

Identification of Major Causes and Strategies Adapted by Chauffeurs to Combat Micro-Sleepiness

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Abstract—Micro-Sleepiness (MS) is a type of temporary biological phenomenon, which can happen from fraction of second to 30 seconds and fails to respond for some arbitrary sensory inputs. It has become one of the major social concerns that cause fatalities, material losses, productivity and quality reductions and eventually negative impact on national GDP. Two surveys were conducted by interviewing relevant person and investigating documentary evidence available in Sri Lanka Police Traffic Statistics Division to identify major causes and current practices adapted to combat it. The collected data were analyzed using Pareto technique. The study reveals 80% of MS is caused by Food habits, Psychological state, Diurnal factors and Bodily status of the affected party. Further 80% practices to suppress MS were Boosting the self-confident level, keep on mortar function, using chemical energy, creating gustatory stung, astonish olfactory and tingling actions. According to the survey MS occur from 14.00 to 16.00h (peak time), 16.00 to 18.00h (least) and again reappearing to some extent from 18.00 to 20.00h. This finding is being in compliance with the Sri Lanka Police Traffic statistics, because road accidents are also befall on the same time intervals.

Index Terms—Micro-sleepiness, caffeine, Road accidents, confectionary, olfactory, melatonin

I. INTRODUCTION

A. Background

MS has become a major concern for road accidents, low productivity, low quality of work and numbness in the society. According to the National Highway Traffic and Safety Administration UK (NHTSA) one in four fatal road accidents may occur due to the micro sleepiness and more than 1550 deaths, 71000 injuries, and USD 12.5 Billion monetary losses were reported [1]. According to the Sri Lanka Police Traffic Statistical Division, road accidents have been increased at an alarming rate from 2005 to 2015 and more than 60 fatal road accidents were reported in 2015 due to micro-sleepiness while driving and there is a continuous increment of road accidents, from 2010 to 2014 such as, 2010-2011 = 4.9%, 2011-2012 = 14.5% and 2012-2013 = 21.8%.

Peak intensity of M.S occurs in between 14.00 to 16.00 hours, especially after taking heavy meals [2]. Furthermore, drowsiness, bad weather, poor luminosity, psychological stress, effect of sleep promoting hormones (such as Melatonin, Serotonin and tryptophan), effect of alcohol, traffic jams and heavy diets are the other probable factors for MS. Driving while sleepy is like driving with a blood alcohol content of 0.08% over the legal limit in many states. And drinking and drowsiness are double trouble when driving because sleep deprivation magnifies the affects of alcohol [3].

B. Psychological Stress and Occurrence of MS

International statistics identify MS as one of the major causes of severe traffic accidents [4]. And the growing complexity of the car and traffic environment, including the operation of assistance and information systems, can easily exceed driver workload limits and create stress that degrades driving performance [5]. Further high intensity of sunlight during daytime as well as insufficient light intensity, bad weather conditions, unavoidable noise conditions, and unfit physical conditions of drivers are also highly responsible for driver MS.

C. MS Detecting Systems

Two types of measurements such as subjective and sensor-based have been developed to measure MS while driving. Evaluation of subjective measures for the MS is based on personal perception on the respondent's verbally expressions or using a questionnaire. The second method based on vehicle-based measurements and these measurements can be taken by placing sensors on in different vehicle components such as steering wheel and the acceleration pedal etc. The signals sent by the sensors are then analyzed to determine the level of MS. Behavioral and psychological measures of the respondents are the widely using characteristics in sensor-based methods to measure MS.

D. Combating MS While Driving

As MS is one of the critical concerns in the dynamic society, productive precautions must be developed to cope with MS. Several researches have been carried out to detect and control sleepiness while driving. As automation technology has progressed, more and more

modern functions such as Pre-crash systems, advanced automatic collision notification, automotive night vision with pedestrian detection, lane departure systems, vehicle tracking systems, adaptive cruise control, adaptive headlamps have been incorporated to automobiles to assist drivers in controlling sleepiness [6].

Due to more comfort in modern automobiles, the person at the wheel inadvertently felt in to the state of MS. In order to cope with this situation high tech systems were introduced in to vehicles to monitor driver-behavior unintentionally, such as eye movement, facial feature movement, brain waves (using electroencephalography-EEG) and steering wheel grip [7]. Moreover previous experiments have also been carried out using coffee and similar caffeinated and decaffeinated drinks. After having such drink immediately before a 15-minute nap, was also very effective way for drivers to overcome sleepiness for a short time span [8].

