Drowsiness and Fatigue, The Most Frequent Causes of Sever Accidents Among Heavy Vehicle Drivers in Iran

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Abstract

Based on the results of the recent study (October 2003) by the coronial organization of Iran, this country at present time possesses the highest rate of the road accidents in the world. The rate of the increase of the said rate and caused losses are also incredible. During the summer 2003, 7933 persons were killed in Iran road accidents. This shows 20.5% increase in comparison to the previous year. The similar rate of increase for injuries, during the said period was even worse; equal to 34.1%.

The results of a study using TRL-MAAP model are presented in this paper. In this study the rural road accidents' data of the province of Khorasan (the biggest province of Iran, with about a fifth of the country's area and a tenth of its 66 million population) is analyzed. The results show that the rates of heavy vehicles' rural road accidents are highest in comparison with the medium size trucks and small size passenger cars, ranging from 440 accidents per 1000 vehicles per year for buses, 639 for mini-buses and 665 for heavy trucks and trailers.

These are caused by many shortcomings in the country's transportation infrastructure, heavy vehicles' crashworthiness, professional drivers' training, law enforcement, drowsiness, fatigue and drug epidemic among heavy vehicles' drivers together with the country's economic upheaval in recent years. But among all different causes, the analysis shows that drowsiness and fatigue are the most frequent and most alarming causes of the said scenario.

Here, the specific reasons for the spread of this epidemic impairing societal problem in Iran, is discussed and the remedial solutions are presented.

Key Words: fatigue, driver, road, accident, heavy vehicle, Iran.

1. Introduction

Motor vehicle injury is responsible for a huge burden of death and disability. The Global Burden of Disease Study estimated traffic injury to be the ninth leading cause of death and disability in the world in 1990, and projected it would be the third leading cause by 2020 (Murray and Lopez, 1997). In many countries including Iran, motor vehicle injury is the biggest threat to life amongst young people.

Road accidents are generally caused by a number of factors and it is rarely possible to attribute the cause to a single factor. There is, however, general agreement that human factors are of major importance in most accidents involving drivers of motor vehicles (WHO, 1967).

The behavior of a driver is determined by many variables, including the condition of his vehicle, of the road and of other environmental factors. Many disciplines are involved in the study and control of human factors in road accidents.

The most significant detrimental consequence of an insufficient quantity or inferior quality of sleep for drivers is the degradation in performance resulting from a diminished state of alertness, increased reaction time, or micro sleep episodes. The term "fatigue" is recognized as a state of reduced physical and mental alertness that impairs a range of cognitive and psychomotor tasks (Haworth & Heffernan, 1989). There is general agreement that fatigue results not only from prolonged activity but also from psychological, socioeconomic and environmental factors that affect the mind and body (Brown, 1994). While most humans are generally aware of these symptoms of fatigue (e.g., head nod, eye closure), they may have a limited ability to predict the onset of sleep (Itio et al., 1993). This has serious implications for road safety.

Continuous physical work, particularly when the muscles are in the state of contraction, leads inevitably to the onset of fatigue. Unsatisfactory driving posture, in which the blood supply to the muscles is restricted by compression and in which the tendons and joints are under continuous strain, or in which an unnecessary amount of effort is needed to operate the controls, considerably shortens the interval before fatigue set in. On the other hand the onset of the fatigue is postponed by frequent of resting, probably because it is only during the period of relaxation that the blood supply to a muscle circulates freely, thereby ensuring the most efficient elimination of the waste products of metabolism.

A number of studies have been carried out to determine the effect on vigilance of prolonged tasks of a repetitive kind. The results of these studies are important in determining the effect of fatigue on various aspects of driving performance. When a subject is allowed to perform a task at his own pace it is done accurately and in good time. But if he is asked to perform the task with complete regularity and within a pre-determined time he is likely to make errors and to miss opportunities. Electroencephalograph readings show that in the former case there are brief interruptions in attention, followed by a period work at increased pace, whereas, in the latter case there is no compensatory increase in the pace of work. This leads to the accumulation of anxiety, further missed opportunities and the earlier onset of fatigue (Broadbent, 1953). It may follow that in tasks such as driving, which requires unremitting attention, vigilance may fail and may be followed by inaccuracy, poor judgment and sluggish reactions, if the task is allowed to continue for too long without respite.

