

## SPECIAL ARTICLE

# Asleep at the Wheel—The Road to Addressing Drowsy Driving

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Drowsy driving is a dangerous behavior that leads to thousands of deaths and injuries each year. It is also a controllable factor for drivers. Drivers are capable of modifying this behavior if given sufficient information and motivation. Our goal is to establish a comprehensive and strategic effort to end drowsy driving crashes and deaths. This article highlights some of the conclusions of a unique recent meeting of sleep experts and highway safety professionals and describes the first steps the community has taken and plans to take in the future to address this issue

**Keywords:** Sleep and Driving, Public Health, Shift Work, Sleep Deprivation.

## BUILDING MOMENTUM TO END DROWSY DRIVING

Drowsy driving is dangerous and leads to thousands of deaths and injuries each year, which are preventable given sufficient information and motivation. Our goal is to establish a comprehensive and strategic effort to end drowsy driving crashes and deaths. This article highlights the conclusions of a recent meeting of sleep experts and highway safety professionals and describes first steps and future plans to address this issue.

Insufficient sleep has serious effects on safety, health, and quality of life. While the solution, “to get more and better sleep,” is simple, garnering public attention is difficult when societal values seldom align with getting sufficient sleep. In the modern 24/7 economy with an emphasis on work, growing commutes, and expanding channels of communication and entertainment, many people find it difficult to get the sleep they need.<sup>1</sup> Effectively dealing with the problem requires a broad change in societal norms involving sleep in general and attitudes about drowsy driving in particular.

Over the last two decades public and private organizations have made a number of attempts to address drowsy driving. These efforts include: stakeholder meetings, public information campaigns, development of detection and alerting technology, revised hours-of-service regulations for commercial drivers, workplace fatigue management programs, and passage of laws to address the issue. These programs, technologies, regulations and laws have contributed in varying degrees to reducing drowsy driving. However, effective strategies are lacking that address the problem among the general driving public.

The traffic safety community has developed effective methods to change behavior related to drinking and driving, seat belt use, and other safety risks, but this community has lacked the scientific foundation necessary to address drowsy driving in an effective, widespread and organized manner. Meanwhile the sleep science community has long recognized the criticality of drowsy driving but has lacked techniques for achieving nationwide change in driver behavior. What is needed to change the national conversation on drowsy driving is a coordinated effort involving the traffic safety and sleep/circadian science communities.

With this in mind, the National Highway Traffic Safety Administration (NHTSA) convened a diverse set of stakeholders to set the stage for the creation of a national plan to address drowsy driving. NHTSA, an agency of the US Department of

Transportation, took on this effort because of its role in the development of regulations and programs to reduce motor vehicle crashes, injuries, and fatalities. By bringing together motor vehicle and highway safety experts with sleep/circadian science experts and the sleep medicine community, NHTSA sought to establish a partnership in which years of unique knowledge and experience combined to effectively address the challenge of eliminating drowsy driving.

NHTSA convened the forum, “Asleep at the Wheel: A Nation of Drowsy Drivers,” on November 4th and 5th, 2015, during National Drowsy Driving Prevention Week.<sup>2</sup> The event was immediately followed by the National Sleep Foundation’s Sleep Health and Safety Conference on November 6. This paper provides a background to the drowsy driving problem, describes the format of the November 2015 NHTSA forum, reviews the recently released “NHTSA Drowsy Driving Research and Program Plan,”<sup>3</sup> and most importantly lays out the future actions that forum participants identified for the traffic safety and sleep/circadian science communities to take to address the problem of drowsy driving.

## THE DROWSY DRIVING PROBLEM

Sleepiness is an inescapable biological phenomenon with profound effects on the mind and body. Whether sleepiness is caused by sleep restriction due to a baby crying all night, a late shift at work, a teenager staying up with friends, or a long fatiguing drive to a relative’s house for the holidays—the negative ramifications are ubiquitous and include: impaired cognition and performance, automobile crashes, accidents at work, and other physical and mental health consequences. Most importantly, the longer someone remains awake—especially during the night and early morning—the more likely the negative outcomes become. Much like alcohol, sleepiness can seriously affect driver performance. But unlike alcohol-impaired driving, every member of the motoring public has probably driven drowsy at some point in their life—and for many this has occurred on multiple occasions.

Drowsy driving contributes to motor vehicle crashes in one of two ways. The first, and most obvious, is a driver falling asleep and running off the road or into another car or obstacle. Even a brief intrusion of sleep while driving can lead to serious consequences. The second involves the decrements in cognition and behavior that impair driving skill and increase accident risk.

The lack of sleep leads to attentional lapses and poor decision making. A recent study objectively measured driving performance in a car on a vehicle test-track following a night-shift.<sup>4</sup> In addition to multiple significant indicators of drowsiness, the participants also made significantly more lane excursions, experienced more near-crash events, and had their drives terminated by experimenters because of failure to maintain safe control of the vehicle more frequently than a control group.