According to the research carried out by the Royal Society for the Prevention of Accidents Driver Fatigue and Road Accidents, they have been carried out a survey to identify driver’s strategies to avoid sleepiness while driving and 68, 57,30,25,14 and 15% of the respondents used to open windows/shutters, stop the vehicle and go for a walk, listen to radio or cassette, drink coffee and other methods respectively. After that they have carried out a research based on these factors and there had no significant effect in reducing sleepiness by listening to the radio or cassette and also there was no any significance in between air conditioning and occurrence of sleepiness. The second study was based on whether exercise can help to reduce sleepiness. And 10 minute light, 10 minutes moderate and 10 minutes heavy exercise were scheduled. Results reveal that, Light and moderate exercise made some of the subjects feel less sleepy, but only for about 10 minutes. Heavy exercise produced better results, and the effects lasted for about 30 minutes. However, it does not seem feasible for people to take heavy exercise during breaks from journeys, or indeed as preparation for a journey. Therefore, exercise is not a practical way of avoiding or reducing driver sleepiness.

There were three studies based on Caffeine intake and its effect on driver sleepiness. According to those studies, the first study found that it takes around 30 minutes for caffeine to take effect but that taking 150mg of caffeine in the early afternoon was effective in reducing sleepiness and sleep related incidents for up to one hour. Also the second study found that combining 150mg of caffeine with a nap of around 15min significantly reduced sleep related incidents for up to 2h’s and finally 3rd study examined the effects of taking 200mg of caffeine on a group of drivers who had only slept 5hrs the night before, and on a group who had no sleep previous night. Again, for the group who had restricted sleep, the caffeine took around 30 minutes to take effect, but then significantly reduced sleep related incidents reported for the next two hrs. So most of the deterrents in addition to caffeine that drivers do to combat sleepiness when driving are ineffective for more than around 10 minutes [9].

II. METHADODOLOGY

A. Chauffeurs Based Survey

The survey was carried out with the participation of chauffeurs (volunteer basis) in southern expressway, Central Transport Board (CTB), Sri Lanka and some other selected private transport services. Sample selection was carried out with reference to ISO 2859-1: 1989 (E) sampling method and 200 chauffeurs were selected. Before commencing the study, prior approval for Ethical Clearances was taken from Ethics Review Committee, Faculty of Medical Sciences, University of Sri Jayewardenepura, Sri Lanka under the application number 38/16 on 26th August 2016.

The pre prepared questioner was used as the study material and it consisted with general personal details, their experiences about MS, road traffic conditions, Psychological stress and its impact, MS preventing methods which they practiced.

B. Police Statistics Based Survey

The documentary survey was carried out with the help of Sri Lanka Police Traffic Statistical Division using available database for the period of 10years beginning from 2005 to 2015.

And data about human perception and experience on MS were gathered through the structured survey.

The collected data from both surveys were analyzed according to Pareto method in order to determine major cases for road accidents as well as preventive measures.

III. RESULTS AND DISCUSSION.

A. Time Period of Occurrence MS

The collected data pertaining to occurrence of MS for time duration were analyzed according to Pareto method and outcome is given in Table I.

According to the Table I, The most MS occurring time period is 14.00-16.00h. This finding has been further validated by Sri Lanka Police Traffic Statistical Division. Because their documentary evidences also stated that peak time period for road accidents due to MS is 14.00-20.00h. And C and B time periods are also responsible for around 30% and 8% of response respectively. In addition to that F, A and E time periods responsible for only around 18% of the responses for occurrence of MS.

TABLE I. CRITICAL TIME PERIOD FOR OCCURRENCE OF MS.

| | Time Period | Responses | Response % | Cum. Responses | Cum. Response% |
|---|-------------|-----------|-------------|----------------|----------------|
| D | 14.00-16.00 | 101 | 39.60784314 | 101 | 39.60784314 |
| C | 12.00-14.00 | 77 | 30.19607843 | 178 | 69.80392157 |
| B | 10.00-12.00 | 22 | 8.62745098 | 200 | 78.43137255 |
| F | 18.00-20.00 | 20 | 7.843137255 | 220 | 86.2745098 |
| A | 08.00-10.00 | 19 | 7.450980392 | 239 | 93.7254902 |
| E | 16.00-18.00 | 8 | 3.137254902 | 247 | 96.8627451 |
| G | No idea | 8 | 3.137254902 | 255 | 100 |

255

Reasons for the occurrence of MS during these periods were food habits, psychological stress, bodily status and diurnal factors of the chauffeurs, as Sri Lanka Chaffers usually may take heavy lunch with high caloric value. Road condition, traffic jam, heat & light intensity and audio sounds are also contributory factors for the psychologically stress for the drivers during this period. Further under this situation, bodily status of the driver is fatigue and exhausted, hence all those factors remarkably contribute to the occurrence of MS.