Too much noise can certainly lead to the earlier onset of fatigue, as has been shown in particularly noisy factories where the performance of the workers falls off, although he may experience no discomfort and be unaware of the deterioration.

As there is no single objectively defined measure of fatigue, we will accept a range of commonly used measures of fatigue and its likely determinants, including sleepiness at the time of the crash, usual daytime sleepiness, acute sleep deprivation, chronic sleep deprivation, sleep fragmentation, shift work or other circadian rhythm disturbance, time on task (driving), snoring and sleep disorders.

2. Safety related consequences of fatigue

Several major reviews and commentaries have suggested that fatigue or sleepiness in car drivers increases the risk of crashing (American Thoracic Society, 1994; Dinges, 1995; Expert Panel on Driver Fatigue and Sleepiness, 1997), but none have systematically reviewed the epidemiological evidence (Connor, Whitlock and others, 2001). Estimates of the proportion of all crashes attributable to fatigue vary 10 fold, from 1-3% for The United States (American Medical Association, 1998), to 25% in Victoria, Australia (Naughton and Pierce, 1991). The estimates for fatal crashes and for highway/freeway crashes have typically been higher than for all crashes combined.

The quantification of the contribution of fatigue to crashes has important implications for development and prioritization of interventions to prevent injuries.

To estimate the proportion of the crash and injury burden attributable to fatigue one needs to know the prevalence of fatigue in the driving population and the degree to which crash risk is increased by fatigue (Rothman and Greenland, 1998).

Given the current uncertainty about the effect of fatigue on car crash risk, a systematic review of the international literature has been conducted (Connor, Whitlock and others, 2001). That work aims to avoid the pitfalls of a selective or uncritical review (Mulrow, 1994).

Estimates of motor vehicle crashes partially or completely attributable to fatigue in The United States, range from 1 to 56 percent (Miller et al., 1997). The efficiency of vehicle-based data for predicting lane departure arising from loss of alertness due to fatigue has been reported (Filitrault et al., 1996).

The degree of sensory stimulation is also important in maintaining alertness while driving. Frequent sensory stimulation preserve a high level of alertness, thereby facilitating perception, co-ordination and other higher brain functions. Diminution in sensory stimulation which is liable to occur during long journeys on monotonous freeways inhibits these functions. It has been suggested that there is an optimum range of environmental stress and that deterioration in driving performance sets in both above and below this range as a result of fatigue. The onset of fatigue is also "arcadian" fluctuations in physiological activity. During the time of the day that the physiological activity is increasing, the onset of fatigue may be offset to some extent by a corresponding improvement in performance. But in periods when physiological activity is depressed, for instance, at times when sleep is taken, the effects of fatigue may be particularly dangerous as they are associated with a corresponding diminution in performance. It follows that the advantages of driving in "off peak" periods of traffic density may be offset to some extents by the effects of reduction in environmental stress. The effects on perceptual efficiency may be partially noticeable if the journey is taken at a time when the driver would normally be sleeping (Brown, 1967).

Another phenomenon which has been detected after prolonged performance of a complex task such as driving is the inability to distribute attention appropriately. Too much attention may be paid to one part of the task, and insufficient to another. Hence, fatigued airline pilots have been known to control the aircraft adequately yet forget to change over the fuel tanks. This kind of disturbance of attention has also been noted in the case of alcoholic intoxication. On the other hand, it seems likely that the diminution in perception which has been noted following prolonged exposure to a particular stimulus is due to adaptation rather than to fatigue.

