Driving Drowsy in West Virginia

Robert B. Walker, MD
Michael Hicks, PhD
Tracy Smith, MS
Kenneth Devlin, MA

EXECUTIVE SUMMARY

Drowsy driving is a serious problem that contributes to the severity and frequency of the numerous automobile crashes each year in West Virginia. The purpose of this report is to provide direction and make recommendations to the State of West Virginia (Department of Transportation, Department of Public Safety, Department of Public Health) in developing educational programs and reducing the risk and prevalence and the associated injuries of driving drowsy. The content of this report is based on an extensive literature review, West Virginia Department of Transportation Division of Traffic Engineering accident data analysis and recommendations of the contributors involved in the project.

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SLEEPINESS & ITS EFFECTS

Sleep is a biological requirement composed of identifiable combinations of sleepiness and wakefulness. Sleepiness arises when the sleep component of the circadian cycle, restriction of sleep, and/or interruption or fragmented sleep occurs. The loss of a single night of sleep often contributes to intense interim sleepiness, while routinely loosing as little as 1 or 2 hours a night can result in chronic sleepiness. The most effective way to reduce sleepiness is uncomplicated – get adequate sleep.

Sleepiness contributes to auto crashes by impairing performance, often rendering a driver powerless to resist falling asleep while operating an automobile. Reaction time, vigilance, attention, and information processing all diminish in sleepy individuals. These functions are vital to the safe operation of an automobile.

CRASH CHARACTERISTICS

There are no definitive criteria available to access the severity of sleepiness prior to an incident or to establish a threshold at which sleepiness affects safe operation of a motor vehicle. However, a typical crash related to sleepiness has the following characteristics (NCSDR/NHTSA 1998):

1. The problem occurs during late night/ early morning or mid-afternoon.
2. The crash is likely to be serious.
3. A single vehicle leaves the roadway.
4. The crash occurs on a high-speed road.
5. The driver does not attempt to avoid a crash.
6. The driver is alone in the vehicle.

RISKS FOR DROWSY-DRIVING CRASHES

While research on the risks associated with drowsy driving is limited, there are a number of identified chronic predisposing factors and acute situational factors that increase the risk of drowsy driving and drowsy-driving related crashes. Among these are: sleep loss; driving patterns that interrupt the normal sleep-wake cycle; increase in time and/or distance driving; use of medication with sedative effects; sleep disorders; and alcohol consumption which increases drowsiness as well as concentration and reaction time deficits (Pack AI, et al 1995). The cumulative effect of any combination of factors substantially increases crash risk.

POPULATION GROUPS AT HIGHEST RISK

Although no one is invulnerable, data clearly defines three population groups that are at increased risk of drowsy-driving crashes: 1) male drivers between 16 and 29 years of age; 2) shift workers; and 3) people with untreated sleep disorders (NCSDR/NHTSA 1998). These findings are based on evidence from crash data, subjective reports of higher levels of sleepiness and chronic or acute factors that underlie risk for all populations.

RESEARCH METHODOLOGY & KNOWLEDGE BUILDING

An extensive literature search of Internet databases was conducted using the keywords (sleep, circadian rhythms, sleepiness, drowsiness, sleep physiology, and sleep disorders, fatigue, technology, alerting devices, industrial accidents, shift work, and the association of these topics with driving risk and crash prevention). Formal and informal summaries and reports from state and federal governmental agencies as well as nongovernmental agencies were reviewed.

Research Design & Data Analysis

The data was analyzed using biometric analysis of accidents with standard biometric statistical tools. Data used in this report was provided by the West Virginia Department of Transportation. Summary statistics for each of the years included in the report are available in *2001 Accident Data* available from WVDOT. Employing the broadest set of variables for these data, observations were characterized as having three drowsy driving contributing categories: hour, type of accident, type of road and vehicle condition. The data comprises electronic data derived from accident reports submitted by state and local police and sheriff departments in the State. For this analysis, data for the first four months of 2001, were used. For this period, 19,880 observations were analyzed.

Literature Review

Summary reports of fatigue-related crashes that identified driver behavior preceding the crash as well as identifiable risk behaviors linked to these crashes were evaluated. Also reviewed were studies involving driving simulations and other types of tests aimed at measuring the effects of sleepiness, sleep loss, and the concomitant effects of sleep loss and alcohol consumption on cognition and performance. Existing research from other states outlining crash histories of fatigued/sleepy drivers and reports analyzing epidemiological studies of drowsy-driving countermeasures were an additional resource used in preparation of this report.

The literature reviewed varied widely in design, method, thoroughness, population, and outcome measures utilized. The amount of study data available is relatively small, and some studies were not representative of large numbers of crashes nor did they highlight the number of crashes or frequency of occurrence as outcome measures. References provided in this document do not reflect all resources available or all of those reviewed during the course of this project.