Several studies over the last two decades estimated time frame-specific, self-reported prevalence of falling asleep while driving (Table 1).

With approximately 214 million registered drivers in the United States,<sup>5</sup> these data indicate that millions of drivers fall asleep at the wheel each month. Even more concerning is that these statistics do not account for all people who did not report driving drowsy or have driven dangerously drowsy without falling asleep at the wheel. Thus, these data underestimate the scope of the problem.

Determining the overall impact of drowsy driving on crash rates is challenging since there is no definitive way to determine whether a crash was caused by drowsiness. Indicating that a crash was due to drowsy driving almost entirely relies on police crash reports and associated hospital records (see: [www.nhtsa.gov/NCSA](http://www.nhtsa.gov/NCSA) for more information on traffic crash, injury, and fatality tracking). Even when sufficient evidence exists to determine the involvement of drowsiness on a crash, few law enforcement and crash investigators receive adequate training to make this determination. Many police crash reports lack dedicated sections to appropriately record the presence of drowsiness. Thus drowsy driving crashes across the United States are almost certainly underreported.

In 2014 there were 846 reported driving-related fatalities involving a drowsy driver (2.6% of all fatalities) recorded in NHTSA's Fatality Analysis Report System (FARS) database. The percentage of reported fatalities associated with drowsy driving (and drowsy driving crashes overall) has remained largely stable across the past decade. Between 2005 and 2009 there was an estimated average of 83 000 crashes each year

related to drowsy driving. This annual average includes almost 1000 fatal crashes (886 or 2.5% of all fatal crashes), an estimated 37 000 injury crashes, and an estimated 45 000 property damage-only crashes.<sup>6,7</sup>

Researchers have inferred the existence of additional drowsy driving crashes by assessing correlations with related factors such as the number of passengers in the vehicle, crash time, and day of week, driver sex, and crash type. One such study<sup>8</sup> analyzed data from NHTSA's National Automotive Sampling System (NASS) Crashworthiness Data System (CDS). By using multiple imputation, missing data on drowsiness was inferred, substantially increasing drowsy driving crash estimates. Accordingly, Tefft<sup>8</sup> estimated that 7.0% of all crashes and 16.5% of fatal crashes involved a drowsy driver. Another study using complementary statistical methodology reached similar conclusions, with 10% of fatal daytime crashes, 24% of fatal nighttime crashes, and 15% of all fatal crashes involving a drowsy driver.<sup>9</sup> These estimates suggest that more than 6000 people die in drowsy driving-related motor vehicle crashes across the United States each year.

Drowsy drivers come from every race and ethnicity, gender, age, income, education level, and employment status. Once sleepy, everyone experiences an increased risk of crashing, regardless of background. However, some groups report driving drowsy more frequently than others. Table 2 summarizes results from two recent studies of the prevalence of drowsy driving.

Many lifestyle and work factors influence drowsy driving incidence. Working long and irregular hours (especially at night), or having multiple jobs, substantially increases the risk of work-related accidents and automobile crashes related to drowsiness.<sup>10</sup> This is particularly relevant in settings such as the medical community, where long and irregular shifts are commonplace. In a large study of medical residents, researchers found that after an extended work shift ( $\geq 24$  hours), compared to a non-extended shift, the odds ratio for a motor vehicle crash was 2.3 and for a "near miss," 5.9. In addition, every additional extended work shift increased the risk of a crash by 9.1%.<sup>11</sup> These numbers were mirrored in a study of nurses. After long

**Table 1—Falling Asleep at the Wheel.**

Time frame	Estimated proportion	Source
In the past 30 days...	4%	Royal, Street, & Suite, 2002 <sup>50</sup>
		Tefft, 2010 <sup>51</sup>
		Wheaton, Chapman, Presley-Cantrell, & Croft, 2013 <sup>25</sup>
		Wheaton, Shults, Chapman, Ford, & Croft, 2014 <sup>26</sup>
In the past 6 months...	7%	Tefft, 2010 <sup>51</sup>
	8%	Royal, Street, & Suite, 2002 <sup>50</sup>
In the past year...	11%	Royal, Street, & Suite, 2002 <sup>50</sup>
		Tefft, 2010 <sup>51</sup>
Since beginning to drive...	37%	Royal, Street, & Suite, 2002 <sup>50</sup>
	41%	Tefft, 2010 <sup>51</sup>

Self-report of falling asleep at the wheel during the past 30 days, 6 months, year, and since beginning to drive.