The effects of fatigue on vision are also important. It has been noted that if peripheral vision is subjected to a series of flickering lights, confusion and error of judgment may occur in respect of objects seen by the central part of the retina. This may occur when driving along a road lined by tall trees on a sunny day. Alternating of bars of lightness and darkness will interfere with the assessment of speed and of the position of objects on the road ahead of the vehicle.

3. Fatigue amongst the drivers of heavy vehicles

Driver fatigue has been recognized as a probable cause and corresponding risk factor of crashes involving heavy trucks (Sweedler, 1990; NTSB, 1995; Massie et al., 1997) and over-the-road commercial buses (NTSB, 1992; NTSB, 1999). The competitive nature of surface transportation imposes unique challenges on commercial drivers compared to other road users. Chief among these is the ability to balance the need for rest with real or perceived consequences that could arise should drivers fail to maintain the externally imposed schedule demands (McCartt et al., 1997; Hanowski et al., 1998).This can be difficult since economic pressure, and not a driver's ability to function, is often the impetus that strongly influences or dictates how delivery schedules will be established (Duck et al., 1997). The anxiety generated by unexpected delays that disrupt delivery schedules can further intensify if commercial drivers and carrier management differ in what they regard as the cause of, and strategies to, manage fatigue (Arnold et al., 1997). In this environment, commercial drivers may not feel adequately empowered to stop and rest when the onset of the sleep develops. The consequences of this behavior, whether self or industry imposed, are direr among long-haul truck drivers than other workers (Abrams et al., 1997).

Several factors, including sleep restrictions and sleep fragmentation, can interfere with commercial drivers' ability to obtain the requisite quantity and quality of sleep. Sleep quality can be restricted by work demands, medication, family responsibilities, personal and life style factors (Lyznicki et al., 1998), irregular work schedules that curtail the periods available for continuous rest and sleep, or splitting sleep taken in a sleeper berth into two or more rest periods (Herts, 1988). Sleep fragmentation can affect both the quantity and quality of sleep (Neylan & Reynolds, 1991) and can be caused by obstructive sleep apnea (Phillipson, 1993), psychiatric disorders including depression (Mendelson, 1987), personality characteristics of neuroticism and anxiety (Dorsey, 1991) and excessive noise or concern about personal safety while resting in sleeper berth of a heavy truck (Neale et al., 1998). An explanatory study has been conducted (Filiatrault, Vavrik and others, 2002) to examine the relationship between the sleep quality and how priorities are assigned by commercial drivers when the need to rest interferes with tight delivery schedules. The results showed that lower sleep quality is associated with commercial drivers who place greater emphasis on their real or perceived duty to fulfill externally imposed schedule demands than to refrain from driving in a diminished state of alertness to satisfy the need for rest. The Rest –Schedule Orientation (RSO) of commercial drivers was the most efficient predictor of sleep quality of all measures that were used in their study. Their findings suggest that there is reason to question the premise that sleep quantity be considered the sole predetermining factor to assess whether commercial drivers can be presumed capable of remaining vigilant while driving.

4. The impact of two-up driving on driver fatigue

The impact of two-up driving on driver fatigue by comparing it to single driving has been studied (Feyer, Williamson and others, 1995). The results indicate that for shorter trips, and longer trips incorporating an extended mid-trip break, two-up driving can be an effective way of managing fatigue.