RECOMMENDATIONS & COUNTERMEASURES

To significantly reduce drowsy driving and its consequences, West Virginians must be educated about the general health implications of poor sleep hygiene and approaches that reduce risks of drowsy driving accidents. This educational campaign should focus on specific behaviors aimed at reducing the probability of becoming drowsy while driving. Specific behaviors include: planning to get sufficient sleep; not drinking any alcohol when sleepy; and limiting driving between midnight and 6 a.m. If a driver is drowsy or fatigued, the primary behavioral strategy is to simply stop driving - let a passenger drive or stop to sleep (nap) before continuing long trips.

Taking short naps and consuming caffeine equivalent to two cups of coffee are options that increase driving alertness for a limited period of time. Other countermeasures to increase alertness, such as opening a window, listening to the radio, and chewing ice have not been shown to be effective.

A better informed medical and public health professional is an essential element of the campaign to reduce drowsy driving. Practicing physicians, medical students and public health officials should understand the problems associated with poor sleep and educate patients about the need for adequate sleep as an important behavior for good health as well as drowsy-driving prevention. West Virginia’s medical curriculum would better serve all by incorporating more information on the prevalence, prompt diagnosis and treatment of sleep disorders.

West Virginia’s public and policymakers should be informed of the purpose and effectiveness of shoulder rumble strips. Rumble strips, however, are not a solution for sleepy drivers. These individuals must view this “wake-up alert” as an indication of impairment and a signal to stop driving and get adequate sleep before driving again.

Employers, unions, and shift work employees should be knowledgeable of the effective measures that can be taken to reduce sleepiness resulting from shift work schedules. Approaches include following strategies for scheduling shift changes. When shift work prevents a normal night of sleep, educate these workers should understand strategies to plan time and establish an environment that is conducive to sleep.

WEST VIRGINIA’S DRIVING DROWSY CAMPAIGN

To reduce the prevalence and economic implications of sleep related crashes, the following approaches are recommended:

1. General Educational Message – promote adequate sleep as a public health benefit while simultaneously reducing the risks of fatigue/sleep related accidents.
2. Focus on Public Safety – integrate sleep related facts into the training of West Virginia’s Public Safety Officials
3. Focus on Drivers Education Programs – integrate risk and prevention strategies concerning sleep and fall-asleep crashes into West Virginia high school driver education curriculum.

4. Focus on the Medical Community – incorporate standardized educational modules on sleep disorders into West Virginia Medical Schools third year curriculum
5. Focus on Highways and Infrastructure Planning – continue expansion and installation of continuous rumble strips on existing and proposed West Virginia roads. Assess the adequacy of public rest areas and renovate where applicable.
6. Focus on High Risk Groups - develop specific educational strategies that effectively target high-risk groups and disseminate information fitting these unique "high-risk" groups.
7. Focus on Research - continue efforts to conduct further research related to fatigued and drowsy driving.

INTRODUCTION

Motor vehicle crashes are a major public health problem – they are the leading cause of death for persons aged 5 – 29 years and the leading cause of injury for all age groups (NCSDR/NHTSA 1998). To address this public health concern, efforts to increase seat-belt use, decrease drinking and driving, and increase the use of child safety seats have been relatively successful in raising public awareness and reducing motor vehicle fatalities. However, one issue relating to motor vehicle accidents that has not received as much attention as the foregoing, until recently, is Drowsy/Fatigued driver related crashes.

In 1996 Congress convened an Expert Panel to investigate the prevalence, associated behaviors, and risks of drowsy driving. Since that time numerous organizations examined the problem and determined strategies to reduce these types of accidents. The American Medical Association's Council on Scientific Affairs published a report describing drowsy/fatigue related motor vehicle crashes in the Journal of the American Medical Association in June of 1998. This report urged physicians to take an active role in "protecting the health and safety of affected drivers and all highway users"(Lyznicki, Doege, Davis and Williams, 1998).

Eye-opening data has emerged out of the work of these interest groups - Drowsy driving leads to thousands of auto accidents each year. According to the National Commission on Sleep Disorders, sleep related accidents cost an estimated $46 billion a year. The US National Highway Traffic Safety Administration reports that drowsy drivers account for at least 100,000 ***reported*** crashes annually. The National Transportation Safety Board estimates that thirty-one percent of fatal commercial truck crashes are the result of drowsy driving. Roughly 40,000 non-fatal injuries and 1550 fatal injuries arise annually as a result of this type of crash (NCSDR/NHTSA 1998).