**Table 2—Drowsy Driving and Demographics.**

Study	Wheaton, Chapman, Presley-Cantrell, & Croft, 2013 <sup>25</sup>	Wheaton, Shults, Chapman, Ford, & Croft, 2014 <sup>26</sup>
Universe	19 States and District of Columbia 2009–2010	10 States and Puerto Rico 2011–2012
Overall estimate	4.2%	4.0%
Gender	Men were more likely to report drowsy driving than women (5.3% versus 3.2%).	Men were more likely to report drowsy driving than women (5.0% compared with 3.0%).
Age	Reporting of drowsy driving decreased with age, from >4.9% among adults aged 18–44 years to 1.7% among those aged ≥65 years.	Reporting of drowsy driving decreased with age, from 5.9% among adults aged 18–24 years to 1.8% among those aged ≥65 years.
Race/Ethnicity	Non-Hispanic whites were less likely to report drowsy driving than other racial/ethnic groups (3.2% vs. ~6% for all other groups).	Non-Hispanic whites were less likely to report drowsy driving than other racial/ethnic groups.
Educational level	Reporting not associated with educational attainment.	Reporting not associated with educational attainment.
Work status	Retired respondents (1.0%), students or homemakers (2.1%), and unemployed respondents (3.1%) were less likely to report drowsy driving than those who were employed (5.1%) or unable to work (6.1%).	

The relationship between reported drowsy driving in past 30 days and demographics.

shifts (≥12.5 hours), nurses reported drowsy driving episodes two times more frequently than after shorter shifts, leading to an odds ratio for a motor vehicle crash or near crash of 1.84. There was also an increased risk of drowsy driving for nurses who only worked night shifts.<sup>12</sup>

There is no reason to believe that other workforces with similar shift compositions are any different. In general, any job that affects a person's sleep/wake schedule such that they get less sleep than needed, extend their wakefulness, or work at night, can increase the risk of being in a motor vehicle crash.<sup>13</sup> This has been demonstrated through numerous studies, including several exploring the effects of drowsiness on commercial truck drivers around the world.<sup>14–24</sup>

Drowsy driving does not just occur among commercial drivers or those working long, overnight, or irregular shifts. A number of studies have shown links between lifestyle choices (eg, workaholicism or frequently visiting night clubs), personality characteristics (eg, sensation seeking) and risky behaviors (eg, nonuse of seat belts) to drowsy driving.<sup>25–28</sup> However, even those not fitting into groups at recurring elevated risk for drowsy driving are likely to drive in a drowsy state at some point due to life events. A typical example is not getting enough sleep prior to a family vacation road trip. One study found that 88% of drivers recruited at a rest stop experienced sleep deprivation in the day preceding their road trip. These drivers were also quicker to fall asleep in a sleep latency test.<sup>29,30</sup> This issue is especially important when driving through monotonous locales or on a lengthy drive, which researchers have found can be particularly dangerous.<sup>31,32</sup>

In 2011, motor vehicle crashes were the leading cause of death for teens aged 13, 14, and 16–19.<sup>33</sup> According to the Centers for Disease Control and Prevention (CDC), motor vehicle crashes account for 35% of all deaths and 73% of all unintentional injury deaths in this age group.<sup>34</sup> Many of these crash fatalities are likely due, at least in part, to sleep restriction and its effects

on driving. Adolescents are notorious not only for their sleep need<sup>35</sup> and their high biological drive for sleep, but also their delayed circadian rhythm causing them to stay up later than during their childhood. This leads to less sleep overall.

Epidemiologic studies show a host of negative effects of sleep curtailment in adolescents, including a greater risk for motor vehicle crashes.<sup>36</sup> Young drivers have been documented to be at greater crash risk when sleeping 6 hours or less per night.<sup>37</sup> Other studies have found heightened crash risk for young drivers when they receive less than 8 hours of sleep per night.<sup>38</sup> Sleep restriction can also affect adolescent safety as pedestrians. A recent study in a virtual environment demonstrated that 14- and 15-year olds who had only 4 hours of sleep were hit by virtual reality cars more often and had more close calls than participants who had 8.5 hours of sleep.<sup>39</sup>

The difficulties adolescents face in getting the appropriate amount of sleep is compounded by the realities of school district scheduling. Many school districts across the United States start their high schools before their elementary and middle schools. This scheduling is often due to busing limitations or conflicts with after-school sports activities. The combination of early school start times, greater teen sleep requirements and delayed teen circadian rhythms can lead to public safety and health issues.