While, overall, the two-up groups show greater fatigue compared to single drivers, some ways of doing two-up were less fatiguing than single driving. Important differences in the organization of the trips for two-up drivers were found in terms of trip length and the distribution of rest obtained across the trip. Striking differences have been seen in recovery and maintenance of alertness associated with these operational distinctions among two-up drivers. Overnight stationary rest for two-up drivers at the time of peak fatigue, at mid trip, is associated with a dramatic reduction in fatigue levels after the break, and allows these drivers to finish the trip with the lowest levels of fatigue of any group, including single drivers. Two-up drivers who have no significant stationary rest, but have the shortest trip duration of any group show minimal recovery at mid trip but show an overall increase in alertness over the homeward journey, finishing the trip at pre-trip levels of fatigue. These drivers also fare better than single drivers. Among single drivers, substantial recovery of alertness is seen after the stationary rest at mid point, but this recovery is not maintained with decreases in alertness evident at the end of trip. In contrast, two-up drivers who do much longer trips, and do these trips without the benefit of stationary rest, show no recovery at mid trip and continue to deteriorate, ending the trip more tired than any other group. The results also highlight the importance of chronic fatigue as a hazard for long distance drivers. Chronic fatigue accumulated before the start of the trip has a clear impact on the development of fatigue during the trip. For two-up drivers, fatigue at the beginning of the trip is clearly influenced by the amount of work they do in the ten or so hours before they start to drive, such that they start the trip more tired than single drivers. Moreover, this disadvantage remains for most of the trip, irrespective of two-up trip type, but is particularly evident over the first leg of the trip where fatigue for two-up drivers continued to worsen at a greater rate than for single drivers. In other words, where fatigue had accumulated before the start of the trip (from activities other than driving) clearly added to the build-up of fatigue to driving once the trip had started.

Compelling evidence for the impact of chronic fatigue is also provided by analysis of changes in the effectiveness of break taken by drivers as the trip progresses. As a whole, two-up drivers appear to gain less from breaks than do single drivers but the work practices among two-up drivers critically influence the utility of breaks. As two-up trips become longer, breaks become increasingly ineffective in the latter part of the trip, and totally lose their effectiveness towards the end of the trip. It seems that these drivers simply become too tired for breaks to be of any use. Breaks are most useful for the two-up groups which have a long overnight stop. These groups show better response to breaks than single drivers and also better than two-up drivers who do not take overnight rest. Thus, where the work practices keep fatigue under control, such as shorter two-up trips and two-up trips including overnight rest, breaks are more likely to be useful. In contrast, on trips where fatigue is allowed to build-up, such as on single trips and the two-up trips going very long distances, breaks do not provide relief once fatigue has accumulated.

Taken together the finding of studies suggest that judicious use of effective rest (that is, night rest) in combination with two-up driving may be the best strategy to manage fatigue on very long trips. The results also underscore that the most effective improvements in managing fatigue must take account of overall work practices, including activities in the past week, activities before driving begins as well as the way the trip is structured.

5. Fatigue in local/short haul trucking

The US Department of Commerce's (1994) Truck Inventory and Use Survey (TIUS) provides definitions for the trucking industry based on "range of operation". Range of operation refers to the type of trip (e.g. distance traveled) in which the vehicle typically operates. TIUS does not provide a definition for local/short haul (L/SH) operations per se; however, it does define local operations and short-range operations. A local range of operation is defined as an operation that makes trips less than 50 miles from the vehicle's home base. Short range or short haul involves trips between 50 and 100 miles from the home base. Based on these two definitions, L/SH operations can be defined as those that primarily engage in trips of 100 miles or less from the home base. To provide some prospective to this definition, long haul operations or those that likely come to mind when one thinks of "trucking", typically make trips that are 500 miles or more from home base.

The US Department of Transportation (1996) lists a multitude of past research efforts aimed at trucking operations. Although, the largest segment of the trucking industry operates within 50 miles of the vehicle's home base (Massie et al., 1997), the majority of research has been directed at long-haul operations. Very few research efforts have been directed at L/SH operations; thus, very little is known about a general safety issues in this industry.

The research that has been aimed at long-haul operations has focused on hours-of-service (HOS) regulations and driver fatigue (Hanowski, Walter and others, 2003). One reason for this is due to the work routine of long-haul drivers. That is, the primary task for long-haul drivers is operating the vehicle. As such, their workday consists mainly of sitting behind the wheel and driving. On the other hand, the L/SH driver's workday tends to be more varied. In addition to driving, a L/SH driver may receive the day's driver schedule, load and unload the vehicle, get in and out of the vehicle numerous times, lift and carry packages, engage in customer relations and perform other miscellaneous tasks. For L/SH drivers, driving is only part of their daily work routine.