Although most, but not all, states reference fatigue and/drowsiness as a causal factor on their standard accident report forms, these types of crashes are under-reported. This is partly due to the lack of accurate techniques for identifying a driver's state of alertness. Most drivers involved in accidents tend to downplay their driving condition to avoid blame. Drowsiness not only causes "falling asleep at the wheel", but also contributes to crashes by decreasing driver concentration and impairing performance, thus adding to the difficulty of determining drowsiness as a causal factor (Brown, 1994)

SLEEPINESS & ITS EFFECTS

Sleep is a biological requirement of the human body that is composed of identifiable combinations of sleepiness and wakefulness. Sleepiness arises when the sleep component of the circadian cycle, restriction of sleep, and/or interruption or fragmented sleep occurs. The loss of a single night of sleep often contributes to intense interim sleepiness, while routinely loosing as little as 1 or 2 hours a night can result in chronic sleepiness (Dement and Vaughan, 1999). The most effective way to reduce sleepiness is simply – sleep.

Sleepiness contributes to auto crashes by impairing performance, rendering a driver powerless to resist falling asleep while operating an automobile. Individuals are poor judges of how sleepy they are and how likely they are to fall asleep (FHWA, 1998). Research indicates that reaction time, vigilance, attention, and information processing diminish when individuals are sleepy (Lyznicki, Doege, Davis and Williams, 1998). These components are vital to the safe operation of an automobile.

Research has also linked the effects of sleep debt to alcohol intoxication (Dement and Vaughan, 1999). One study revealed that subjects who were deprived of sleep for 17 hours cognitive-psychomotor test performance equaled that of a rested person with a blood alcohol concentration (BAC) of 0.05 percent; and after 24 hours of sleep deprivation, performance was equivalent to a BAC of 0.10 percent (Dawson and Reid, 1997).

BACKGROUND

West Virginia has 1.3 million licensed drivers traveling over 18 billion miles annually. In 2000, there were over 50 thousand accidents, 352 fatalities, and over 17 thousand injuries from motor vehicle crashes. The economic loss of is estimated at over $3 billion. Motor vehicle crashes are a major public health concern in the state of West Virginia.

Most of West Virginia's roads, which traverse mountains, valleys, rivers and countryside, are rural routes. These rural roadways account for the majority of motor vehicle accidents that occur in the state. Nationally each year, there are 40% more accidents on rural roads than on urban roads (Tessner J, 1996).

Statewide accident totals are summarized in the table below:

STATEWIDE ACCIDENT TOTALS

(WV Department of Transportation, Division of Highways, Traffic Engineering, 2000)

Hwy Type	Accident	Injury	Property Damage Only	Fatal
Rural Interstate	**3,453**	**1297**	**2160**	**46**
Urban Interstate	891	258	625	8
Rural Primary	**14,180**	**5,943**	**8,044**	**193**
Urban Primary	10,991	3,441	7,521	29
County & Local Routes (State Maintained – Urban & Rural)	11,622	4,322	7,233	67
Statewide Total	50,897	17,009	33,531	357

REPORTING IN WEST VIRGINIA

The State of West Virginia requires that all motor vehicle crashes be reported on the *West Virginia Uniform Crash Report*. (A copy of this document is included in the appendices). WV's crash reports contain a separate and distinct section entitled "Driver Condition". Under this section there are two individual check boxes that indicate drowsy driving as a causal factor: **1) Fatigued** and **2) Asleep**.

CRASH PROFILE

Although there are no definitive criteria available to access the severity of sleepiness prior to an incident or a threshold at which sleepiness affects safe operation of a motor vehicle, studies show that:

1. These crashes occur during late-night/early morning hours or in the late afternoon
2. Fall asleep crashes tend to be serious
3. A single vehicle leaves the roadway
4. The crash occurs on highways or roadways with speed limits of 55 – 65 mph.
5. Drivers do not attempt to avoid the crash
6. The driver is alone in the automobile

RISK FACTORS

While research on the risks associated with drowsy driving is limited, there are a number of identified chronic predisposing factors and acute situational factors that increase the risk of drowsy driving and drowsy-driving related crashes. Among these are: sleep loss; driving patterns that interrupt the normal sleep-wake cycle; increase in time and/or distance driving; use of medication with sedative effects; sleep disorders; and alcohol consumption which increases drowsiness as well as concentration and reaction time deficits (Pack AI, et al 1995). The cumulative effect of any combination of factors substantially increases crash risk.

Although no one is invulnerable, data clearly defines three population groups that are at increased risk of drowsy-driving crashes. They are predominately male drivers between 16 and 29 years of age, shift workers, and people with untreated sleep disorders. These groups higher risk is based on evidence from crash data and subjective reports of higher levels of sleepiness and more chronic or acute factors that underlie risk for everyone else.

