ABSTRACT

Nowadays with the increasing number of cars, daily driving activity has become a source of stress. The increase in drivers' stress level may affect their decisions while driving causing accidents or it may have a long term effect on their health. Therefore, it is important to be aware of factors that increase stress level of drivers. This paper presents results of a survey in Jordan that investigates factors that may cause increase in stress levels from the drivers' point of view, such as time of driving, other drivers’ behavior, weather conditions, and road types. Results of survey are compared with similar studies reported in literature. It will also present an idea of a novel computerized system that detects stress level of drivers based on physiological sensors of the body. This system will validate the real effect of perceived factors causing stress on driver's health based on physiological data detected.

Keywords: Subjective Factors, Driving, Stress Level, Accidents, computerized system, physiological sensors
1. Introduction

Globally, driving and road safety are among the current and leading problems. World Health Organization (WHO) conducted a report in both 2013 and 2015 on road safety around the world. Both reports demonstrated that the number of annual traffic-related fatalities is 1.24 million person (WHO, 2013) and has plateaued at 1.25 million a year (WHO, 2015). In (WHO, 2013), driving and road safety were reported as the leading causes of death for people aged 18-29. In (WHO, 2015), driving and road safety were also reported as the leading causes of death for people aged 15-29. Most of these deaths are in low- and middle-income countries where rapid economic growth has been accompanied by increased motorization and road traffic injuries. As well as being a public health problem, road traffic injuries are a development issue: low-and middle income countries lose approximately 3% of Gross Domestic Product (GDP) as a result of road traffic crashes. Although road traffic injuries have been a leading cause of mortality for many years, most traffic crashes are both predictable and preventable. There is considerable evidence on interventions that are effective at making roads safer: countries that have successfully implemented these interventions have seen corresponding reductions in road traffic deaths. Rolling out these interventions globally offers huge potential to mitigate future damage and save lives at a global level.

In Jordan, Public Security Directorate (PSD) reported that in 2015 (111,057) traffic accident occurred, where in 9,712 of these accidents human injuries resulted. These human injuries are divided into: 608 deaths, 2,021 people seriously injured, and 14,118 people with minor injuries. The age group (18-35) is the category that is most affected by traffic accidents, which constitutes (42.74%) of the total number of causalities. Such accidents have an estimated cost of 275 million dinars (Jordan loses more than 0.75 million JD per day due to traffic accidents) (PSD, 2016). Since Jordan is one of the developing countries, many steps have been taken and investigated to reduce the number of injuries and deaths related to traffic accidents. But the reduction rates for the last ten years are slow such that: the annual decline rate in the number of accidents, that injuries occurred in is 1.6% only, while the annual decline rate in the number injuries is 1%, and the annual decline rate in the number fatalities is 3.2% (PSD, 2016). One of the leading factors that cause accidents is the human factor. Among the factors that affect human performance during driving is stress. This work will present the results of a survey in Jordan that investigates the factors that may cause an increase in the stress levels from the drivers’ point of view. The paper will also present an idea of a novel computerized system that detects the stress level of the driver based on physiological sensors of the body.

This paper is organized such that section 2 presents literature review. Section 3 presents the results of a survey specifically oriented to identify the factors that may cause an increase in the stress levels from the drivers' point of view. Section 4 presents a discussion and analysis of survey’s results. We present, in section 5 an idea of a novel computerized system that detects the stress level of the driver based on physiological sensors of the body. Finally section 6 concludes this paper. Next a brief description of available relevant research is presented.

2. Literature Review

This part presents results of research work concerning which physiological data have an effect on the stress levels for drivers. Also, we present a brief description of implemented machine learning techniques related to this study.

Studies have shown that a high level of stress is associated with a tendency for people to make mistakes (Różanowski et al, 2015). In order to reduce the number of accidents, there is a need to investigate the extent of stress level effect in causing accidents. Some research has been conducted to investigate the effect of stress level on drivers’ performance while driving. Also,
some research work have investigated the physiological data that detects stress level (Barua et al., 2015; Rodrigues et al., 2015). In (Rodrigues et al, 2015), only the effect of ElectroCardioGraphy (ECG) and Heart Rate Variability (HRV) data were investigated on drivers’ stress level. In (Barua et al, 2015), the effect of respiration rate, oxygen saturation, heart rate, and finger temperature data, as well as Global Position System (GPS) of the car were investigated on drivers’ stress level. Scheengass et al, (2013), chose the following physiological data: ECG (for heart rate and heart rate variance), skin conductance, and body temperature. Examples of Machine learning methods that were used for stress diagnosis are: Artificial Neural Networks (ANN), Support Vector Machine (SVM), and Case-Based Reasoning (CBR) (Barua et al, 2015), or Hidden Markov Models (HMM), Bayesian techniques, Decision Trees, Genetic algorithms, Clustering methods as k-means, and Fuzzy logic based techniques (Meiring and Myburgh, 2015).

