crashes captured on in-vehicle camera have many noteworthy strengths, particularly regarding the ability to ascertain the contribution of drowsiness; however, the vast majority of crashes observed in such studies are lower severity crashes, limiting generalizability to crashes resulting in injuries or fatalities. The current study sought to overcome these limitations by using data from in-depth crash investigations to develop a model that could then be used to impute, or infer, the involvement of drowsiness in other samples of crashes, including fatal crashes. When the model was then applied to data on all fatal crashes in the United States, the resulting estimates matched those from the original sample of crash investigations on which the model was validated, but they also provided far greater precision due to the large sample size of fatal crashes and the strong associations of the variables included in the model with driver drowsiness. This methodology could be useful in future studies to investigate trends over time in drowsy driving crashes or to evaluate the impact of countermeasures intended to reduce drowsy driving crashes.

A secondary benefit of the methodology used in the current study is that imputing drowsiness in FARS enabled the examination of drowsiness in relation to alcohol in fatal crashes. Several resulting findings are important. First, a non-negligible proportion of drowsy drivers in fatal crashes—about one-third—had been drinking. Second, drinking drivers in fatal crashes, including those with BACs below the level used in most U.S. states, were nearly twice as likely as sober drivers to have been drowsy, a finding consistent with previous laboratory-based studies (Horne et al., 2003), but not previously examined in studies of large numbers of real-world crashes. Third, significant overlap between drowsiness and alcohol notwithstanding, two-thirds of all drowsy drivers in fatal crashes had not been drinking. Even if all drowsy driving crashes that involved any alcohol were attributed solely to alcohol, results indicate that approximately 11% of all traffic fatalities over the study period occurred in drowsy driving crashes that did not involve alcohol.

Limitations

This study has several limitations that should be noted. While the model used in the current study was shown to produce imputations that accurately estimated the percentage of drivers classified as drowsy in crash investigations, these data included few fatal crashes. Using this model to impute drowsiness among all fatal-crash-involved drivers in the United States assumes that the relationships of predictor variables (e.g., age, sex, time of day, type of crash, etc.) with drowsiness in fatal crashes are similar to their relationships in the sample of in-depth crash investigations from which the model was created. Additionally, the crash investigators' assessments of drowsiness may have been inaccurate on occasion, if, for instance, interviewed drivers or witnesses failed to recognize or were unwilling to admit that they were drowsy (Tefft, 2012). A recent simulator-based study designed to induce drowsiness found that drowsy drivers often underestimated how drowsy they were (Gaspar et al., 2023). Relatedly, the investigators were instructed to classify drivers as drowsy "when the driver was sleeping or dozing" prior to the crash (NHTSA, 2022). Using this definition, not all drivers whose performance was likely impaired due to lack of sleep would have been classified as drowsy. Previous AAAFTS research has shown that mild to moderate sleep deprivation (e.g., sleeping for 5–6 hours instead of 7–9 hours) measurably increases crash risk, and that much of the risk manifests in "ordinary" crashes in which the driver did not fall asleep (Tefft, 2018). The multiple imputation methodology used in the current study would not be able to correct this type of bias. Thus, results of the current study may still underestimate the role of drowsiness in crashes, especially those in which its manifestations are more subtle than the driver falling asleep.

Implications

Drowsy driving remains a major contributor to motor vehicle crashes, injuries, and deaths. This research estimates that approximately 17.6% of all fatal motor vehicle crashes involved drowsy driving and resulted in the deaths of nearly 30,000 people in the United States in years 2017–2021. There is a need for more effective countermeasures to combat drowsy driving and prevent drowsy driving crashes, as well as for research to evaluate the effectiveness of potential countermeasures.

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