DROWSY DRIVING AND ITS IMPACT ON WEST VIRGINIA

Research into drowsy driving related accidents has primarily focused on independent identification of human factors (see NHTSA, 2002 and Dinges, 1995 for a review). From an epidemiological standpoint, human factors are important in understanding drowsy driving. So, research into sleep-wake cycles, sleep deprivation and performance and their causes offer much insight into causes of drowsy driving. This research area is especially important in determining educational needs aimed at drivers and their employers regarding appropriate ameliorative measures for drowsy driving. Understanding human factors may also result in engineering and design changes that mitigate potential drowsy driving losses. Additional research into the contributory factors of drowsy driving is warranted. In particular, the joint evaluation of driver, road and vehicle conditions is an area where additional analysis may shed light on the prevalence and causes of drowsy driving under a number of conditions.

In the remainder of this section we present a series of associative and causative factors in drowsy driving accidents in West Virginia. This type of research is critical to aid engineering and education efforts designed to mitigate the impact of drowsy driving. Also, we indentify important paths for future research as well as policy recommendations designed to reduce the probability of drowsy driving accidents.

Drowsy Driving Correlates

The following paragraphs analyze a basic set of available data on drowsy driving in West Virginia. This proceeds as a biometric analysis of accidents using standard biometric statistical tools. Data used in this report was provided by the West Virginia Department of Transportation. Summary statistics for each of the years included in the report are available in *2001 Accident Data* available from WVDOT. Employing the broadest set of variables for this data, accidents were characterized as having three drowsy driving contributing categories: hour, type of accident, type of road and vehicle condition.

The basic biometric model suffers weaknesses. First, since data on driver conditions is limited to traffic accident report data, this analysis is unlikely to extend the physiological understanding of accidents. Fortunately, this area of research is well developed. Also, the data employed are all categorical or binary. Thus, data collection is subject to some human bias. These are merely data limitations common in this type of analysis.

The biometric approach has several strengths not typically employed in existing analysis of driving accidents. First, these data provide the widest available range of accident correlates available. This suggests that the ability to correct for multiple causative factors is possible. For example, studies that focus on engineering or human factors, but do not correct for other correlates suffer omitted variable bias. Given the limit of available data, this biometric study formally minimizes this problem.

Data and Model

As mentioned, the data is from the *2001 Accident Data* published by the West Virginia Department of Transportation. This data comprises electronic data derived from accident reports submitted by state and local police and sheriff departments in the State. For this analysis, data for the first four months of 2001 were used, resulting in 19,880 observations.

For each observation the data offered variables concerning driver condition. These are presented as dependent variables in our estimation. The categories possible are FATIG, NORMAL, ASLEEP and DRINK. Several different characteristics were employed as independent variables reported in the accident report regarding time and light conditions, road conditions, type of accident, type of injuries, number of vehicle occupants and state of license. The dichotomous dependent variable model takes the form:

$$P(y_i = 1 | x_{i,j} \beta) = \beta_0 + \beta_n X_n + \varepsilon_i$$

Equation 1

where the probability of any of the events FATIG, NORMAL, ASLEEP or DRINK is conditioned on the independent variables relating road and light conditions, number of occupants, type of accident. This standard model is typically referred to as a probit or logit model depending upon the underlying distributional assumptions of the error term. The examples presented below display our distributional assumptions based on model fit criterion using the Akaike Information Criterion. The basic model is displayed in Table 1.

TABLE 1, ANALYSIS OF FATIGUED DRIVING, N= 19,880

Variable Categories	Variable	Probit[1]	Logit	Gompit
	C	-2.066194***	-4.084690***	-1.341135***
Time	2400-0300	0.304542***	0.734341***	0.188057***
	0300-0600	0.517655***	1.133808***	0.348792***
	2100-2400	-0.002420	0.046084	-0.012849
Light Conditions	Artificial Light	-0.038168	-0.140203	-0.014586
	Daylight	-0.216813	-0.509569	-0.135690
	Dark	-0.123603	-0.332298	-0.068572
	Dusk	-0.251426	-0.578807	-0.162812
Road Type	Interstate	0.305412***	0.684142*	0.199884***
	Curve and Hill	0.086956	0.374875	0.015826
	Curve and Grade	-0.102639	-0.176261	-0.080024
	Curve and Level	0.099553	0.315799	0.043358
	Straight and Hill	0.091389	0.455136	0.005017
	Straight and Level	0.046737	0.216765	0.004164
	Straight and Rolling	-5.482898***	-28.12413***	-2.315763***
	Straight and Grade	-0.081552	-0.113085	-0.071292
Injuries	Total Fatalities	-0.049822	-0.132831	-0.032185
	Total Injuries	0.176810***	0.462609***	0.103251***
Accident Type	Head on	-0.057947	-0.166445	-0.030215
	Opposite Sideswipe	0.344439**	0.966655*	0.193467**
	Rear End	0.262476	0.816129**	0.136736**
	Rear to Rear	-4.750253***	-26.40589***	-1.930016***
	Same Sideswipe	0.317385	0.984380**	0.164467**
	Single	0.706749	1.923474***	0.405247***
Misc.	Total Occupants	-0.221736***	-0.584880***	-0.127906***
	Number of Vehicles	-0.154655	-0.459346	-0.085056
	WV License	-0.197163***	-0.499844***	-0.114998***
	McFadden R-squared	0.142571	0.142922	0.141970
	Akaike info criterion	0.120392	0.120344	0.120475
	Log likelihood	-1169.697	-1169.217	-1170.517
	Probability(LR stat)	0.000000	0.000000	0.000000