Unfortunately teens are likely to drive even when they perceive sleepiness.<sup>40</sup> To combat these issues some school districts in the United States have begun shifting to later high school start times. The American Academy of Pediatrics recently released a policy statement recommending that middle and high schools delay school start times to 8:30 AM or later to make it easier for teens to obtain more sleep and in turn improve school attendance and cognitive performance, decrease the risk of obesity and depression, and decrease teen drowsy driving crashes.<sup>39</sup>

Many medical conditions, both primary sleep disorders (such as sleep apnea and insomnia) and other chronic medical

conditions that impact sleep quality (such as lung disease, asthma, renal disease, gastroesophageal reflux, depression, and anxiety) can lead to sleep-related cognitive decrements that increase crash risk.<sup>41-43</sup> Primary sleep disorders have been linked to an increased risk of motor vehicle crashes in a recent large study of French drivers.<sup>44</sup> This study also highlighted the overall incidence of drivers on the roads with treated and untreated sleep disorders. Obstructive sleep apnea (OSA) was present in 5.2% of drivers (of which 22.8% were treated for the disorder), and insomnia was present in 9.3% (of which 9.9% were treated). Narcolepsy was present in 0.1% (of which 20.8% were treated), and multiple other pathologies including depression-anxiety and restless leg syndrome were present in 4.4% of the drivers. Considering the link between obesity and OSA,<sup>45</sup> the prevalence rates of OSA may be even higher among drivers in the United States because of the greater prevalence of obesity.<sup>46</sup>

The total cost of societal harm from all motor vehicle crashes in 2010 was \$836 billion.<sup>47</sup> A significant portion of these costs are related to crashes where drowsy driving was a factor. Taking advantage of Tefft's estimates<sup>8</sup> of drowsy driving crash prevalence (1999–2008), where 16.5% of fatal crashes and 13.1% of injury crashes in which at least one person was hospitalized were estimated to be drowsy driving related, and assuming the proportions did not differ in 2010, we can make an approximate estimate of the associated societal costs of drowsy driving based on a 2010 NHTSA report reporting the societal costs of motor vehicle crashes.<sup>47</sup> In 2010, there were 32 999 total fatal crashes (at a societal cost of \$9 146 000 each) and 3 900 000 estimated total injury crashes (\$115 250 each—injury severity levels were collapsed into a total mean injury cost for this analysis). Applying Tefft's estimates of drowsy driving (5445 fatalities and 510 900 non-fatal hospital admissions) leads to an overall estimated societal cost of drowsy driving crashes of \$109 billion per year.

While the prevalence rate of drowsiness among crashes in which at least one person was hospitalized may be lower than in injury crashes in which no one required hospitalization, crashes involving a drowsy driver appear to be more severe. Crashes identified as involving a drowsy driver in NHTSA's NASS-CDS system (between 1999 and 2008) were more likely to be identified as resulting in serious injuries (6% of drowsy crash injuries were categorized as MAIS  $\geq 3$  or more severe) than those that were not drowsy driving related (2% severe). Severe injuries are much more costly than less severe injuries. Also these estimates do not include property damage only crashes involving drowsy drivers. Regardless of the exact monetary cost of drowsy driving crashes, it is clear that the costs are tremendous.

## THE NHTSA FORUM

NHTSA convened the forum, "Asleep at the Wheel: A Nation of Drowsy Drivers," on November 4 and 5, 2015, to launch a new drowsy-driving initiative. The event began with an introduction by NHTSA Administrator, Mark Rosekind, followed by a presentation of the NHTSA Drowsy Driving Program Plan. The presentation covered the agency's short-term priorities for research, safety programs, and vehicle technology to address drowsy driving. This was followed by a speech from a victim's

advocate, Jennifer Pearce ([www.love4nicki.com/](http://www.love4nicki.com/)), who told the powerful story of her sister who died in a drowsy driving crash.

For the remainder of the day and a half forum, there were five panels focusing on (1) problem identification and measurement of drowsy driving, (2) public awareness and education, (3) public and corporate policy, (4) vehicle technology, and finally (5) balancing the needs for research and action. Each panel, except for the final panel, consisted of two presentations by panel members, followed by panel discussion, and then questions and comments from the invited audience members consisting of members from other panels and other stakeholders. The final panel on balancing the needs for research and action actively developed, with the participation of the panel and the audience, a Next Steps Matrix of research, program, and policy needs for addressing drowsy driving. The remainder of this paper is primarily based on this matrix.

The panels were made up of world-renowned experts on sleep science and traffic safety, state legislators, vehicle manufacturers, representatives from many federal agencies (eg, Department of Defense, multiple US Department of Transportation modes, National Institutes of Health, CDC, National Institute for Occupational Safety and Health), the insurance industry, advocacy groups, and other public and work safety oriented organizations. The event is archived at the following website, including video: [www.nhtsa.gov/nhtsa/symposiums/november2015/index.html](http://www.nhtsa.gov/nhtsa/symposiums/november2015/index.html).