The remedies related to mortar function adapted by chauffeurs were analyzed by the Pareto analysis and outcome is given in Table II.

TABLE II. CURRENT PREVENTIVE MEASURES TO COMBAT MS

| Treatment | No of Responses | Response % | Cum. Responses | Cum. Response% |
|-----------|-----------------|-------------|----------------|----------------|
| E | 74 | 31.3559322 | 74 | 31.3559322 |
| C | 65 | 27.54237288 | 139 | 58.89830508 |
| B | 36 | 15.25423729 | 175 | 74.15254237 |
| A | 33 | 13.98305085 | 208 | 88.13559322 |
| D | 22 | 9.322033898 | 230 | 97.45762712 |
| F | 6 | 2.542372881 | 236 | 100 |
| | 236 | | | |

B. Current Preventive Measures to Combat MS.

A: Short nap/Exercising, B: Wash faces/body wash while swirling mouth, C: Chew gum or chew beetles, D: Smoking/alcohol/other, E: Consuming Toffee/Sweets., F: Using Ointments or medicines.

Most of the respondents (More than 80%) have been used to consume chewable food products to control MS while driving, such as toffee or some sort of sweet confectionaries (31.36%), chewing gums and chew beetles (27.54%). In addition to that 15.24, 13.98, 9.32, 2.54% of responses were practice to have a short nap/Exercise, Smoking/consuming alcohol and using ointments or medicines respectively.

While consuming aforesaid food products the mouth cavity starts functioning and oral activity begins physically and biologically. All those activities related to mortar function. Therefore mortar function or activities of the mouth largely contribute to combat MS. According to neurology mortar function will stimulate the brain to combat MS.

The data commonly used beverage to suppress MS were analyzed according to same method and outcome is showing in Fig. 1.

C. Commonly Used Beverages to Combat MS by Chaffers

Cumulative percentage of the responses is more than 80 for tea, coffee and water according to the Fig. 1. Furthermore 6.49, 5.63 and 1.30% of the responses are responsible for drinking soft drinks, Energy drinks and Sour taste beverages such as lime respectively. Tea, coffee and water are readily available and cheap in price in Sri Lanka. In addition to that tea and coffee contain

caffeine as the major phytochemical which is beneficial to combat/control MS by providing chemical energy. Caffeine molecules binds with adenosine receptors in the brain to form caffeine-adenosine receptor complex to control sleepiness.

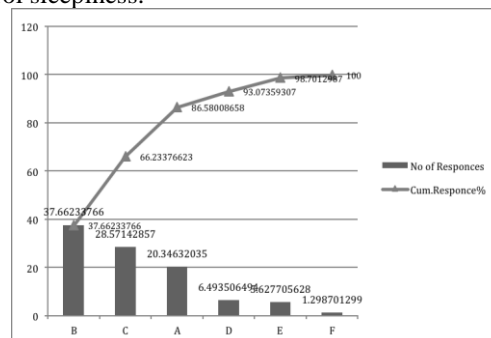


Figure 1. Commonly used beverages to combat MS.

A: Water, B: Tea, C: Coffee, D: Soft drinks, E: Energy drinks, F: Sour taste drinks such as lime

Caffeine increased sleep latency and affected all other sleep variables. In addition, caffeine consumption decreased secretion of melatonin. In a simulated shift work situation, the influence of 200 mg caffeine was studied in none to moderate caffeine users (≤ 2 cups a day; aged between 19 and 36 years). Work started at 5:30 p.m. and went on until 10 a.m. the next morning. During the 1-h rest period from 1:30 to 2:30 a.m., the participants performed performance tests lasting 90–95 min. Caffeine was found to be beneficial for performance during the night, which was ascribed to its lowering effect on melatonin, an endogenous regulator of the sleep-wake cycle secreted nocturnally by the pineal gland. In addition to the effect of caffeine on the circadian rhythm, it has been argued that caffeine primarily promotes wakefulness by its effect on adenosine. In other words, consumption of caffeine might be responsible for the altered expression of sleep homeostatic pressure [10].

Psychological stresses due to internal and external environmental factors are highly responsible for occurrence of MS of drivers as shown in Table III.