*** significant to the .01 level using z-statistic, *** significant to the .-5 level using z-statistics, * significant ot the .10 level using z-statistic.

In this model there is a strong positive relationship between an accident attributable to fatigued driving and the hours of midnight to 6:00 A.M. This is consistent with virtually every other study that employees these variables. Surprisingly, lighting conditions do not appear to matter, though there is a weak negative relationship between daylight and fatigued driving accidents in these data. Road type does correlate with fatigued driving, with interstates suffering the strongest positive correlation. Straight and rolling road types are negatively correlated with drowsy driving, while the other reported road characteristics are not significantly correlated with drowsy driving. Without constructing a formal model it seems clear that these variables may be considered causative factors in drowsy driving accidents.

Other factors that may be described as correlates were also evaluated. The type of accidents positively correlated with drowsy driving included sideswipe accidents (both opposite and same direction), rear end collisions and single car accidents. Not surprisingly, the small numbers of rear-to-

[1] Probit, Logit and Gompit regressions employ differing assumptions regarding the distribution of the error term. The probit employs the normal distribution $f(x) = (2\pi)^{-\frac{1}{2}} e^{-\frac{x^2}{2}}$, the logit employs the logistic distribution of $f(x) = \frac{1}{1+e^{-x}}$, and the gompit the extreme value distribution of $f(x) = \exp(x - e^x)$.

rear accidents were negatively correlated with drowsy driving. Also, the fewer the number of drivers, the less probable was a drowsy driving accident. Also, out of state drivers were more likely to be involved in drowsy driving accidents than were West Virginia drivers.

The regression diagnostics for this model do not identify any particular concerns regarding the performance of this regression. In particular, the biggest concern, that of multicollinearity, does not seem to bias the variance of the regressors. Also, this model is not sensitive to distributional assumptions. Regressions for both logistic and gomphertz distributions reveal markedly similar results as illustrated.

Other dependent variables are also of interest. Primarily, we are interested in whether reports designating drivers asleep generate similar results as the drowsy driving reports. The same regressors were used for this model, employing and testing the same distributional assumptions. We found very similar results. See Table 2.

TABLE 2, ANALYSIS OF DRIVERS ASLEEP, N= 19,880

Variable Categories	Variable	Probit	Logit	Gompit
	C	-2.419368***	-5.130833***	-1.517017***
Time	2400-0300	0.244895	0.622116	0.144374*
	0300-0600	0.549851***	1.291753***	0.348995***
	2100-2400	-0.035011	-0.072053	-0.022132
Light Conditions	Artificial Light	-0.017785	0.201652	-0.058664
	Daylight	-0.031512	0.175035	-0.068782
	Dark	0.017510	0.252580	-0.034133
	Dusk	-0.030787	0.219084	-0.080379
Road Type	Interstate	0.332744***	0.829489***	0.199574***
	Curve and Hill	-5.357788***	-32.31884***	-2.110352***
	Curve and Grade	0.019978	0.189509	-0.011162
	Curve and Level	0.322017	0.984383	0.160790
	Straight and Hill	0.165370	0.723010	0.046075
	Straight and Level	0.340589	1.059433	0.167105
	Straight and Rolling	-5.347171***	-32.44750***	-2.060004***
	Straight and Grade	0.240319	0.760258	0.113642
Injuries	Total Fatalities	-5.671507***	-33.40271***	-2.235366***
	Total Injuries	0.180566***	0.495781***	0.100069***
Accident Type	Head on	-5.302983***	-31.50906***	-2.121042***
	Opposite Sideswipe	0.491814**	1.480534**	0.261002**
	Rear End	0.127204	0.514690	0.050975
	Rear to Rear	-4.966111***	-31.40276***	-1.899262***
	Same Sideswipe	0.156868	0.578672	0.072631
	Single	0.506055**	1.454454*	0.278554**
Misc.	Total Occupants	-0.293829***	-0.792694***	-0.166767***
	Number of Vehicles	-0.313149	-1.006733	-0.160915
	WV License	-0.094823	-0.266695	-0.049958
	McFadden R-squared	0.148253	0.147159	0.148778
	Akaike info criterion	0.060210	0.060284	0.060175
	Log likelihood	-571.4904	-572.2244	-571.1383
	Probability(LR stat)	0.000000	0.000000	0.000000

*** significant to the .01 level using z-statistic, *** significant to the .-5 level using z-statistics, * significant ot the .10 level using z-statistic.