With this diverse gathering of stakeholders, NHTSA used the forum to build consensus on research, program and policy objectives, across the stakeholder community, to stimulate connections between diverse stakeholders, and to identify key resource needs and core information for the public to address the risks, consequences, and countermeasures related to drowsy driving. Each of the following sections focuses on a priority topic area for addressing drowsy driving. We point out challenges to overcome and needs for future research, but most importantly we aim to highlight areas for collaborative action across the diverse drowsy driving stakeholder community.

## PRIORITIES AND ACTIONS

### Drowsy Driving Measurement and Problem Identification

The first and most critical priority to address drowsy driving is to understand the overall prevalence of the problem and who is at greatest risk. With this information in hand, we can prioritize research, policy, and safety programs to most efficiently address the issue. In addition, with appropriate data we can track the effect of our prevention efforts. One of the biggest challenges we face is an inability to collect reliable and valid drowsy driving crash data that gives us a true count, or a sound estimate, of the extent of the problem.

Police crash reports are the traditional source of information on crash-related behaviors. In lieu of an objective measure of pre-crash drowsiness, investigating officers can only report testimony from the driver or passenger, or circumstantial evidence that is suggestive of drowsiness. As a result of this uncertainty, estimates of drowsy driving are significantly underreported. The panel identified a number of near- and long-term priorities to address future research needs in drowsy driving measurement and problem identification.



### **Improve Motor Vehicle Crash Investigation and Reporting**

Each year NHTSA provides the number of reported drowsy driving-related fatalities and estimates the number of drowsy driving injury crashes. These numbers are gathered from police accident reports (PARs) and corresponding hospital data and are likely underestimated due to underreporting. This underreporting is due to a number of factors including: the difficulty that police and crash investigators have in determining whether a crash is drowsiness-related, insufficient drowsiness investigation training, and insufficient resources dedicated to investigating the role of drowsiness in a crash. To effectively address the underreporting of drowsy driving crashes, improvements need to be made at multiple levels, including changes to PARs, training for crash investigators, and improvements to crash databases.

### **Support for Continued Research on Drowsy Driving**

The last 30 years have shown an explosion of research on sleep and drowsy driving. It is clear from this research that driving while drowsy is dangerous. However, there are still many research gaps to be filled. Research is needed to track the risk and incidence of drowsy driving; to understand people's knowledge, attitudes and behaviors; to more effectively target high risk groups for education; to quantify the economic impact; and to evaluate the impact of graduated driver's license (GDL) laws in reducing drowsy driving among new drivers. There are many existing, as well as new and innovative, research methodologies available to fill these research gaps including case-control methods, use of in-vehicle event data recorders or other vehicle-based data, and mobile and wearable technologies.

### **Develop Biomarkers for Measuring Sleep Deprivation**

One of the biggest challenges for research and public and corporate policy development is the lack of a reliable, valid, easily administered, and economically viable measure of sleep deprivation that does not require an individual baseline measurement. A number of questionnaires and performance tasks are validated and used throughout the scientific literature. Unfortunately, these methods all present challenges outside the laboratory setting. The most promising avenue for developing a technology that overcomes these issues is based on identifying biomarkers for sleep deprivation and other circadian factors. A number of researchers have recently published studies demonstrating the early potential for this type of measure of sleep deprivation. However, even if this technology is possible, there are many years of research and development needed to create a product that can be effectively used at the road-side in much the same way as an alcohol breathalyzer is used today.

### **Public Awareness, Behavior, and Education**

An important step in changing drowsy driving behavior is ensuring people understand the risks, signs, and countermeasures so they can make better decisions about their own behavior. This understanding may increase support for drowsy driving laws and policies such as fatigue management programs in the workplace. While experience with other safety behaviors, including seat belt use, drinking and driving, and driver distraction, indicates that awareness alone will not yield sufficient behavior

change, public education is a necessary program component along with policy development and enforcement.

To effectively convey messages, we must first understand what communication materials have been used in the past for drowsy driving and other safety and health campaigns. This can help to identify ways to successfully convey messages. Second, target audiences must be identified and characterized to most effectively deliver the messages. Third, appropriate messages and communications materials need to be developed for these specific audiences. Finally, the communications must be delivered to the intended target audiences. The following priorities highlight a number of promising areas that can lead to effective communication about risk for drowsy driving.

### **Increase the Use of Victims' Messages**

One of the most effective ways to convey the risk of drowsy driving to the public is by demonstrating its consequences. Victims' advocates have had major impact on a number of traffic safety and other public health issues, most notably drunk driving. Organizations such as Mothers Against Drunk Driving (MADD) helped move drunk driving into the national spotlight and played a major role in getting impaired driving state laws passed across the United States. Drowsy driving needs similar voices.