TABLE III. TYPE OF PSYCHOLOGICAL FACTORS, WHICH MAY AFFECTS TO BEGIN MS.

| Treatment | No of Responses | Response % | Cum. Responses | Cum. Response% |
|-----------|-----------------|-------------|----------------|----------------|
| A | 54 | 28.125 | 54 | 28.125 |
| B | 51 | 26.5625 | 105 | 54.6875 |
| C | 36 | 18.75 | 141 | 73.4375 |
| D | 18 | 9.375 | 159 | 82.8125 |
| E | 17 | 8.854166667 | 176 | 91.6666 |
| F | 16 | 8.333333333 | 192 | 100 |
| | 192 | | | |

A: Luminosity of Light, B: Bad weather, C: Traffic jams, D: Job or work stress, E: Sound/Noise, F: Other factors

D. Psychological Factors Contribute for MS

Light luminosity of internal and external environment (28.13%), Bad weather conditions (26.56%), Traffic jams

(18.75) and job/work stress (9.38) may highly influenced in psychological stress (more than 80%) according to the Table III. Either internal and external environment sound/noise or other factors may responsible around 8% for psychological stress of the respondents. Either psychological condition, food habits also directly affect to this inadvertent phenomenon as shown in Fig. 2.

E. Food Consumption Patterns of the Chauffeurs.

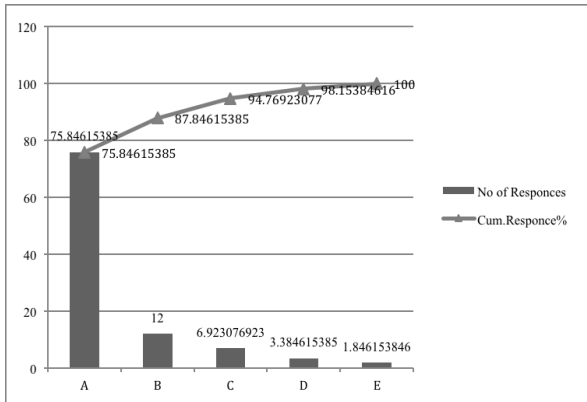


Figure 2. Food consumption Patterns for all three meals of the respondents.

A: Rice, B: Instant foods, C: Other Types of foods, D: Grains and Pulses, E: No food.

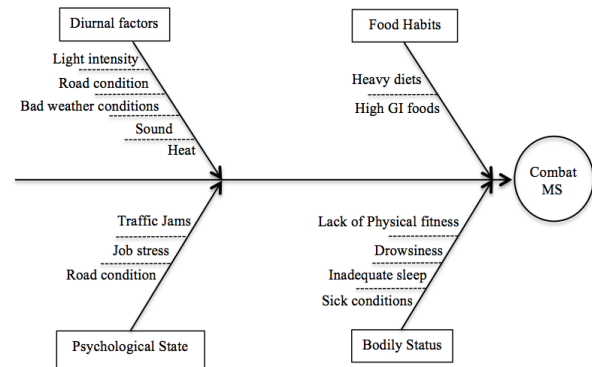
According to the Fig. 1, 75.85, 12.00, 6.92, 3.39% of respondents consumed rice, Instant foods, Other types of foods such as Parata, koththu. etc and Grains and pulses respectively while 1.85% of the respondents who don't have major meals for an entire day because of their duty shifts and many other reasons. And more than 80% of the responses were used to consume rice and some sort of instant foods for their main staples. Since Glycemic Load (GL) of the lunch is very high, the body requires more energy to digest it. Under this circumstance, the person unintentionally tends to relaxations. And brain of the individual inadvertently transformed into another mode, which called beginning of the micro-sleepiness [2].

Causes and strategies for occurrence of MS could be identified by the Pareto analysis carried out using a cause and effect diagram with each responsible factor. And Root cause analysis was also carried out to determine the most critical factors to befall MS while driving as given in Fig. 3.

F. Root Cause Analysis for Chauffeur MS

According to the Fig. 3, there were four critical factors responsible for occurrence of MS while driving such as Diurnal factors, Food habits of the respondents, Psychological state of the automobile drivers as well as Bodily status. These critical factors were identified through the survey and brainstorming. These identified factors must be properly addressed to combat MS efficiently. Further 80% practices to suppress MS were Boosting the self-confident level against MS, keep on mortar function to stimulate the brain to combat MS, using chemical energy such as caffeine to overcome chemical reactions responsible for occurrence of MS, and

creating gustatory stung, astonish olfactory and tingling actions over the mouth cavity to start quick shock against MS and to stimulate brain for alertness.



Conclusion:

1. Peak time periods.
2. Chewable food products to keep on mortar function

Figure 3. Cause and Effect diagram for chauffeur MS.

IV. CONCLUSIONS

- According to the results of pareto analysis, fundamentals (which responsible for around 80% of the responses) and effective preventive measures for MS were determined.
- Diurnal factors, Food habits of the respondents, Psychological state and the Bodily status of the automobile drivers were identified as the critical factors for occurrence of MS.
- Most of the current applying precautions to control MS were not efficient.
- Boosting the self-confident level, keep on mortar function, using chemical energy, creating gustatory stung, astonish olfactory and tingling actions had been identified as preventive strategies to suppress MS.

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