These results were very similar to the drowsy driving outcomes reported in Table 1 above. The midnight to 6:00 A.M. time period was positively correlated with reports of the driver asleep (thought the statistical significance of the midnight to 3:00 A.M. was lower, and outside the 10 percent significance level from the drowsy model. Again, there was no statistical significance associated with light conditions. Also, interstate accidents were more likely to be categorized as asleep. Curves and hills and straight and rolling roads were strongly negatively correlated with asleep drivers. These are the causative factors examined in this model.

The correlates are also of interest. Accidents involving drivers that were asleep are much less likely to be correlated with fatalities, but are positively correlated with the number of injuries. Head on and rear-to-rear accidents are indirectly correlated with asleep drivers, while single car accidents and opposite direction sideswipes are positively correlated with asleep drivers. Also, cars with fewer occupants are less likely to be involved in accidents caused by asleep drivers. Other than magnitudes of the parameter estimates, there were only slight differences between these two regressions.

A third test involves treating both variables related to fatigue as functionally identical. The results of this model are displayed in Table 3.

TABLE 3, ANALYSIS OF DRIVERS ASLEEP AND FATIGUED DRIVERS, N= 19,880

Variable Categories	Variable	Probit	Logit	Gompit
	C	-2.066194***	-4.084690***	-1.341135***
Time	2400-0300	0.304542***	0.734341***	0.188057***
	0300-0600	0.517655***	1.133808***	0.348792***
	2100-2400	-0.002420	0.046084	-0.012849
Light Conditions	Artificial Light	-0.038168	-0.140203	-0.014586
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Road Type	Interstate	0.305412***	-0.166445	-0.030215
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	Straight and Rolling	-5.482898***	0.455136	0.005017
	Straight and Grade	-0.081552	0.216765	0.004164
Injuries	Total Fatalities	-0.049822	-28.54670***	-2.325538***
	Total Injuries	0.176810***	-0.113085	-0.071292
Accident Type	Head on	-0.057947	-0.132831	-0.032185
	Opposite Sideswipe	0.344439**	0.462609***	0.103251***
	Rear End	0.262476**	0.966655*	0.193467**
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Misc.	Total Occupants	-0.221736***	1.923474***	0.405247***
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	Log likelihood	-1169.697	-1169.217	-1170.517
	Probability(LR stat)	0.000000	0.000000	0.000000

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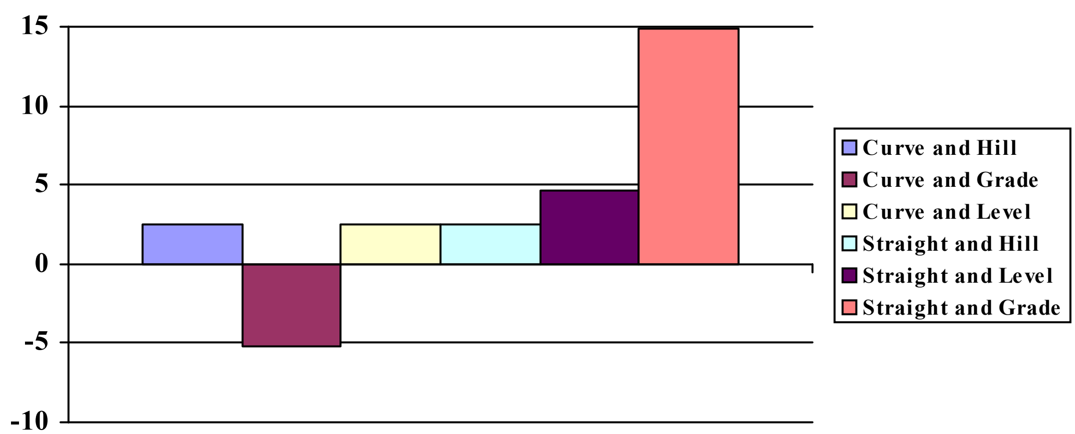
These results of this analysis remain quite similar to the earlier regression results. The following analysis relies on the model results displayed in Table 3 that model the correlates of both fatigued conditions.