3. Survey Questions and Results

The survey contained 21 questions and was posted on Google surveys. 180 people filled this survey. The questions of the survey can be classified into three types:

- A. Demographic information about participants (8 questions).
- B. Perceived stress and factors affecting it (8 questions).
- C. Participants’ opinions about good driving practices (5 questions).

The following subsections will present results of each category.

A. Demographic information about participants

The 180 participants of the survey were 108 males (60%) and 66 females (37%). Age ranges of participants cover most of the ranges, but the highest percentage is for ages between 18 and 29 (58.9%). (30-39) participants formed 12.8%, while (40-49) formed 3.9%, and (50-59) formed 6.0%. Above 60 years old formed 2.3%. Although the survey targeted Jordan as most of the participants drive in Jordan (83.9%), however, we did not restrict the participation of people from other countries (8.9%) as it is a global problem.

The survey asked participants about the number of years of driving, where most of the participants had more than 4 years (47.8%). Participants with experience less than one year formed 12.8%. While participants with 1-2 years of experience formed 15.6% and 3-4 years formed 21.1%.

Most of the participants drove 1-2 hours a day (41.1%). 22% of participants drove 3-4 hours daily, while 13.9% drove more than 4 hours daily.

The survey asked the participants to rate their driving experience and the percentages were as follows:

- Excellent 44.4%,
- Good 45.6%,
- Acceptable 5.6%,
- Weak 1.7%

The survey asked the participant about any medical conditions that he/she may have in order to relate these conditions to any perceived stress levels later, and the results are as follows:

- Blood pressure 6.1%,
- Heart problems 1.1%,
- Problems in respiratory system 8.3%,
- Diabetes 3.9%
- Not answered or No disease 80.6%

Finally, the survey asked participants about the number of accidents that they were involved in and the results came as follows:
- Zero 38.9%
- (1-2) 45.6%
- (3-4) 7.8%
- more than 4 5%

B. Stress and factors affecting it

Eight questions in this category asked participants about symptoms associated with stress and the frequency of feeling stressed while driving. Participants were also asked about the time of driving, road type, other drivers’ behavior and weather conditions in order to establish the factors that may affect stress. Figures 1-8 present the results of these questions.

Figure 1: Frequency of feeling stress during driving

Figure 2: The effect of time of driving

Figure 3: Symptoms of stress while Driving

Figure 4: road types at which stress increases
Figure 5: Suggested Techniques to reduce stress while driving

Figure 6: Other drivers’ behavior and factors that increase stress

Figure 7: Weather conditions that increase stress during driving

Figure 8: Benefit of having a device to monitor driver’s stress level

Results of figures above show that the following options for respective questions had the majority/highest percentages: “breath increases rapidly” (26%), “at night time” (56%), “few times” (64%), “narrow subways” (26%), “sudden moves of cars around driver” (31%), “fog” (36%), “listen to something soothing” (41%), and “always beneficial” (53%) corresponding to symptoms, time of driving, frequency of feeling stress, road types, other drivers’ behavior, weather conditions, techniques to reduce stress, and benefits of having a monitoring device for stress respectively.

C. Good driving practices

This part shows the results of questions that asked participants about good practices while driving, whether they practice them or their opinions about them. Table 1 below presents these questions and their results.

TABLE 1: Questions and Results of Survey (Good driving practices)

<table>
<thead>
<tr>
<th>Question</th>
<th>Options</th>
<th>Percentages</th>
</tr>
</thead>
<tbody>
<tr>
<td>DO you use the mobile while driving?</td>
<td>a lot</td>
<td>10%</td>
</tr>
<tr>
<td></td>
<td>sometimes</td>
<td>36%</td>
</tr>
<tr>
<td></td>
<td>rarely</td>
<td>33%</td>
</tr>
<tr>
<td></td>
<td>no</td>
<td>17%</td>
</tr>
<tr>
<td></td>
<td>not answered</td>
<td>4%</td>
</tr>
<tr>
<td>Do you put the safety belt while driving</td>
<td>yes</td>
<td>51%</td>
</tr>
</tbody>
</table>

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4. Discussion and Analysis of Survey