### **Create and Conduct a Broad Public Health and Safety Campaign**

There have been a number of limited advertising campaigns to address drowsy driving in the last two decades. Unfortunately, these efforts have not had broad visibility or impact. This is due to a number of factors including insufficient financial resources and ineffective messaging. In order to more effectively promote changes in public knowledge, attitudes, and behavior, the community needs to develop new and improved messaging materials for both the general public and high-risk groups.

To create appropriate drowsy-driving messaging, the stakeholder community needs to study past successes with similar public safety and health campaigns. In addition, the stakeholder community needs to conduct research to identify the most appropriate types of messages and communication styles for at-risk populations that convey the risks of drowsy driving, the prevention of it, the danger signs when driving, and what to do when driving drowsy.

### **Develop and Promote Corporate Sleep-Wellness Programs**

Employers should develop and promote sleep-wellness programs. These programs will complement public safety campaigns and will be an integral part of corporate fatigue management programs (detailed as a separate priority below). These programs can help lead to a safer, healthier and more productive business environment.

### **Promote the Inclusion of Information About Drowsy Driving in Driver's Manuals, Driver's Education Curricula and License Exam Questions**

In addition to many new drivers not knowing about the dangers of drowsy driving, many of those new drivers are also teens—one of the groups at highest risk for drowsy driving crashes. One important avenue to address drowsy driving is through

driver's education curricula, state driver's manuals, and questions on State's license exams. By adding significant focus on the issue of drowsy driving, the seriousness of the impairment can be communicated at an authoritative level.

### **Vehicle Technology**

Motor vehicles have evolved from purely mechanical systems into multi-technology systems reliant on significant computer processing capacity and digital sensors. The computer systems in vehicles not only assist with the entertainment and comfort of the vehicle occupants, but are also increasingly used to offload some of the driving task from the operator to the vehicle itself. The decreasing cost of computing and sensing power has led to manufacturers developing new vehicle functions that can collect significant amounts of real-time driving data, perform data fusion, and perform complex algorithms.

These technological advances are now being used in some vehicles to detect driver states such as drowsiness. However, it is not clear how valid or reliable the current systems are, how consumers feel about the systems, whether they provide any awareness and safety benefits, or what the future may bring with these systems. The priorities highlighted below seek to answer some of these questions and ensure that future vehicle technologies can effectively address drowsy driving.

### **Promote the Development and Deployment of Drowsy Driving Warning Systems**

There are a number of driver-state monitoring systems available in motor vehicles today. These include systems that are reported to detect either attentional impairment, which may include drowsiness, or drowsiness alone. These systems are early in their technological development and just entering the market. To ensure that future systems designed to detect drowsiness are effective and accepted by consumers, it is important to demonstrate their validity and reliability. Furthermore, the alerts and countermeasures provided after detection of drowsiness must be accepted by the consumer in order to motivate the driver to cease driving, keep the driver alert long enough to reach either a proximal or final destination, and encourage drivers to get appropriate amounts of sleep and to avoid driving drowsy.

In addition to simple alerting, there is a potential for drowsy driving detection systems to alter the way vehicle systems operate. For example, factory-installed navigation systems could automatically give directions to the nearest rest stop where caffeinated drinks are available. Alternatively, an Automatic Emergency Braking (AEB) system could change its threshold to brake further in advance of a potential collision when drowsiness is detected. Furthermore, recording the history of detection and alerting of drowsiness in the event of a crash would help investigators to determine the contributing causes of a crash.

### **Educate Consumers on the Use of Drowsy Driving Warning Systems**

Although implementation of drowsy driving warning systems in vehicles is not yet widespread, it is necessary to begin educating consumers both on the benefit of having a vehicle with a drowsy driving warning system and on the operation of such a system including the appropriate response to the alerts they

generate. It is unlikely that many consumers have an understanding of how the system detects their drowsiness level and they may incorrectly believe that it is simply based on how long they have been driving.

It is also important to educate drivers on the appropriate personal countermeasures (eg, caffeine use and nap sleep) to combat drowsy driving. Training can take many forms, including: interactive websites, computer programs, training by the dealership at time of purchase, and a help-desk either available at a dealer or remotely. This training could be used not only to educate consumers on drowsy driving but also on other new advanced vehicle features.

### **Encourage Adoption of Collision Avoidance Technologies**

Human error or poor decision making was the primary causal factor in 94% of motor crashes, according to a NHTSA report.<sup>48</sup> NHTSA, as well as the rest of the US Department of Transportation, are working to accelerate the spread of crash-avoidance technologies that have the potential to prevent the thousands of transportation deaths caused by human error. As part of this effort, NHTSA and the Insurance Institute for Highway Safety recently announced a commitment by 20 automakers (99% of the US auto market) to make AEB a standard feature on new cars by 2022. The Department is also working to make vehicle-to-vehicle safety communications a part of the future motor vehicle fleet and to identify and address potential obstacles to safety innovations within its existing regulations.