In addition to different routines, another major difference between long-haul and L/SH drivers are that L/SH drivers typically start and end their workday at their home base. This allows L/SH drivers to return to their homes after their shift and sleep in their own beds at night. Contrast this with long-haul drivers who may be on the road for several days or weeks at a time, who drive and sleep at irregular times and who may sleep in the truck's cab or sleeper berth during off-hours. Given the typical work routine of long haul drivers, it is not surprising that HOS and driver fatigue have been research areas of focus. Because fatigue is such a prevalent research topic for long-haul operations, the question arises as to whether fatigue is also an issue in L/SH. It has been found (Hanowski, and others; 2003) that there is a statistically significant level of incident involvement where signs of fatigue are present for a 3 min period immediately preceding incident involvement where the L/SH driver is judged to be at fault. As such, the answer is yes; fatigue does appear to be also an issue in L/SH trucking operations. Based on the results of the multiple analyses that are conducted, it seems much of the fatigue experienced by such drivers is brought with them to the job rather than being caused by the job. That is, poor sleep quantity/quality is prominent for drivers who demonstrated signs of fatigue on the job. Therefore, it is suggested that the off-duty behavior of the drivers is likely a primary contributing factor in the level of fatigue that is demonstrated during the workday. Another important finding is that the younger, inexperienced drivers are more likely to be involved in critical incidents, cause incidents, and be fatigued prior to incidents. Also, the majority of the critical incidents caused by L/SH drivers involved a small group of drivers. That is, only a few drivers caused the majority of L/SH driver at-fault critical incidents.

6- Heavy vehicles' safety situation in Iran and the justification of this research-work

Iran is one of the developing countries that is suffering from one of the worst traffic safety situations in the world. The accidents and casualties rates are so high, that the situation is evaluated as "critical". The number of fatalities with a yearly increasing rate of 20 to 25 percent has reached to an astonishing figure of 26000 in 2003. The rate of fatalities per 10000 registered vehicles, which is 1.5 to 3 in developed countries; is at the threshold of 50 in Iran. Based on a recent research-work by the author (Ayati, 2002), the economic losses of traffic accidents in Iran, are equivalent to 3.5% of the country's Gross National Product. The most sever accidents which are happening frequently with great losses, are those in which heavy vehicles are involved. Especially front to front accidents between heavy trucks and busses are happening frequently. In one of such accidents, which happened in March 2004, 30 people including the drivers of both vehicles where killed and 5 persons were injured.

The shocking rate of killed to injured obviously shows the severity of the accident. Because of the economic situations in Iran, most of the heavy vehicle drivers' working hours are extremely high and their both quantity and quality of rest seams to be insufficient. The research-work, which its results are presented in this paper, would has been conducted to clarify the role of drowsiness and fatigue among heavy vehicle drivers in the causation of the said critical road safety situation in Iran.

7- Methodology

The data used for this research-work, are the police rural road accidents of the province of Khorasan. Khorasan is the biggest province of Iran, with the area of 330 thousands square kilometers (one fifth of the total area of the country) and the population of 6700 thousands, which accounts for about one tenth of the population of the country. This province is located in the eastern north corner, and is neighboring the two countries of Afghanistan and Turkmenistan.

Accident report forms were received from the police accident department, and after a through check by a team consisting of traffic engineering experts and police officers; they were fed into a special form designed by the author for this work. Through the process of the abovementioned data transfer, many shortcomings and defects were detected; and the related forms were sent back to the police department for further considerations and corrections. Having completed the said forms, then the data were fed into the computer. At this stage, the data were analyzed; using Micro Computer Accident Analysis Package (MAAP). MAAP is a powerful model for the analysis of traffic accident data, and is developed by The Transport Research Laboratory (TRL) in United Kingdom.

MAAP defines 84 variables for each accident. Some of these variables are compulsory and without knowing them, the records are not accepted by the system, but the other variables are not compulsory. Naturally, the more variables being defined for each accident record, the more exact and reliable results will be generated by the system.