All questions were analyzed relative to participants’ genders (whether in Jordan only or for all countries)\(^1\). However, results with significant different percentages between genders in Jordan only (90 males and 60 females) are presented below:

a. When considering the "participants' driving skills of both options” excellent and good, the percentages of males and females are similar and indicate a high self-esteem for both genders. However, when combining this question the results of the participants’ driving years of experience (3 -4 or more than 4), the percentages of males were still high but for females the percentages dropped considerably. This is an indication that both gender’s self-esteem is high but not highly related to their years of driving experience.

b. We tried to find out if the number of accidents that participants were involved in is affected by age ranges. So we investigated the "number of accidents the participant was involved in” (0 to 2 accidents only) and the age range (from 18 to 39) only, the percentages of males and females are similar but relatively much lower than when considering only the answers of number of accidents the participant was involved in (0 to 2 accidents). However, when the answer of participants driving skills (excellent, good) and years of driving (from 3 - 4 or more than 4 years) were included with number of accidents the participant in (0 to 2 accidents), the percentages of female participants dropped considerably more than their male ones. Results presented here are similar to those presented in (Abojaradeh et al, 2015). Looking further in statistics provided in this study, we can deduce that female drivers that have high years of experience and with low number of accidents and excellent to good skills are about half the male drivers.

c. With regard to the results of "illnesses that participants have, it is not possible to give an indication of the effect of illnesses on drivers’ performance because of the small number of participants with illnesses.

d. With regard to "participants' using safety belts while driving", the percentage of male participants putting their safety belts is much lower than that for female. However, when the answer to this question is “sometimes”, the percentage of female participants putting their safety belts is much lower than that for male. This is an indication that male drivers have less regard to traffic laws. Such an indication was also noticed in (Abojaradeh et al, 2015).

e. With regard to responses of participants to "Do you think using mobiles while driving causes accidents?" the percentages of males (91%) and females (95%) who confirmed are very high

\(^1\) Data are available for further research. Please contact authors if data is required.
and similar. These high percentages indicate that drivers are aware of the effect of mobiles while driving.

f. With regard to "Do you use mobile while driving?" Table 2 shows the effect of gender on percentages. In general, the percentages of males using mobiles (a lot or sometimes) are higher than females. Actually, the percentage is almost double in case of male drivers using their mobiles “sometimes”. When adding up the percentage of all choices in this question, the percentage of male participants is 92.2%, showing that almost all male drivers don’t abide by traffic laws. Meanwhile, the percentage of female participants is 68.3% indicating that the majority of female drivers also don’t abide by traffic laws. The very high percentage of participants answering (a lot, sometimes, and rarely) (about 80%) in this study is slightly higher than those reported in USA, Australia, and European countries (AboJadi and Fraihat, 2015). Also, although the answers of participants in question “Do you think using mobiles while driving causes accidents?” were high, nevertheless the actions of those participants in using mobiles were also high. This is an indication that although drivers are aware of the regulations forbidding the use of mobiles and their possible harmful effects leading to accidents, their behavior indicates a lack of responsibility or for some a consequence of mobile addiction.

<table>
<thead>
<tr>
<th>TABLE 2: Do you use mobile while driving question (further analysis)</th>
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<tbody>
<tr>
<td><strong>Original Percentages of choices for</strong></td>
</tr>
<tr>
<td><strong>you use the mobile while driving?</strong></td>
</tr>
<tr>
<td>a lot 10%, sometimes 36%, rarely 33%, no</td>
</tr>
<tr>
<td>17%, not answered 4%</td>
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g. With regard to the question "Do you write and send SMS through mobile while driving?", although the majority of drivers answered NO (61%), here we concentrate on those who answered YES (35%). The percentage of male drivers who said yes (40%) is found to be higher than that of female drivers (26.7%). However, the numbers of drivers that send and write SMS in this study are much lower than those who use the mobile. This might be explained by the fact that writing SMS requires from a person more concentration than talking on the mobile. This is partially due to the new microphones that drivers use while driving to talk to others through their mobiles.

h. With regard to the question "causes of accidents", percentages for all options of males and females are similar. Such results are in agreement with those in (Magableh et al, 2015). In (Magableh et al, 2015), other important behaviors of drivers that cause accidents were investigated as using phones, sleepy, aggressive, taking wrong lanes among others.

i. With regard to frequencies of feeling stressed while driving, Table 3 shows the percentage according to gender for all options of the question. In general, male drivers’ percentages are much higher than females’ percentages. However, the percentages of males and females for the option “sometimes” are low but similar. As seen in figure 1 and table 3, the option “few times” has the highest score (64%), so we further investigate whether other factors like age, driving experience, and number of accidents would affect this percentage. However, percentages were very low here, so no definitive conclusion can be reached.