To better interpret the models outlined above it is necessary to illustrate the marginal effect variables have on the probability of drowsy or sleepy driving as reported in the standard accident report. There are several methods for estimating the marginal effects from the coefficients derived in these regressions. Only a few of these provide useful interpretation.

Perhaps the clearest marginal effect is displayed by the relative change in likelihood of a drowsy driving accident occurring during late night hours. This analysis suggests that accidents occurring between midnight and 3:00 A.M. were 62 times more likely to be attributed to drowsy driving than accidents occurring between the hours of 9:00 P.M. and midnight. Accidents occurring between 3:00 A.M. and 6:00 A.M. were 131 times more likely to be caused by drowsy driving than accidents occurring between 9:00 P.M. and midnight. These probabilities controlled for all the other factors analyzed in the probit analysis in Table 3.

We also compared the change in likelihood of accidents occurring on different road conditions when compared to a straight and rolling highway. These effects are illustrated Figure 1.

Figure 1, Change in Likelihood of a Drowsy Driving Accident, (compared to a straight and rolling)



When we compare the likelihood of an accident type, we find that head on accidents are 2.6 times less likely than opposite sideswipe accidents and 1.45 times as likely as rear end collisions to be reported as a fatigue related.

The finding presented in this empirical review of almost 20,000 accidents in West Virginia strongly reinforce earlier research on time, road condition and accident types. This research extends earlier studies by providing more evidence of road type correlates and statistical measure that implement a larger set of control variables than others we have seen.

SUMMARY & RECOMENDATIONS

Drowsy driving continues to be critical contributing factor in automobile accidents in West Virginia. Our analysis suggests that the problem is one that requires policy action on a number of fronts. In addition to the recommendations derived from other research – primarily related to educational needs – our empirical analysis provides several distinct policy recommendations.

First, knowing the relative probability of fatigue related accident occurring on interstates and along straight and rolling interstates clearly establishes priority for rumble strips and future engineering considerations. Mapping, and marking these areas as high risk for drowsy driving should be considered an important next step in research efforts.

Second, our regression results show that West Virginia drivers are less likely than out of state drivers to be involved in a fatigue related accident. Also, that interstate highways are more likely to experience drowsy driving accidents. This suggests needed policy efforts directed by the federal government, with state level coordination and data sharing.

General Education and Awareness

There is a compendium of research indicating individuals with poor sleep patterns are less alert and attentive, more inclined to irritability and other mood problems. Concentration and judgment are impaired, the ability to perform even simple tasks declines, and productivity diminishes. Sleeplessness, due to a sleep disorder or an overextended lifestyle, creates a diminished quality of life contributing to existing health problems. Those who lose sleep or have poor sleep habits put themselves and others at high risk for accidents. Major industrial catastrophes like the Three Mile Island incident, for example, have been attributed to human error occurring during times when the body is at its sleepiest. If the need for sleep is ignored and individuals get behind the wheel of an automobile, lives are at stake. It takes only seconds to run off the road or into an oncoming car.

- Implement a comprehensive public awareness campaign on the necessity of good sleep hygiene; the effects of poor sleep hygiene on general health and the risks of drowsy driving for **All West Virginians.**

FOCUS ON PUBLIC SAFETY

Drowsy/fatigued driving crashes are under-reported. This occurs partly due to the lack of accurate techniques for identifying a driver’s state of alertness and most drivers involved in accidents tend to downplay their driving condition to avoid blame.

- Integrate information on drowsy driving into the training programs provided to WV Public safety officials (i.e. police officers) on common characteristics of drowsy driving.

- Partner with law enforcement agencies and other public safety and health officials specializing in youth programs to research and develop resources for identifying and dealing with fatigued driving.

There is no “test” to determine if someone fell asleep or drowsiness contributed to an accident.

- Add a section to the current uniform traffic report form that indicates, “potential” fall asleep/drowsiness as contributing factors. This would help to further quantify the prevalence as well as flag potential accidents for further research.

FOCUS ON DRIVERS EDUCATION PROGRAMS

There are numerous tools currently available from governmental and medical organizations that could be easily and cost effectively integrated into high school drivers’ education programs.

- Develop and integrate a standardized, medically precise curriculum on risks and prevention of drowsy driving into West Virginia High School Drivers education programs.

FOCUS ON MEDICAL & PUBLIC HEALTH PROFESSIONALS

Nearly 70 million Americans suffer from some form of sleep problem and almost 60 percent of these disorders are classified as chronic (NCSD 1992). Sleep problems affect men as well as women of every age, race, and socioeconomic class. Despite this widespread prevalence, it is estimated that 95% remain undiagnosed and untreated (NCSD 1992). Each year, sleep disorders, sleep deprivation, and sleepiness contribute an estimated $15.9 billion to the national cost of healthcare. (NCSD 1992). And the economic impact of lost worker productivity and accidents have not been accurately quantified. Furthermore, the contribution of these sleep disorders to serious health problems like heart disease and stroke, which kill and incapacitate thousands of Americans each year, has not been calculated.