While safety innovations based on vehicle automation may be able to prevent a number of drowsy driving crashes, intermediate stages of automation will require human decision making and input at various points during driving. Such interactions between the driver and the vehicle will likely be impacted by drowsiness. Additionally, some of these technologies may lead to greater levels of drowsiness as less driver involvement is required due to increasing levels of automation. These interactions with new intermediate levels of automation may be an emerging safety concern that should be monitored as these systems become more ubiquitous.

### **Public and Corporate Policy**

Experience with a wide variety of driver risk behaviors has consistently shown that establishing clear policies is necessary to motivate widespread behavior change. Such policies can take the form of state and local laws, administrative regulations, and corporate or workplace policies. The priorities highlighted below seek to address a number of the most important avenues to creating new policies.

### **Develop and Promote a Model Drowsy Driving Law for US States**

In the United States, driving laws are under the purview of the individual States. There are currently only two States with laws specifically addressing drowsy driving: New Jersey and in Arkansas. These laws were the direct result of a State resident dying in a drowsy-driving motor vehicle crash and the resulting outcry over the difficulty in prosecuting the offending driver. These laws do not make drowsy driving a punishable offense if a driver is pulled over in a drowsy state. Instead, they allow

States to prosecute someone for a more serious offense (eg, negligent homicide).

Laws making it illegal to drive drowsy would be difficult currently to enforce, and current public attitudes make passing such laws difficult. When serious crashes can be investigated in depth, it becomes much easier to establish the driver's previous sleep history. This situation typically only occurs in crashes where there is a fatality or there is substantial property damage (depending on the State or locality).

To ease the passage of drowsy driving laws, stakeholder organizations need to draft model legislation that allows the prosecution of drivers who negligently drive and cause a motor vehicle crash because of drowsiness. Once a model law is created, stakeholder organizations need to coordinate, assess barriers to passage, and promote the drowsy driving model legislation to members of each of the State legislatures.

### ***Promote Drowsy Driving Policies and Fatigue Management Programs in the Workforce***

Motor vehicle crashes, both on and off the job, cost employers \$47.4 billion in 2013 accounting for physical property damage, workplace disruption, and liability (\$20.6 billion) as well as health-related fringe benefit payments (\$26.8 billion).<sup>49</sup> These numbers do not account for the substantially larger cost of all injuries on the job or other costly workplace mistakes leading to lost time and productivity or law suits. Sleep deprivation may play a significant role in these workplace incidents and cost businesses billions of dollars annually.

To address these costs, employers as well as organizations with volunteers (eg, Emergency Medical Services and Fire Departments) should implement policies on appropriate sleep prior to and during work and, more ideally, institute robust evidence-based fatigue management programs. This recommendation is especially true for work forces that are required to work extended hours and/or regular or rotating night shifts. Robust fatigue management programs have been instituted in several modes of transportation (eg, aviation, rail, and motor carriers) and others with policies in place (eg, resident work hours) can provide an example to follow.

### ***Develop a Federal Government Employee Drowsy Driving Policy***

In order to protect its workforce as well as provide an example and leadership for other employers to follow, the Federal Government should create a policy that provides training on sleep health and drowsy driving. In addition, the Federal Government should explore ways to ensure that the workforce is not only protected against the risks of drowsy driving but also protected against performing other risky work while in a drowsy state.

### ***Provide Guidance for State Policy and Programs***

With regard to drowsy driving, State governments are responsible for creating public policy and programs to protect their citizens. The Federal Government can support these efforts in a number of ways, such as fiscal incentives or technical resources. Moreover, enforcement partners (ie, police, judges, prosecutors) may require help implementing newly enacted drowsy driving policies and laws. The Federal Government and stakeholder organizations can provide significant technical expertise

(eg, training, communications and outreach, data collection and analysis) to the States in order to most effectively address issues of drowsy driving.

## **Roadway Infrastructure**

### ***Encourage the Development of Infrastructure to Protect Against Drowsy Driving***

A number of improvements can be made to our Nation's roads and surrounding infrastructure that will protect against drowsy driving crashes. Rumble strips are an example of one well documented and already well deployed countermeasure. Rumble strips can alert a driver that they are approaching the edge or center line of the roadway, thus allowing the driver to correct the vehicle's direction of travel before departing the roadway or entering into oncoming traffic. Research on rumble strips illustrates this particular infrastructure countermeasure is an effective means to reduce roadway departures or center line crossings.

Rumble strips are not the only method of improving infrastructure. There is evidence that drowsy driving crashes are decreased around highway rest-areas. By creating, improving, and supporting rest-areas on our Nation's roads, places can be available for people to get off of the road during dangerous periods of drowsiness and offer countermeasures that can help (eg, caffeinated drinks or a place to take a brief nap). By offering support to State and local highway offices, the Federal Government can encourage the proliferation and support of infrastructure interventions to prevent drowsy driving.