<table>
<thead>
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<th>TABLE 3: You feel stressed more while driving question (further analysis)</th>
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<tr>
<td><strong>Original Percentages of choices for</strong></td>
</tr>
<tr>
<td><strong>You feel stressed while driving</strong></td>
</tr>
<tr>
<td>always 4%, frequently 7%,</td>
</tr>
<tr>
<td>sometimes 22%, few times 64%,</td>
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j. With regard to participant's feeling stressed while driving at night time, the percentages of males (27.8%) and females (33.3%) are slightly low and similar. Also, for the choice of feeling stressed at day time, the percentage of males (26.7%), although still low, is much higher than females (6.7%). For the choice of feeling stressed at both times, the percentages of males (5.6%) and females (8.3%) are very low and similar. In (PSD, 2016) the number of accidents during a 24 hour interval was concentrated in the periods (8-1 daytime), (3-6 afternoon), (8-12 evening), and (1-4 near sunrise). The highest number of accidents was at day time compared to those at night time, sunrise, sunset, etc. Although (PSD, 2016) reports the relation between accidents and time and our study reports the relationship between stress and time, the results are comparable and may indicate a correlation between accidents and stress.

k. In all options of symptoms of stress question, the percentages of males and females are low and similar. However, the majority of participants' choices concentrated on “breathing speed up and/or pain in head symptoms” (26%).

l. With regard to places that increase the driver’s stress level, the percentages of males and females for all options are similar. In (Al-Shannaq, 2015), a conclusion was reached that the number of accidents was high at roundabouts especially at peak times. In this study, the “narrow subways” choice collected the highest percentage (26%), while “roundabouts” came in second (22%).

m. With regard to weather conditions that increase stress level while driving, the percentages of males and females for all choices are similar. In (PSD, 2016), the percentages of accidents in Jordan at clear weather (i.e. the “no conditions” choice in this study) was the highest compared to those for snow, fog, etc. This is different from percentages obtained here since the percentages for this point are relating weather conditions with stress. Foggy weather collected the highest percentage (36%).

n. The question about "How to reduce stress while driving", the percentages of most of the options for both males and females are low and similar, except for “someone sits beside you”, the percentage of males (17.8%) is much higher than percentage of females (6.7%). In this study, 50% of participants though that any of the methods would reduce their stress.

o. For the last question "Do you think it is useful to have a device that monitors the driver’s stress level and alerts him/her while driving?", percentages of males and females for the “useful at all times” option are low and similar. However, the percentage of males (22.2%) for the choice “not useful” is higher than that of females (15%).

5. Future Work

We can see from the results of this study that some people perceive stress while driving. The questions we raise next are: what is the effect of this stress produced from this daily activity on our health? What are the physiological symptoms inside our body from this stress? Would the stress level differ between genders?

So to answer these questions, our future work will use data mining methods to investigate any correlation between the physiological data of a driver and the perceived stress levels. The physiological data will be collected through a mobile application that is currently under development. This app will be used first to collect general information about the driver participating in the investigation. The driver's car will be set up with two cameras, one for collecting photos for the road and the other for collecting photos for the driver's face. A highly accurate device (called NeXus-10) will be used to collect the required physiological data as:

- EMG: muscle contraction of the shoulders.
- ECG: heart rate variability
- Respiration
- Skin Conductance measured from the fingers

Figure 9: (a) Cameras setup in the car, one recording the road and the other recording the driver's face (b) Respiration belt and ECG sensors on the driver (c) Car set up with Nexus-10 device (d) GRS and ECG sensors on the driver.

These data were chosen based on literature review of previous stress measurement studies in section 2. Figure 9 above shows a picture of the car set up for the future work.

Conclusions

Many of survey’s results are consistent with previous research work as cited above. However, some survey results raised the need for further investigation regarding the relation to stress. So while collecting data it is important to consider taking empirical physiological data that identifies stress level variation and its effect on driver's behavior. It is also important to: take into account a comparable percentages of female drivers to male drivers, to investigate the effect of other factors.
that cause accidents such as using phones, sleepy, aggressive, taking wrong lanes among others on stress level, collecting data at different time intervals, investigate if the stress level can be detected by any of mentioned symptoms, investigate the effect of at roundabouts as well as other places on physiological data and stress level variations, study the effect of sudden moves of cars around the driver on stress level, and study the effect of weather conditions on stress levels.

References