- Develop and integrate education modules into the curriculum of West Virginia’s Medical and Nursing schools to train students on the diagnosis and treatment of sleep disorders.

Primary care physicians are an ideal means of identifying signs and symptoms sleep disorders and initiating appropriate care of the patient, including education on the dangers of functioning while impaired by sleepiness.

- Develop an educational program for primary care physicians on the prevalence, diagnosis and treatment of common sleep disorders.

FOCUS ON HIGHWAYS AND INFRASTRUCTURE PLANNING

Shoulder rumble strips are an effective way to gain a driver's attention and provide a warning that the vehicle is about to leave the roadway. It has been estimated that rumble strips can reduce run-off-road crashes by an estimated 20 to 50 percent (FHWA 2002).

- Continue the expansion of installation of continuous shoulder rumble strips on existing and planned interstate highways and rural roadways where possible.

- Implement the use of rumble strips to warn motorists of upcoming changes in the roadway or situations that demand a driver's immediate attention. (At toll plazas, in work zones, and before dangerous intersections, for example).

Research conducted by the Federal Highway Administration shows that demand-and-supply factors--such as distance from the previous rest area, adequate lighting, and food and repair facilities--increase the use of public rest areas by commercial truck drivers.

- Expand /renovate public roadside rest areas. These efforts include assessing current rest areas, potential construction of new rest areas, renovation of existing facilities, expansion of parking for commercial vehicles, and enhancing security.

FOCUS ON HIGH RISK GROUPS (YOUNG MEN & SHIFT WORKERS)

Chronic sleep deprivation is clearly the principal cause of drowsy driving among young males and shift workers.

- Develop specific educational strategies that effectively target high-risk groups and disseminate information fitting these unique "high-risk" groups.

- Promote empirically demonstrated effective strategies that prevent drowsy driving (i.e., setting a bedtime, mapping, getting off the road to sleep, etc.) versus strategies that have minimal efficacy (e.g., radio, singing, sticking head out the window, extreme temperatures, chewing ice).

- Implement educational programs focusing on advance planning (e.g., preceding long trips, prior to the work shift, prior to going out for the night) and ensure that individuals are sufficiently well rested before making long trips.

- Implement media-based approaches in the employment setting directly targeting high-risk groups (e.g., shift workers, young men in entry-level service positions).

YOUNG MALES

Young men often have high social needs, few responsibilities, and a greater acceptance of relative risk. Prior research indicates that young men are aware that drowsiness is a hazard when driving, yet seem to accept these risks as part of their lifestyle, and are often unwilling to change either their sleep routines or driving behavior.

- Implement educational programs focusing the consequences of "lifestyles choices" (i.e. risky behavior and its acceptance) made by young men that increase risk for automobile crashes require further investigation.

- Expand efforts to explore the underlying motivation involved in engaging in risky behavior or the concomitant behaviors of drowsy driving and other risky behaviors (e.g., drinking driving, aggressive driving).

Intermediaries may be a source of potential persuaders of high-risk individuals deterring their risky behavior (i.e. as family, friends, girlfriend/boyfriend/spouse, employers, law enforcement, medical professionals, and sleep researchers).

- Target educational materials to those individuals who may have potential influence.

SHIFT WORKERS

The financial incentives for those who engage in shift work are strong and seem to motivate these individuals to work late night and rotating shifts. Changing the structure of these incentives is highly improbable since coverage for these shifts is economically necessary for employers.

- Develop and implement educational messages aimed at improving sleep hygiene of shift workers.

- Encourage individuals to alter their sleep schedule and set priorities to use their time more efficiently.

- Partner with West Virginia Worker's Compensation, unions and other labor organizations/

Research indicates that sleep deprived individuals think and move more slowly, make more mistakes, and have difficulty remembering things. These negative effects lead to lower job productivity and cause accidents. The risk of workplace and automobile accidents rises for tired shift workers.

- Conduct additional qualitative research: For example, - focus groups to examine sub groups of shift workers to investigate the information needs and intervention strategies for each identified sub group (e.g., men only, women with young families, single women with children).

Focus of Future Efforts

Continue efforts to conduct further research related to fatigued and drowsy driving.

- Including: focus group research; expanded crash-based and survey research on the scope, nature, and risk factors related to drowsy driving among the West Virginia driving population; crash-based and survey research on sleepiness-related driving among long distance truck drivers utilizing West Virginia's Highway system; and a study of truck drivers' use and perceptions of public rest areas and other areas these drivers utilize for resting.

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