## **THE NHTSA DROWSY DRIVING RESEARCH AND PROGRAM PLAN**

The "NHTSA Drowsy Driving Research and Program Plan" was developed to guide NHTSA's efforts over the next several years. This is the first time that NHTSA has developed a comprehensive initiative directed at curtailing drowsy driving. The plan firmly establishes the program alongside other successful NHTSA behavioral safety programs focusing on impaired driving, including drunk, drugged, and distracted driving.

The plan addresses six broad focus areas: Measurement and Problem Identification, Public Awareness and Education, Policy Development, High-Risk Populations, Vehicle Technology, and Infrastructure. A total of 10 projects are included under these focus areas, including projects focusing on analyzing naturalistic driving data and crash data, a national survey, identification of drowsy driving by law enforcement, a drowsy driving traffic safety toolkit for employers, evidence-based guidelines for fatigue management in Emergency Medical Services, and more.

This plan is an initial effort by NHTSA and an important step toward an enduring commitment to enhancing the science and program initiatives to reduce drowsy driving.

## **A CALL TO ACTION: THE FUTURE OF DROWSY DRIVING PREVENTION**

NHTSA's recent forum held during National Drowsy Driving Prevention Week, "Asleep at the Wheel: A Nation of Drowsy Drivers," is the beginning of a new national drowsy driving initiative. This article highlights a tremendous amount of work that needs to be accomplished in order to eliminate drowsy driving motor vehicle crashes. The priorities require significant



leadership, resources, and financial commitment. By bringing together motor vehicle and highway safety constituents with the sleep/circadian science and sleep medicine communities, will help establish and strengthen existing connections.

## RESOURCES

One significant challenge to the future of drowsy driving prevention is obtaining the necessary funding to successfully implement the research and programs highlighted above. A societal cost of over \$109 billion justifies significant investment toward the elimination of drowsy driving. The US Department of Transportation and NHTSA specifically, have the capacity to sponsor some of the necessary work under its current Congressional Authorization and Appropriations. States also have the ability to use Federal Grant Funds to sponsor drowsy driving programs. Considering that drowsy driving affects everyone, the current minimal level of support does not provide sufficient means to effectively address the issue. The necessary resources will only come from a combination of federal government, local government, industry, academia, and other non-governmental organizations providing more substantive financial backing of drowsy driving solutions.

Two important avenues to address drowsy driving were identified during the creation of the Next Steps Matrix. These suggestions were improving communications between stakeholders and creating a national plan to coordinate drowsy driving prevention activities. This is something that a consortium of stakeholders is beginning work on now: we are developing a “National Plan to Address Drowsy Driving” (see below).

## A NEW DROWSY DRIVING CONSORTIUM

Regular meetings and ongoing collaboration are needed to devise and implement new programs that are capable of achieving permanent behavioral change. The NHTSA November 2015 Forum should be the beginning of a commitment by traffic safety and sleep/circadian science stakeholders to work together to develop, implement, monitor and continually improve drowsy driving countermeasures.

In addition to the new partnership between the traffic safety and sleep/circadian science communities, the commitment to collaborate needs to connect other stakeholders and permeate the communities themselves. More collaboration is needed among the National Sleep Foundation, the Sleep Research Society, the American Academy of Sleep Medicine, and other groups concerned with sleep/circadian science and sleep medicine. There must also be more collaboration between government agencies involved in safety, health, labor, and defense which are also impacted by sleep deprivation in the workplace. These government agencies are ideal starting places to coordinate stakeholder involvement and stimulate interactions among employers, scientists, industry members and healthcare professionals for the purpose of coordinating messaging, and sharing resources, policy development and research findings.

## A NATIONAL PLAN TO ELIMINATE DROWSY DRIVING

This article provides a list of broad priorities that will help stakeholders address drowsy driving across the United States.

However, it is only the beginning of the conversation and the work to be done. A comprehensive and more detailed “National Plan to Eliminate Drowsy Driving” needs to be drafted by the full range of government and private stakeholders, which should include specific actions to be taken to address all of these priorities. This comprehensive plan will facilitate communications between all of the stakeholders and help with planning for the long-term future of drowsy driving prevention. Only with a comprehensive and detailed plan will we begin to make significant progress toward eliminating drowsy driving.

The recommendations outlined above from the November 2015 NHTSA Forum will form the basis of the National Plan. Forum participants will be engaged in identifying actions to be taken from their organizations, professions or fields of work, and a consolidated national strategy will be released.

This is the beginning of a national movement that requires strong and dedicated partners. Accomplishing the goal of eliminating drowsy driving depends on the involvement of all relevant stakeholders.

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## DISCLOSURE STATEMENT

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