One of the most important data base problems, even in developed countries is the lack of adequacy of defined variables and deficiency in the information provided in police accident reports. In order to solve this problem at least to some extent in this work, many orientation classes were formed for the Khorasan police officers and satisfactory results were obtained. Realizing the importance of providing correct and sufficient accident data, then considerable improvement both quantitatively and qualitatively was obtained.

MAAP model is a powerful analysis tool, which provides the following facilities for the user:

SELECT: This option enables the user to find a group of accidents that meets some particular criterion that is wished to set.

STANDARD AND NON-STANDARD CROSS-TABULATIONS:

Cross-tabulations are one of the most important tools of accident analysis, particularly in establishing the general pattern of accidents. Three types of cross-tabulation are available in this model: 1. Accident cross-tabulations 2. Casualty cross-tabulations

3. Vehicle cross-tabulations

We are offered at the beginning of all the programs that analyze our accident files. It gives us the opportunity to restrict the accidents that are to be analyzed to some particular group that we are interested in. There are four methods for defining our condition if it is more than a single value:

: To separate individual values

- To give a range of values

< For "less than a value"

> For "greater than a value"

The standard cross-tabulations are defined by sets of numbers in the following files:

Standard Accident Tables	ACCTABS.SPC
Standard Casualty Tables	CASTABS.SPC
Standard Vehicle Tables	VEHTABS.SPC

The tables defined can be changed by editing these files. For ACCTABS.SPC and CASTABS.SPC, there are three numbers to define each table:

(i) The Table Type

(ii) The Column Variable

(iii) The Row Variable

In VEHTABS.SPC, only the column and row variables are specified.

For casualty tables, there are five different TYPES of table as listed below:

A = ALL CASUALTY TYPES

B = DRIVERS CASUALTIES ONLY

C = PASSENGER CASUALTIES ONLY

D = DRIVERS AND PASSENGERS CASUALTIES ONLY

P = PEDESTRIANS CASUALTIES ONLY

In general, there are no restrictions to the accident items that can be cross-tabulated, but only casualties are counted and added to the tables. In road casualty tables, it common practice to group driver age, passenger age and pedestrian age together into a single variable – ROAD USER AGE.

8. Results and discussion

The results of this study show that in the province of Khorasan the rates of heavy vehicles' rural road accidents are highest in comparison with medium size trucks and small size passenger cars. This is from 440 accidents per 1000 vehicles per year for buses, 639 for mini-buses and 665 for heavy trucks and trailers.

Traffic accidents are multi-cause events that rarely might be attributed to a single cause. The Organization for Economic Cooperation and Development (1984) has summarized the development of the conceptualization of road safety problems, suggesting that over time it has been progressed through six stages, each successively recognizing the reality of road traffic as part of a system and acknowledging that solutions need to be sought in a systems context. These stages are as follows:

1- Mono-causal casuistic approach, 2- Mono-causal accident proneness approach, 3- Mono-causal chance phenomenon approach, 4- Multi-causal chance phenomenon approach, 5- Multi-casual static systems approach, and finally: 6- Multi-casual dynamic systems approach.

The last approach, which is the only efficient and rationale way to tackle the problem, is a dynamic system; and thus in concept, develops into a method to search for critical lines or sequences through all the processes leading to road trauma.

Considering the above-mentioned facts, the exceptionally high rates of rural road accidents of heavy vehicles in Iran, must be attributed to a complicated transportation system of such vehicles. This system is suffering from many shortcomings. Transportation infrastructure, heavy vehicles' crashworthiness, professional drivers' training programs, law enforcement, emergency services, and both physical and emotional stability of heavy vehicles' drivers; all are encountered by serious problems which contain both quantitative and qualitative natures. But the results of this study shows that drowsiness and fatigue are the most frequent and most alarming causes of the severe accidents among heavy vehicles in Iran.

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